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FASCIA: HISTOLOGICAL STUDY

The pectoral fascia: Anatomical and histological study

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Summary
Aim: Analysis of the pectoral fascia from a macroscopic and histological point of view.
Results: The pectoral fascia appears as a thin collagen layer (mean thickness of 297 μm) formed by undulated collagen fibres and many elastic fibres, within which small nerves are highlighted. Numerous septa detach from its internal surface, creating an intimate connection between the fascia and the pectoralis major muscle.
Discussion: The pectoral fascia and the pectoralis major muscle should be considered together, given that the anatomical base is effectively a myofascial unit, term that defines the muscles and the fascia of a specific region that have a precise functional organization. The capacity of force transmission between the inferior and superior limbs needs to be attributed to this entire myofascial complex. We hypothesize that the superficial, large muscles of the trunk developed inside the superficial layer of the deep fascia to enhance modulation of tension transmission between the different segments of the body.

Introduction

Ida Rolf (1977) was one of the first authors to consider fascia as an important element in musculoskeletal pain, describing it as an element of connection between different anatomical structures. Over the following years, other authors have

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focused on the role of the fascia as a three-dimensional network extending throughout the whole body (Bienfait, 1995; Stecco, 1996; Myers, 2001; Langevin, 2006). This connective tissue network is stretched by the contraction of underlying muscles and can transmit tension at a distance (Maas et al., 2005; Meijer et al., 2006). Nonetheless, extensive scientific studies with reference to fascia are still lacking. In fact, only a few specific fascial structures have been analysed in detail. In particular, studies concerning the thoracolumbar fascia (Gracovetsky et al., 1985; Vleeming et al., 1995; Yahia et al., 1992; Langevin and Sherman, 2007; Loukas et al., 2007), the iliotibial tract (Gerlach and Lierse, 1990; Birnbaum et al., 2004; Fairclough et al., 2006) and the plantar aponeurosis (Mitchell et al., 1991; Putz and Müller-Gerbl, 1991; Kitaoka et al., 1997; Hedrick, 1996; Yu, 2000; Theodorou et al., 2001) are known. All these fasciae are very strong, and their capacity for force transmission is evident.

This limited number of studies has produced rather generalized results concerning the anatomy of the human fasciae, attributing the same macroscopical, histological and biomechanical characteristics to all of the above-mentioned deep fasciae. Some authors (Myers, 2001; Paoletti, 2002; Stecco, 2004) affirm that, like the thoracolumbar fascia, the fasciae of the anterior region of the trunk may also be implicated in the transmission of traction between inferior and superior limbs, as well as between contralateral limbs. In previous studies (Stecco, 2006, 2007), we have demonstrated that the muscular fasciae of the different regions of the body present different anatomical and mechanical features. In fact, most anatomical textbooks do describe these fasciae in different ways: the thoracolumbar fascia is described as an aponeurosis and the pectoral fascia as a thin layer of loose connective tissue (Testut and Jacob, 1905; Chiarugi, 1975; Basmajian, 1989; Standring et al., 2005). However, if the pectoral fascia is effectively as thin as suggested, then it is improbable that it could transmit traction generated by the contraction of the abdominal muscles to the fasciae of superior limbs, as proposed by Myers (2001) or Paoletti (2002).

Therefore, the purpose of this study is to analyse the pectoral fascia from a macroscopic and histological point of view, and to examine its relationship with the following muscles: pectoralis major and minor, rectus abdominis, external oblique and serratus anterior. Its relationship with the other surrounding fasciae will also be evaluated in order to understand whether the pectoral fascia is part of a more complex structure, or if it is to be considered as an autonomous element.

Materials and methods

Collaboration between the Institute of Anatomy of the University of Padova, and the Anatomy Department of the René Descartes University of Paris, provided us with the opportunity to perform macroscopical and microscopical analysis of fasciae from the regions of the anterior thorax in six cadavers (4 males, 2 females, mean age of 69 years). These cadavers were neither embalmed nor frozen prior to examination.

