



PERSPECTIVES

# Possible Applications for Fascial Anatomy and Fasciaology in Traditional Chinese Medicine

Yu Bai<sup>1</sup>, Lin Yuan<sup>1\*</sup>, Kwang-Sup Soh<sup>2</sup>, Byung-Cheon Lee<sup>2</sup>, Yong Huang<sup>3</sup>, Chun-lei Wang<sup>3</sup>, Jun Wang<sup>4</sup>, Jin-peng Wu<sup>1</sup>, Jing-xing Dai<sup>1</sup>, Janos Palhalmi<sup>5</sup>, Ou Sha<sup>4</sup>, David Tai Wai Yew<sup>6</sup>

<sup>1</sup>Department of Anatomy, Southern Medical University, Guangzhou, China

<sup>2</sup>Biomedical Physics Laboratory, Department of Physics and Astronomy, Seoul National University, Seoul, Korea

<sup>3</sup>Department of Traditional Chinese Medicine, Southern Medical University, Guangzhou, China

<sup>4</sup>Department of Anatomy, Shenzhen University School of Medicine, Shenzhen, China

<sup>5</sup>East-West Biomedicine Limited, Monorierdo, Hungary

<sup>6</sup>Department of Anatomy, The Chinese University of Hong Kong, Hong Kong, China

Received: March 9, 2010  
Accepted: April 13, 2010

**KEY WORDS:**

acupoints;  
anatomy;  
fasciaology;  
meridians;  
primo-vessel;  
traditional Chinese  
medicine

**Abstract**

Research using medical imaging instruments such as computed tomography and magnetic resonance imaging has led to the proposal that the fascial network distributed over the human body is the anatomical basis for the acupoints and meridians of traditional Chinese medicine. Therefore, we put forward a new theory of anatomy called fascial anatomy. In fascial anatomy, a human body is divided into two major systems. One is the supporting-storing system of unspecialized connective tissues. The other is a functional system. An undifferentiated non-specific connective tissue network, with the participation of the nervous and the immune systems, constitutes the supporting-storing system of the human body. The various differentiated functional cells in the body that are supported and surrounded by the supporting-storing system constitute the functional system. The discipline that studies the supporting-storing system and the mutual relationship between this system and the functional system in a living human body is called *fasciaology*. The establishment of fascial anatomy and fasciaology opens a new research field in anatomy; consequently, fasciaology will play a significant role in biological medicine and traditional Chinese medical research, as well as future clinical practice.

## 1. Introduction

Meridian and collateral theory is the basis of traditional Chinese medicine (TCM). Much work has been carried out to find the anatomical component of meridians and collaterals; however, their existence is still disputed [1]. In the visible Chinese human project, a national basic research program of China,

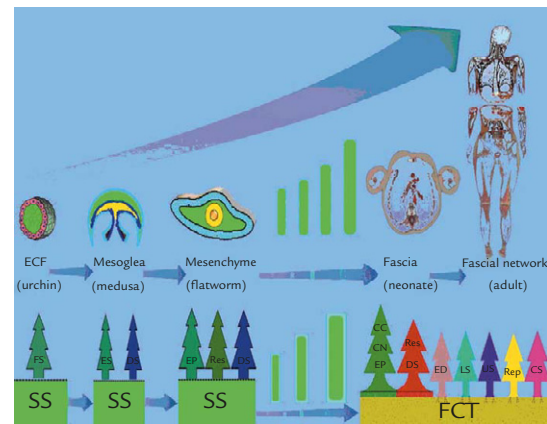
the computer constructed areas rich in fascial connective tissues were found to be very close to the locations of meridians and collaterals [1–3]. Based on the visible Chinese human digital datasets, virtual three-dimensional (3-D) structures of the areas rich in fascial connective tissues along meridians in the body's trunk and limbs were constructed [4]. They revealed a line-like structure similar to that

\*Corresponding author. Department of Anatomy, Southern Medical University, 11/F Life Science Building, 1838 Guangzhoudadao Street North, Baiyun District, Guangzhou 510515, China.  
E-mail: yuanl@fimmu.com

of acupoints and meridians or collaterals [5]. Furthermore, these fascial strings were also close to virtual meridians in distance. More fascial connective tissue areas were constructed into 3-D structures, and more line-like structures were found. After the 3-D structures of all fascial connective tissues throughout the body had been constructed, a body-shaped connective tissue network appeared. Subsequently, based on computed tomography and magnetic resonance images of living human bodies, the 3-D structures of fascial connective tissue were constructed [6]. Similarly, fascial connective tissue also appeared in a line-like pattern and was co-localized with traditional Chinese meridians. Furthermore, using dynamic ultrasound, “*Deqi*” (a sore and numb feeling at acupoints) was found to occur only when a needle penetrated or stimulated the connective tissue of the fascia [7]. The histological composition of meridians has been regarded as non-specific connective tissue, including loose connective tissue and fat tissue [8–11]. The effective sites of acupuncture are therefore thought to be fascial connective tissue, including, amongst others, cells and tissues inside sites such as nerve endings, capillaries, fibroblasts, undifferentiated mesenchymal cells and lymphocytes.

The fascia of the human body is homologous in structure to the extracellular matrix of a single germ layer organism, the mesoglea of a diploblastic organism, and the mesenchyme of a triploblastic organism. Their common function is to sustain stability of the internal environment of an organism [12]. During evolution, the constitutive elements of organisms can be summarized into two types of systems (Figure 1), which are (1) the supporting and storing system containing adipose and loose connective tissues and (2) the functional systems composed of specialized cells. In other words, the fascial network, the mesenchyme, and the extracellular fluid are homologous, and their common function is to sustain stability of the internal environment of an organism. The mesoderm further evolves into organs and systems with specific functions, including the locomotor, urinary, reproductive and circulatory systems [13]. Mesenchyme remnants then differentiate into connective tissues that are distributed throughout the body. The network of fascial connective tissues provides support for the functional systems, which are composed of specialized cells [14]. The functions of the connective tissues play an important role in maintaining a longer life span for the organism. Organisms whose fascia systems are not well evolved have shorter life spans; conversely, those organisms with well evolved fascia systems have longer life spans.

Consequently, two new terms have been defined. First, fascial anatomy is a new anatomical theory



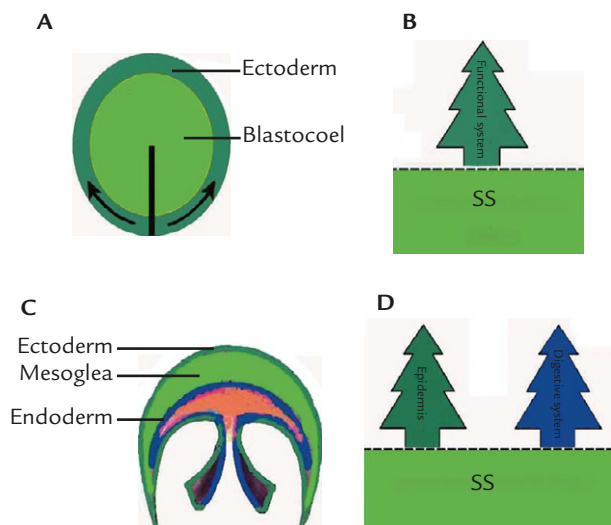
**Figure 1** Schematic diagram showing that the fascia of the human body is homologous in structure to the extracellular matrix of a single germ layer organism, the mesoglea of a diploblastic organism, and the mesenchyme of a triploblastic organism. SS=supporting-storing system; FS=functional system; CC=cerebral cortex; CN=central nerve; EP=epidermis; Res=respiratory system; DS=digestive system; ES=endocrine system; LS=locomotor system; US=urinary system; Rep=reproductive system; CS=cardiovascular system; FCT=fascial connective tissue; ECF=extracellular fluid.

[4,6,8]. According to fascial anatomy, each living organism is composed of two major systems. One is the supporting-storing system, which is composed of a network of unspecialized connective tissues. The other is the functional system, which contains organs and tissues surrounded by the supporting-storing system. Second, fasciaology is the research field that studies the supporting-storing system and the mutual relationships between the above two major systems in a living organism. The theories of fascial anatomy and fasciaology highlight the significance of fascial research, which is important not only in the field of TCM but also in other fields of biomedical research and clinical therapy. TCM theories may be scientifically interpreted through the use of fasciaology.