Each dissection was performed according to the following protocol:

In the first phase, only the skin was removed in order to display the subcutaneous tissue and the superficial fascia layer. Following the removal of the superficial fascia, we evaluated the deep fascia and its relationships with the underlying muscle groups. The various muscular insertions onto the fascia were isolated and photographed (Canon EOS 350 digital camera), and then mapped by means of photographs and sketches.

Full-thickness specimens ($1 \times 1.5\,cm^2$) were removed from each subject, together with specific deep fascia specimens for histological analysis. Specimens were taken from the upper third, middle third and inferior third of the pectoral region, along the midclavicular line. Hence, from each subject, three full-thickness specimens were obtained. All specimens were preserved in formaldehyde 4% in phosphate buffer saline (PBS) 0.1 M, pH 7.0, and then embedded in paraffin. Each specimen was prepared by slicing in parallel and in perpendicular with respect to the fascial surfaces. The following stains were then used: hematoxylin and eosin, Van Gieson for the elastic fibres, and Azan-Mallory for the collagen fibres. The immunohistochemical stain for nerve structures, anti-S100 antibody, was also applied. The reaction was then highlighted using the peroxidase–antiperioxidase immunocytochemical method. All preparations were observed with a Leica DMR microscope.

Morphometrical measurements of the deep fascia were made utilizing the full-thickness specimens. The mean and the standard deviation of these measurements were then calculated. Analysis of the differences in thickness between the different regions was accomplished by comparing the results obtained with appropriate statistical tests (Kurskal–Wallis test and Dunn's multiple comparison test as a control).

Results

After removing the skin, the superficial fascia is evident in all subjects. The superficial fascia appears as a thick layer of fibroadipose tissue, forming a tridimensional network (mean thickness $151.5 \pm 40\,\mu m$). It is firmly connected with the dermis, while it is easily separable from the deeper anatomical planes (Figure 1).

The platysma muscle and the mammary gland are recognizable as inclusions within the superficial fascia. Following removal of the superficial fascia, the fascia of the pectoralis major muscle (the pectoral fascia) can be examined. It has the same appearance as a thin collagen layer. The pectoral fascia is firmly connected to the underlying muscle by many intramuscular septa, which originate from the inner surface of the fascia and penetrate between the muscular fibres, dividing the muscle itself into many bundles. The pectoral fascia originates from the clavicle, and then it divides itself into two layers to include the pectoralis major muscle. In effect, only the deep layer of the pectoral fascia adheres to the clavicular periosteum, whereas its superficial layer continues with the superficial lamina of the deep cervical fascia, which surrounds the sternocleidomastoid muscle. Laterally, the pectoral fascia continues with the deltoid fascia and extends a fibrous expansion into the brachial fascia. The deltoid fascia encloses the deltoid muscle in a similar manner as that of the pectoral fascia and the pectoralis major muscle. Over the serratus anterior, the two layers of the pectoral fascia adhere to form a single fascial lamina. Posteriorly, this single layer divides itself again to enclose the latissimus dorsi muscle in the same manner as the pectoral fascia and the pectoralis major muscle. Medially, the deep layer of the pectoral fascia inserts into the sternum, while the superficial layer extends beyond the sternum to continue with the pectoral fascia on the other side (Figure 2). Distally, the pectoral fascia is reinforced by some fibrous expansions originating from the rectus abdominis sheath and by the fascia of the contralateral external oblique muscles (Figure 3). For this reason, the distal portion of the pectoral fascia appears to be stronger and a clearly visible, interwoven pattern of fibres forms over the xyphoid process. After detaching the pectoralis major muscle, the clavipectoral fascia is visible. There is an ample plane of cleavage between these two structures due to the presence of loose connective tissue, which allows the deep layer of the pectoral fascia to glide autonomously with respect to the clavipectoral fascia (Table 1).

Figure 1 The superficial fascia is removed to show the pectoral fascia adhering to the pectoralis major muscle.

Figure 2 The superficial layer of the pectoral fascia passes over the sternum (S) and continues with the superficial layer of the controlateral pectoral fascia (PM), whereas the deep layer continues with the sternal periosteum. (X) Xyphoid process.