## 2. Anatomy of Fascia

### 2.1. The origin of fascia

The fascia network is homologous with the extracellular matrix of a single germ layer organism, the middle lamella of a two germ layer organism, and the mesenchyme of a three embryonic layer organism. When the structures are retrospectively displayed and modeled, the components of an organism during each period can be summarized into two major systems (Figure 1). Functional systems are composed of cells with specific functions. They



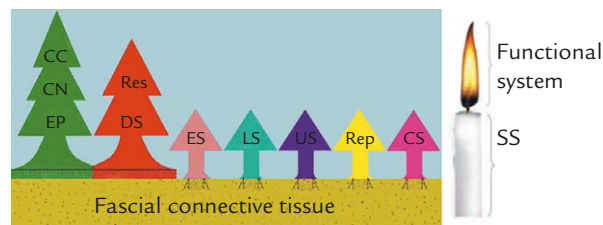
**Figure 2** (A,B) Schematic diagram of a sea urchin embryo, the ectoderm is its functional system, and the blastocoel is its supporting-storing system (SS). (C,D) Diagram of a jellyfish, the ectoderm and the endoderm are its functional system while the mesoglea is its SS.

derive from twists and folds of the ectoderm and the endoblast (Figure 2). In contrast, the network fascia is composed of undifferentiated mesoderm tissue. The major histological compositions of fascia are loose connective tissue and adipose tissue. These tissues provide a stable internal environment for the cells of the functional system [15,16]. The above theory is the basis of fascial anatomy.

## 2.2. Fascial anatomy

Fascial anatomy is a new perspective on anatomy. It classifies body structures into the supporting-storing system and the traditional functional system. This perspective is also applicable to all living organisms, from a primitive unicellular organism to a higher mammal. It studies the morphological transformation during organic evolution from simple to complex. It also investigates how an organism maintains a longer life span through the evolution of the supporting-storing system.

During evolution, the constitutive elements of each organism can be divided into two major systems, the supporting-storing system composed of undifferentiated cells from the network of unspecialized connective tissues, including adipose tissue and loose connective tissue, and the functional systems composed of specialized cells (Figure 3). The boundary of the two major systems is the basement membrane originating from the endoderm and ectoderm and the basement-like membrane originating from the mesoderm. Undifferentiated stem

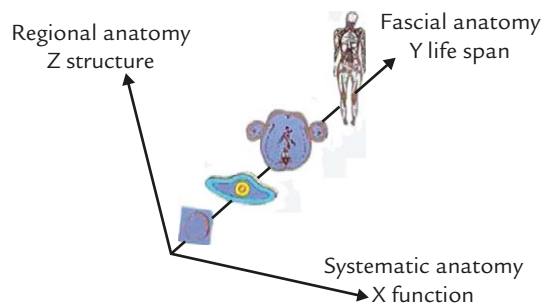


**Figure 3** Schematic diagram showing that the living condition of an organism is like that of a lit candle. The fascial system composed of the network of unspecialized connective tissues is equivalent to the wax of the candle, and the functional system is equivalent to the flame. CC=cerebral cortex; CN=central nerve; EP=epidermis; Res=respiratory system; DS=digestive system; ES=endocrine system; LS=locomotor system; US=urinary system; Rep=reproductive system; CS=cardiovascular system, FCT=fascial connective tissue; SS=supporting-storing system.

cells in the supporting-storing system incessantly migrate over the above membranes, differentiate into committed-stem cells, and further differentiate into functional cells. The structures and functions of an organism are maintained by the incessant supplementation and refreshment from the supporting-storing system to the functional system. Meanwhile, under the regulation of the nervous and immune systems, the fascia network throughout the body regulates the functional and living status of cells and provides a stable environment for the survival of functional cells [17,18].

The functional system does not refer to the traditional nine major systems in systemic anatomy, which include the musculoskeletal, nervous, endocrine, cardiovascular, immune, respiratory, urinary, digestive and reproductive systems; rather, it refers to all the cells, tissues and organs that are wrapped and segmented by the supporting-storing system. The functional system is composed of various committed stem cells and functional cells. These cells differentiated from the mesoderm and the folded endoderm and/or from ectodermal cells [9]. Functional cells work together to fulfill living activities.