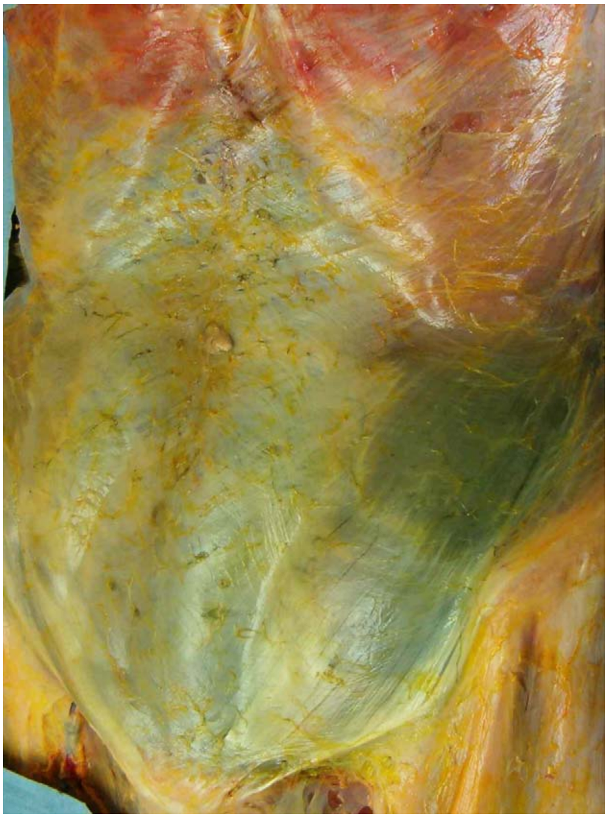
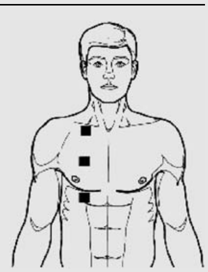


Figure 3 Photograph of the trunk showing the continuity between the pectoral fascia and the ipsilateral and contralateral rectus abdominis sheaths.

Table 1 Age and sex of the subjects.

Subjects	Age	Sex
1	65	M
2	48	F
3	81	F
4	93	F
5	52	M
6	74	M



In the figure, the zones where the full thickness specimens were removed are shown.

On histological examination, the pectoral fascia appears to be formed by undulated collagen fibres and some elastic fibres in an irregular mesh (Figure 4a).

Morphometrical analysis of the histological specimens (Table 2) confirmed that the deep fascia of the pectoral region is a thin lamina (mean thickness 151 μm $\pm$ 37) that adheres to muscle. In particular, its thickness increases in a cranio-caudal direction: it presents a mean thickness of 131 μm ($\pm$19 μm) in the subclavicular region, 182 μm ($\pm$84 μm) in the mammary region and 578 μm ($\pm$42 μm) in the inferior thorax region. An epimysial fascia, or epimysium, is not discernible between this deep fascia and the underlying muscle, but the pectoralis major muscle does insert directly onto the pectoral fascia itself. Undulated collagen fibres, arranged more or less transversely with respect to the underlying muscle, form the pectoral fascia. An elevated number of elastic fibres are evident with the Van Gieson stain (Figure 4b). These fibres form an irregular mesh. The estimated percentage of elastic fibres, with respect to the collagen fibres, could be approximately 15%. The S100 stain-highlighted rare nerve terminations are arranged in a homogenous manner throughout the entire pectoral fascia.

Discussion

The pectoral fascia is a thin lamina of connective tissue, relatively rich in elastic fibres, and it is firmly adhered to the underlying muscle. The variations in thickness of the pectoral fascia are comparable to those reported by Jinde et al. (2006), which is the only other study we are aware of that details precise morphometric measurements of this tissue. We also confirm, as this author reported, that there is a progressive increase in the thickness of the pectoral fascia in a proximal–distal direction. Furthermore, the deep pectoral fascia adheres closely to the underlying muscle due to many intramuscular septa that extend from its inner surface and numerous muscular fibres that insert onto these same septa, as well as onto the inner surface of the fascia itself. A true epimysium of the pectoralis major is not identifiable, but it can be affirmed that the deep fascia itself acts as a surrogate for the epimysium in this region. In fact, the histological structure (thickness, arrangement of the collagen fibres, elastic component, etc.) of the pectoral fascia is similar to that of the epimysium of the limbs. This latter finding contradicts the description given by Hwang and Kim (2005); Graf et al. (2000); Tebbetts (2004) who describe the pectoral fascia as an independent structure with respect to the pectoralis major. Probably, these different anatomic descriptions depend more on differences in terminology rather than true anatomical variations. These authors apparently refer to the pectoral fascia when they are actually referring to the superficial fascia that, even in our dissections, appears as a thick, strong structure, easily separable from the pectoralis major muscle.

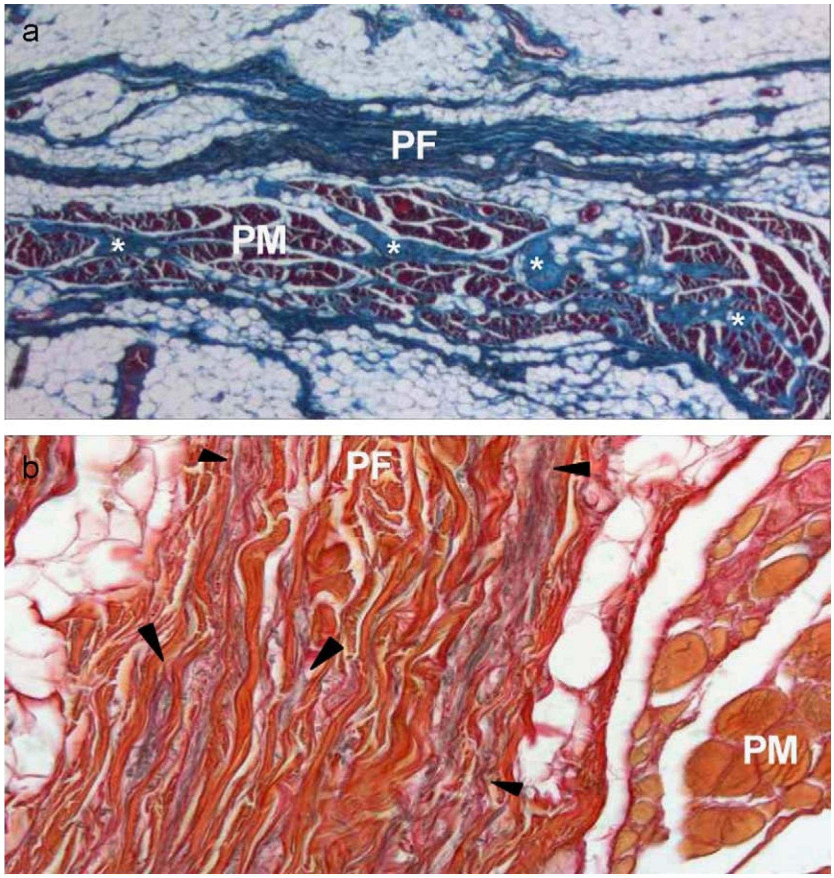


Figure 4 Two histological samples of the pectoral fascia. (A) Azan Mallory stain, showing the connection between the pectoral fascia (PF) and the pectoralis muscle (PM) by means of many intramuscular septa (*). (B) van Gieson stain, showing an abundance of elastic fibres (black arrow).

Table 2 Thickness (μm) of the pectoral fascia evaluated in the full thickness specimens of the three analysed regions.