Fascial anatomy studies the structure of an organism based on the two-system theory. Fascial anatomy is different from traditional regional anatomy and systematic anatomy. Regional anatomy usually only studies human structures according to different regions of the body, whereas systematic anatomy studies the human body according to both the morphologies and functions of organs. Fascial anatomy encloses a third parameter, time (Figure 4), studying not only the structures and functions of the body, but also the morphological transformation during organic evolution and embryonic development. It investigates how an organism, such as an



**Figure 4** The relationship between fascial anatomy, systematic anatomy and regional anatomy.

advanced primate, can maintain a longer life span through evolution of the supporting-storing system from the mesoderm. Therefore, fascial anatomy helps scientists better understand the biological essence of an organism by reminding them to study anatomy in a dynamic perspective, that is, all cells and organs maintain their normal structures and functions through the interaction between the supporting-storing system and the functional system. In other words, fascial anatomy switches anatomical study from the “dead” to the “living”. When the supporting-storing system wears out, the body will die. If the living condition of an organism is regarded as a lit candle, then the fascial system, the network of unspecialized connective tissues containing adipocytes and stem cells, corresponds to the wax of the candle, and the functional system corresponds to the flame of the candle (Figure 3). The supporting-storing system provides energy and cell reserve for the functional system, in the same way that the wax of the candle provides fuel to the flame. When the wax is depleted, the flame will extinguish, as with the human body. When the supporting-storing system wears out, the body will die.

### 3. Physiology of Fascia

Fasciaology studies the supporting-storing system, looking, for example, at how this system influences the functional system after medical treatments, and how its mesenchymal stem cells differentiate into functional cells and supplement the functional system. Fasciaology also studies the role of the supporting-storing system in the living human body and the interactions between the two major systems involved in the mechanisms of acupuncture and TCM, evolutionary biology, holistic therapies, integrated medicine and complementary medicine. The research methods of fasciaology include developmental biology analysis, non-specific connective tissue function research, stem cell research, cytobiology, molecular biology, and TCM theory research. Fasciaology also studies the curative property of

mesenchymal stem cells for certain diseases, such as senile dementia, cancer, osteoporosis, degenerative disease, etc. Fasciaology helps us to study the mechanism of some therapies, such as the acupuncture, herbal medicine, holistic therapies, integrated medicine and complementary medicine of TCM. Therefore, fasciaology promotes the discovery of new therapies.

Stem cells in the supporting-storing system are undifferentiated cells. These cells have potential to differentiate into committed stem cells. Committed stem cells are the intermediate types of cells between stem cells and functional cells. They may also have certain proliferating ability to increase in number. Functional cells are those that possess strong specialized physiological functions in the human body. However, they have already lost proliferating ability. All functional cells have a short life-span because the maintenance of normal morphology and physiological functions of an organism requires an incessant renewal of functional cells. This corrects the erroneous idea that the number of certain functional cells is unchangeable in the human body. For example, it had previously been thought that the number of neurons in the central nervous system could only decrease rather than increase after birth and that myocardial cells could only increase in volume, but not in number. Fasciaology corrects these mistakes and provides clear explanations [7].

Cells can migrate and differentiate over the germ layers. According to traditional developmental biology, cells can only differentiate in their own blastoderm rather than migrating into another germ layer. Recently, differentiation over blastoderms has been found to occur in special conditions, for example, during recovery from a trauma and the growth of a carcinoma. The theory of fasciaology addresses the above scientific question of cell differentiation. In fasciaology, all cells originate from the stem cells of the supporting-storing system. As previously mentioned, stem cells are undifferentiated cells from the mesoderm. Undifferentiated stem cells differentiate into various committed stem cells and finally into functional cells during migration over basement and basement-like membranes [6].

### 4. Biomedical Significance of Fascial Anatomy and Fasciaology

Fascial anatomy studies the morphological changes from growing to aging and offers a new perspective on the study of anatomy. Therefore, it is different from both regional anatomy and systematic anatomy. In developmental biology, the mesoderm-derived mesenchyme differentiates into multiple organ systems during individual development, while

the endoderm and ectoderm form a network of non-specific fascial connective tissues. This network is an independent system composed of stem cells and constitutes the supporting-storing system regulated by the nervous and the immune systems [19]. Stem cells in non-specific connective tissue constantly differentiate into committed stem cells and functional cells. Therefore, human cells can be classified into three categories: stem cells, committed stem cells and functional cells. To maintain a longer biological life span and a stable interior environment in the body, body cells constantly renew themselves. In fascial anatomy, human life involves the continuous consumption of the supporting-storing system.