Subjects	Pectoral fascia		
	Subclavear region	Mammary region	Inferior thorax region
1	99	101	601
2	163	124	524
3	126	131	631
4	125	240	552
5	134	145	540
6	140	351	625
Mean values ($\pm$SD)	131.2$\pm$19.1	182$\pm$87.4	578.8$\pm$42

From our study, it is evident that the pectoralis major is comprised between two layers of the deep fascia. In the trunk, we can describe three different layers of the deep fascia: the superficial layer, the intermediate layer and the deep layer. In particular, in the thorax the deep layer covers the intercostal muscles, the intermediate layer covers the pectoralis minor (corresponding to the clavi-pectoral fascia) and the serratus anterior muscles. The superficial layer envelops the pectoralis major, passes over the serratus anterior and then, in the dorsal region, envelops the latissimus dorsi and trapezius muscles. This layer also continues with the fasciae of deltoid, proximally, and gluteus maximus, distally. It is evident that all of these muscles present the same features. Specifically, they are large muscles, formed by different muscular bundles, and they adhere firmly to their fascia due to many intersecting intramuscular septa. This close connection between fascia and muscles allows the fascia to perceive the state of contraction of the enveloped muscle. Our dissection also demonstrated that the pectoral fascia does not originate at the level of the clavicle and the sternum but, via its superficial lamina, it passes over these structures to continue, cranially, with the superficial lamina of the cervical deep fascia and, medially, with the contralateral pectoral fascia. This myofascial arrangement agrees with the description of the trunk fascia as reported by Sato and Hashimoto (1984). These authors affirm that the pectoralis major, latissimus dorsi and trapezius muscles form an additional myofascial layer with respect to the muscular planes in the rest of the trunk. From our dissections, it is also evident that this additional myofascial layer of the trunk continues with the deep fasciae of the limbs; in particular, with the brachial fascia of the upper limbs and with the fascia lata of the inferior limbs. The connections between the fasciae of the trunk and of the limbs follow a precise spatial organization, permitting accurate transmission of the myofascial forces from the trunk to the limbs (Stecco et al., 2008). Furthermore, during the lifting of a weight, the two pectoralis major muscles necessarily modulate their contraction in order to generate a balanced strength (Figure 5). The specific arrangement of the pectoral fascia, connecting the right and left pectoral muscles and passing over the sternum, could permit this type of synchronization. In particular, the transmission of forces by fascia could stretch the muscle spindles present in the epimysium (which, in this region, corresponds to the pectoral fascia) and the endomysium (Strasmann, 1990; Von Dΰring and Andrei, 1994), allowing muscular contraction to be modulated by "peripheral" demands. This mechanism could give the anatomical bases of the peripheral motor coordination. In the dorsal region, a similar structure can also be found between the trapezius muscles, which are activated in a synchronous way during the opening out of the upper limbs.

The fact that the pectoral fascia is thin and elastic does allow it to expand with the elongation of the pectoralis major muscle and then to return to its basal status. Conversely, it is more difficult to attribute it with a capacity of transmission of myofascial forces. Therefore, the capacity of force transmission is not to attribute to the pectoral fascia alone, but to the entire myofascial complex. We hypothesize that all the large muscles are developed within the superficial layer of the deep fascia of the trunk in order to modulate the transmission of tension between the different segments of the body more effectively.