Fasciaology is a combination of developmental biology, embryology, cytobiology, anatomy, TCM, and holistic therapies. With the theory of fasciaology, scientists may perceive the human body in a simpler, easier and more understandable way because the human body and all other organisms are simplified into two major systems. In this way, we can understand how important the supporting-storing system is, and determine the key effect of non-specific connective tissue upon the human body. The mechanisms of some therapies can also be easily understood in fasciaology and inscrutable TCM therapies can be explained in a scientific way [8].

The simple generalization that each organism is composed of two major systems may explain the mechanism of TCM and may free TCM from the shackles of its traditional theories and ancient records, promoting the modernization of Chinese medicine. The proposal of fasciaology also frees classical acupuncture therapy from the fetters of ancient meridian records by looking at the human body from a new perspective. The simple theory explains the mechanism of TCM and ushers it into a new frontier of medical science. This theory will guide people to find new and more effective treatments.

## 5. Possible Applications of Fasciaology Research in TCM

The theory of fasciaology may scientifically explain the mechanism of TCM which is an empirical subject. The foundation of TCM theories originates from many subjective assumptions rather than scientific experiments [20]. There may be some placebo effects and other unknown mechanisms existing in TCM therapy. Different ancient TCM books have different records on TCM theories [21], creating the impression that TCM is a pseudo-science. In fasciaology, stimulated stem cells in the supporting-storing system differentiate to functional cells in the functional system, and therefore, provide a cell

supplement for this system. This may be one of the mechanisms for TCM therapy. The result is a mobilization of the body's reserves of stem cells and a regulation of the endocrine system. Electrolyte balance and the water balance in the body can also occur via this system allowing disease cure. Although TCM treatment regimes differ from person to person, a common principle and mechanism for treatment has been addressed above [22,23].

In TCM, there are many kinds of physical treatments, including acupuncture, *Gua Sha*, plum blossom needle, and so on. They all stimulate the fascia network so as to regulate the metabolism and functions of the functional cells [11,24]. The essence of TCM meridians may be explained in the view of fascial anatomy. The anatomical basis of meridians is the fascia network throughout the body, and the histological composition of meridians is non-specific connective tissues, including loose connective tissue and fat tissue. The histological structure where an acupuncture needle produces an action is fascial connective tissue containing nerve endings, capillary vessels, fibroblasts, undifferentiated mesenchymal cells, lymphocytes, etc. [25–27]. Acupoints are those sites that produce strong biological reactions when stimulated. Since fascial connective tissue is distributed throughout body, acupoints may exist in every part of the body [28–30]. The difference between clinically so-called acupoints and non-acupoints and between main acupoints and supplementary acupoints is the intensity of the biological reactions rather than the structural components.

Since non-specific connective tissue is the anatomical basis of meridians and acupuncture and the connective tissue network is distributed throughout the body, the targets of acupuncture therapy may exist all over the body [22,31,32]. Acupoints in the human body are sites that can generate significant response when stimulated. Non-meridian extra acupoints are areas rich with fascial connective tissues, and they are located outside meridians. The locations and depths of these areas differ among individuals, as do their sensitivity, causing therapeutic effects to also differ [33–35]. The ancient records of meridians and acupoints, as well as those of herbal medicine, have no scientific basis. These books, therefore, can only serve as references and should not be strictly followed as textbooks [11,23,24,36]. Fascial research may provide evidence for the accuracy of acupoints.

## 6. Primo-vascular System in the Fascia

Several authors have suggested that an acupuncture meridian corresponds to connective tissue, as histological features can distinguish the acupuncture

points from surrounding tissues [37,38]. Heine found that acupuncture points perforated the dermal fascia that separated subcutaneous tissue from muscle tissue [39–41]. He demonstrated the lung meridian as a fascia-myo-tendon chain [42,43], a finding which has been supported by others [44–48]. Some others consider acupuncture points as neurovascular bundles [49–51] or veins perforating the dermal fascia [52]. Langevin observed that most acupoints appeared to coincide with intermuscular or intramuscular connective tissue planes [11].

Although many investigators have observed a close connection between acupuncture meridians and fascia, separate anatomical structures corresponding to acupuncture points or meridians that are not known in Western biology or medicine have also been suggested. Bong-Han Kim is unique in the sense that he found a novel circulatory system that formed a weblike network throughout an animal's body [53,54]. His claims, however, remained unconfirmed by other groups, except for a Japanese anatomist Fujiwara [55] who reproduced some parts of Kim's claims. Only recently has intensive reinvestigation revealed the primo-vessels (Bonghan ducts) that correspond to the meridian-like structures in the animal body [56]. It turns out that almost all the primo-vessels lie in the fascia. For example, the primo-vessels on the surfaces of internal organs were sometimes attached to the peritoneal fascia surrounding abdominal organs or abdominal walls. The primo-vessels were well visualized by using Trypan blue and were observed to form a network in the omentum and the peritoneum, which are representative fascia [57]. A surprising discovery was made by using this Trypan-blue-staining method; that is, the primo-vascular system existed on the fascia surrounding tumor tissues [58], which, in turn, raised two possibilities. One is control or treatment of a tumor by acupuncture through the primo-vascular system. Another is the metastasis of cancer through the primo-vessels. These two opposing possibilities may offer novel approaches to cancer biology and medicine. Further observation of primo-vascular systems on the arachnoid mater of the brain and perineurium of nerves have been reported very recently [57].

The close relationship between the primo-vascular system and the fascia is natural considering recent developments in anatomical understanding and in applications to manual and movement therapies, including acupuncture, of the fascia system [59]. The significance of fascia anatomy as a supporting-storing system is augmented by the presence of the novel primo-vascular system in various fascia. It also explains why acupuncture meridians (or the primo-vessels) are difficult to identify by using ordinary histological techniques involving hematoxylin and

eosin. The primo-vessels are made of the same material, collagen fibers, as the fascia, and their distinction requires specific techniques, which need to be fully developed in the future.

## 7. Conclusions

The anatomical basis of acupoints and meridians is the fascial network distributed throughout the body. Meridians consist of non-specific connective tissues, including loose connective tissue and fat tissue. Acupoints are sites that produce strong biological reactions when stimulated. The non-specific connective tissue network has been proposed as the supporting-storing system in the hypotheses of fascial anatomy and fasciaology. Recent observation of the primo-vascular system in various fascia surrounding internal organs and tumor tissues allows more detail and evidence for these hypotheses. These hypotheses are being investigated through research into the mechanism of acupuncture and TCM, evolutionary biology, holistic therapies, integrated medicine, and complementary medicine. Research methods include developmental biology analysis, aging mechanism research, non-specific connective tissue function research, stem cell research, cytobiology, molecular biology, and TCM theory research.

## Acknowledgments

The work described in this paper was supported by the National Basic Research Program (973 Program, grant no. 2007CB512705) and by the National Natural Science Foundation of China (grant no. 30801464).

## References

1. Yuan L, Tang L, Huang WH. Construction of dataset for virtual Chinese male. *Di Yi Jun Yi Da Xue Xue Bao* 2003; 23:520–3. [In Chinese]
2. Wang CL, Yuan L, Wang J, Jiao PF. Contrast study on the line course of fascia meridians made by three dimensional reconstruction and classical meridians in human body. *Chin J Anat* 2007;30:340–3.
3. Wang JW, Dong W, Wang C, Yao D, Zhao B, Shen B, et al. From meridians and acupoints to self-supervision and control system: a hypothesis of the 10th functional system based on anatomical studies of digitized virtual human. *J South Med Univ* 2007;27:573–9.
4. Wang CL, Wu JP, Wang J. An interpretation on the essence of meridians and acupuncture mechanism from fasciaology view. *Chin J Basic Med Tradit Chin Med* 2008;14:312–4.
5. Zhong SZ, Yuan L, Tang L, Huang WH, Dai JX, Li JY, et al. Research report of experimental database establishment of digitized virtual Chinese No.1 female. *Di Yi Jun Yi Da Xue Xue Bao* 2003;23:196–200. [In Chinese]