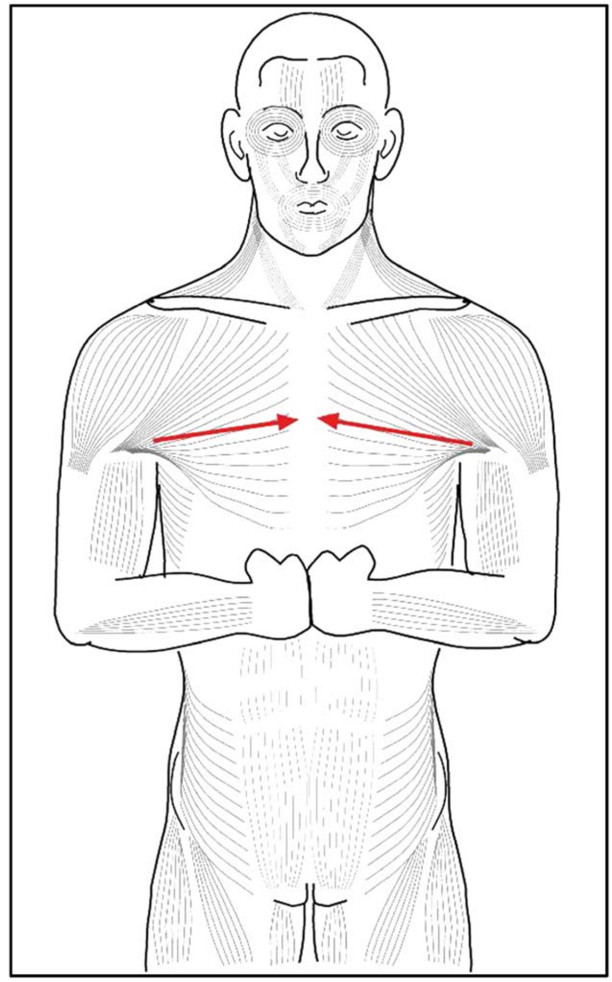


Figure 5 During the lifting of a weight, or when pressing hands together in front of the chest, the two pectoralis major muscles have to modulate their contraction in order to generate a balanced strength. By passing over the sternum, the pectoral fascia connects the right and left pectoral muscles, permitting synchronization of the two muscles. This mechanism could provide the anatomical bases of the peripheral motor coordination.

References

Basmajian, J.W., 1989. Grant's Method of Anatomy, 11th ed. Williams & Wilkins, Baltimore, pp. 359–371.

Bienfait, M., 1995. Le fascia et son traitement. Les pompages. Spek ed, Paris.

Birnbaum, K., Siebert, C.H., Pandorf, T., Schopphoff, E., Prescher, A., Niethard, F.U., 2004. Anatomical and biomechanical investigations of the iliotibial tract. Surgical and Radiologic Anatomy 26, 433–446.

Chiarugi, G., 1975. Istituzioni di Anatomia dell'uomo, vol 1. Società editrice libraria, Milano, p. 146.

Fairclough, J., Hayashi, K., Toumi, H., Lyons, K., Bydder, G., Phillips, N., Best, T.M., Benjamin, M., 2006. The functional anatomy of the iliotibial band during flexion and extension of the knee: implications for understanding iliotibial band syndrome. Journal of Anatomy 208, 309–316.

Gerlach, U.J., Lierse, W., 1990. Functional construction of the superficial and deep fascia system of the lower limb in man. Acta Anatomica 139, 11–25.

Graf, R.M., Bernardes, A., Auersvald, A., Damasio, R.C., 2000. Subfascial endocscopica transaxillary augmentation mammaplasty. Aesthetic Plastic Surgery 24, 216–220.

Gracovetsky, S., Farfan, H., Helleur, C., 1985. The abdominal mechanism. Spine 10, 317–324.

Hedrick, M.R., 1996. Current topic review: the plantar aponeurosis. Foot Ankle 17, 646–649.

Hwang, K., Kim, D.J., 2005. Anatomy of pectoral fascia in relation to subfascial mammary augmentation. Annals of Plastic Surgery. 55, 576–579.

Jinde, L., Jianlianq, S., Xiaopinq, C., Xiaoyan, T., Jiaqinq, L., Qun, M., Bo, L., 2006. Anatomy and clinical significance of pectoral fascia. Plastic and Reconstructive Surgery 118, 1557–1560.

Kitaoka, H.B., Luo, Z.P., An, K.N., 1997. Mechanical behavior of the foot and ankle after plantar fascia release in the unstable foot. Foot Ankle International 18, 8–15.

Langevin, H.M., 2006. Connective tissue: a body-wide signalling network? Medical Hypotheses 66, 1074–1077.

Langevin, H.M., Sherman, K.J., 2007. Pathophysiological model for chronic low back pain integrating connective tissue and nervous system mechanisms. Medical Hypotheses 68, 74–80.

Loukas, M., Shoja, M.M., Thurston, T., Jones, V.L., Linganna, S., Tubbs, R.S., 2007. Anatomy and biomechanics of the vertebral aponeurosis part of the posterior layer of the thoracolumbar fascia. Surgical and Radiologic Anatomy 30, 125–129.