6. Yuan L, Wang J, Wang CL, Wang CL, Dai JX, Huang Y. Fasciology: a new theory on the human self-supervision and control system. *Sci Tech Rev* 2006;24:85–9.
7. Yuan L, Zhong SZ. Human auto-testing and modulating system-anatomic basis involved in meridial system. *Tianjin J Tradit Chin Med* 2004;21:356–9.
8. Huang Y, Yuan L, He ZQ, Wang CL. Study on the meridians and acupoints based on fasciology: an elicitation of the study on digital human being. *Zhongguo Zhen Jiu* 2006; 26:785–8. [In Chinese]
9. Wang XY, Zhong C. The morphological basis of mesotherapy. *Chin J Aesth Plast Surg* 2007;18:166–8.
10. Langevin HM, Churchill DL, Cipolla MJ. Mechanical signaling through connective tissue: a mechanism for the therapeutic effect of acupuncture. *FASEB J* 2001;15:2275–82.
11. Langevin HM, Yandow JA. Relationship of acupuncture points and meridians to connective tissue planes. *Anat Rec* 2002;269:257–65.
12. Marieb EN, Mallatt J, Wilhelm PB. Basic Embryology. In: *Human Anatomy*. San Francisco: Benjamin Cummins, 2008: 51–60.
13. Ross MH, Pawlina W. Connective Tissue. In: *Histology, A Textbook and Atlas*. Baltimore: Lippincott Williams & Wilkins, 2005:146–8.
14. Thomas WM. Structural integration-developments in Ida Rolf's 'Recipe'-I. *J Bodywork Mov Ther* 2004;8:131–42.
15. Robert S. Fascial plasticity—a new neurobiological explanation: Part 1. *J Bodywork Mov Ther* 2003;7:11–19.
16. Robert S. Fascial plasticity—a new neurobiological explanation Part 2. *J Bodywork Move Ther* 2003;7:104–16.
17. Ciczek LSW, Szopinski J, Skrzypulec V. Investigations of morphological structures of acupuncture points and meridians. *J Tradit Chin Med* 1985;5:289–92.
18. Moore KL, Agur AMR. Introduction to clinical anatomy. In: *Essential Clinical Anatomy*. New York: Lippincott Williams & Wilkins, 1995:8–9.
19. Hashimoto PH. The perineurial vessel: a possible candidate for the structural basis of the meridian (Jing-Luo) in Chinese medicine. *Anat Sci Int* 2005;80:177–80.
20. Board of Science and Education, British Medical Association. The evidence base of acupuncture. In *Acupuncture: Efficacy, Safety and Practice*. Amsterdam: Harwood Academia Publishers, 2000:11–21.
21. Birch SJ, Felt RL. The theoretical basis of acupuncture: fundamental concepts and explanatory models. In: *Understanding Acupuncture*. Edinburgh and New York: Churchill Livingstone, 1999:110–13.
22. Sutherland JA. Meridian therapy: current research and implications for critical care. *AACN Clin Issues* 2000;11:97–104.
23. Ho MW, Knight DP. The acupuncture system and the liquid crystalline collagen fibers of the connective tissues. *Am J Chin Med* 1998;26:251–63.
24. Omura Y, Takeshige C, Shimotsuura Y, Suzuki M. Imaging of the stomach, and localization of the stomach meridian & its acupuncture points in a human cadaver by the use of the indirect “Bi-Digital O-Ring Test Imaging Technique”. *Acupunct Electrother Res* 1988;13:153–64.
25. Ma W, Tong H, Xu W, Hu J, Liu N, Li H, et al. Perivascular space: possible anatomical substrate for the meridian. *J Altern Complement Med* 2003;9:851–9.
26. Yung KT. Birdcage model for the Chinese meridian system: part VI. Meridians as the primary regulatory system. *Am J Chin Med* 2005;33:759–66.
27. Konofagou EE, Langevin HM. Using ultrasound to understand acupuncture. Acupuncture needle manipulation and its effect on connective tissue. *IEEE Eng Med Biol Mag* 2005;24:41–6.
28. Ahn AC, Wu J, Badger GJ, Hammerschlag R, Langevin HM. Electrical impedance along connective tissue planes associated with acupuncture meridians. *BMC Complement Altern Med* 2005;5:10.
29. Robb RA. 3-D visualization in biomedical applications. *Annu Rev Biomed Eng* 1999;1:377–99.
30. Swartz MA, Tschumperlin DJ, Kamm RD. Mechanical stress is communicated between different cell types to elicit matrix remodeling. *Proc Natl Acad Sci USA* 2001;98:6180–5.
31. Dung HC. Anatomical features contributing to the formation of acupuncture points. *Am J Acupunct* 1984;12:139–43.
32. Bensoussan A. The nature of the meridians. In: *The Vital Meridian: A Modern Exploration of Acupuncture*. Melbourne and New York: Churchill Livingstone, 1991:51–3.
33. Langevin HM, Churchill DL, Wu J, Badger GJ, Yandow JA, Fox JR, et al. Evidence of connective tissue involvement in acupuncture. *FASEB J* 2002;16:872–4.
34. Bossy J. Morphological data concerning the acupuncture points and channel network. *Acupunct Electrother Res* 1984;9:79–106.
35. Scheip R, Klingler W, Lehmann-Horn F. Active fascial contractility: fascia may be able to contract in a smooth muscle-like manner and thereby influence musculoskeletal dynamics. *Med Hypotheses* 2005;65:273–7.
36. Langevin HM, Churchill DL, Fox JR, Garra BS, Krag MH. Biomechanical response to acupuncture needling in humans. *J Appl Physiol* 2001;91:2471–8.
37. Matsumoto K, Birch S. *Hara Diagnosis: Reflections on the Sea*. MA: Paradigm Publications, 1988.
38. Ho MW, Knight DP. The acupuncture system and the liquid crystalline collagen fibers of the connective tissues. *Am J Chin Med* 1998;26:251–63.
39. Heine H. Anatomical structure of acupoints. *J Tradit Chin Med* 1988;8:207–12.
40. Heine H. Morphologie der Ohrakupunkturpunkte. *Dtsch Zschr Akup* 1993;36:99–103. [In German]
41. Heine H. Der Akupunkturpunkt—ein Meridianorgan. *Dtsch Zschr Akup* 1996;39:75–80. [In German]
42. Heine H. Zur Morphologie der Akupunkturpunkte. *Dtsch Zschr Akup* 1987;30:75–9. [In German]
43. Heine H. Functional anatomy of traditional Chinese acupuncture points. *Acta Anat* 1995;152:293–7.
44. Zerlauth B, Böheim C, Moriggl B. Histologie der akupunkturpunkte. *Dtsch Zschr Akup* 1992;35:34–8. [In German]
45. Egerbacher M. Veterinaeakupunktur. Anatomische und histologische Struktur ausgewählter Akupunkturpunkte bei Rind und Hund. *Dtsch Zschr Akup* 1993;36:75–80. [In German]
46. Draempfle D, Ottensmeier A, Kleinpeter A, Kiupel M. Morphologische Untersuchungen an den Akupunkturpunkten und Meridianen bei Katzen und Hunden. *Dtsch Zschr Akup* 1993;36:104–9. [In German]
47. Zhang B. Studies on the morphology and function of meridian lines with reference to neurogenic inflammation by ICR mouse. *Dtsch Zschr Akup* 1996;39:29–38.
48. Stecco L. *La Manipolazione Neuroconnettiva. Disfunzioni segmentarie dell'apparato locomotore*. Roma: Marrapese, 1996. [In Italian]
49. Rabischong P, Niboyet JEH, Terral C, Senelar R, Casez R. Bases experimentales de l'analgesie acupuncturale. *Nouv Presse Med* 1975;4:2021–6. [In French]
50. Senelar R. Les caracteristiques morphologiques des points Chinois. In: Niboyet JEH ed. *Nouveau traite d'acupuncture*. Paris: Maisonneuve, 1979. [In French]
51. Bossy J. Morphological data concerning the acupuncture points and channel network. *Acupuncture Electrother Res* 1984;9:79–106.
52. Plummer JP. Anatomical findings at acupuncture loci. *Am J Clin Med* 1980;8:170–80.
53. Kim BH. On the Kyungrak system. *J Acad Med Sci DPR Korea* 1963;90:1–41. [In Korean]

54. Kim BH. Sanal Theory. *J Jo Sun Med* 1965;108:39–62. [In Korean]
55. Fujiwara S, Yu SB. ‘Bonghan Theory’ Morphological Studies. *Igaku no Ayumi* 1967;60:567–77.
56. Soh KS. Bonghan circulatory system as an extension of acupuncture meridians. *J Acupunct Meridian Stud* 2009;2: 93–106.
57. Lee BC, Soh KS. A novel model for meridian: Bonghan systems combined with fascia (Bonghan-Fascia Model). In: *Proceedings, Fascia Research II: Basic Science and Implications for Conventional and Complementary Health Care*. Amsterdam: Elsevier, 2009:144.
58. Yoo JS, Kim HB, Ogay V, Lee BC, Ahn S, Soh KS. Bonghan ducts as possible pathways for cancer metastasis. *J Acupunct Meridian Stud* 2009;2:118–23.
59. Myers TW. *Anatomy Trains: Myofascial Meridians for Manual and Movement Therapists*, 2nd ed. Oxford: Churchill Livingstone, 2008.