Maas, H., Meijer, J.M., Huijing, P.A., 2005. Intermuscular interactions between synergists in rat originates from both intermuscular and extramuscular myofascial force transmission. Cells Tissues Organs 181, 38–50.

Meijer, H.J., Baan, G.C., Huijing, P.A., 2006. Myofascial force transmission is increasingly important at lower forces: firing frequency related length–force characteristics of rat extensor digitorum longus. Acta Physiologica 186, 185–195.

Mitchell, I.R., Meyer, C., Krueger, W.A., 1991. Deep fascia of the foot. Anatomical and clinical considerations. Journal of American Podiatric. Medical Association 81, 373–378.

Myers, T.W., 2001. Anatomy Trains. Churchill Livingstone, Oxford, pp. 171–194.

Paoletti, S., 2002. Les Fascias. Rôle des Tissus Dans la Mécanique Humaine. Sully, Vannes, pp. 193–199.

Putz, R., Müller-Gerbl, M., 1991. Functional anatomy of the foot. Orthopade 20, 2–10.

Rolf, I., 1977. Rolfing: The Integration of Human Structures. Harper and Row.

Sato, T., Hashimoto, M., 1984. Morphological analysis of the fascial lamination of the trunk. Bull Tokyo Med Dent University 31, 21–32.

Standring, S., Ellis, H., Healy, J., Johnson, D., Williams, A., 2005. Gray's Anatomy, 39th ed. Churchill Livingstone, London, pp. 817–852.

Stecco, L., 1996. La Manipolazione Neuroconnettivale. Marrapese, Roma, pp. 45–62.

Stecco, L., 2004. Fascial Manipulation for Musculoskeletal Pain. Piccin, Padova, pp. 123–130.

Stecco, C., Porzionato, A., Macchi, V., Tiengo, C., Parenti, A., Aldegheri, R., Delmas, V., De Caro, R., 2006. Histological characteristics of the deep fascia of the upper limb. Italian Journal of Anatomy and Embryology 111, 105–110.

Stecco, C., Gagey, O., Belloni, A., Pozzuoli, A., Porzionato, A., Macchi, V., Aldegheri, R., De Caro, R., Delmas, V., 2007. Anatomy of the deep fascia of the upper limb. Second part: study of innervation. Morphologie 91, 38–43.

Stecco, C., Porzionato, A., Macchi, V., Stecco, A., Vigato, E., Aldegheri, R., Delmas, V., De Caro, R., 2008. The expansions of the pectoral girdle muscles onto the brachial fascia: morphological aspects and spatial disposition. Cells Tissues Organs, 19 [Epub ahead of print].

Strasmann, T., 1990. Functional topography and ultrastructure of periarticular mechanoreceptors in the lateral elbow region of the rat. Acta Anatomica 138, 1–14.

Tebbetts, J.B., 2004. Does fascia provide additional, meaningful coverage over a breast implant? Plastic and Reconstructive Surgery 113, 777–779.

Testut, J.L., Jacob, O., 1905. Précis d'anatomie topographique avec applications medico-chirurgicales, vol III, Gaston Doin et Cie, Paris, p. 302.

Theodorou, D.J., Theodorou, S.J., Farooki, S., Kakitsubata, Y., Resnick, D., 2001. Disorders of the plantar aponeurosis: a spectrum of MR imaging findings. American Journal of Roentgenology 176, 97–104.

Vleeming, A., Stoeckart, R., Snijders, C.J., 1995. The posterior layer of the thoracolumbar fascia. Spine 20, 753–758.

Von Dÿring, M., Andrei, K.H., 1994. Topography and fine structure of proprioceptors in the hagfish, myxine glutinosa. European Journal of Morphology 32, 248–256.

Yahia, H., Rhalmi, S., Newman, N., 1992. Sensory innervation of human thoracolumbar fascia, an immunohistochemical study. Acta Orthopaedica Scandinavia 63, 195–197.

Yu, J.S., 2000. Pathologic and post-operative conditions of the plantar fascia: review of MR imaging appearances. Skeletal Radiology 29, 491–501.