

Connective tissue: A body-wide signaling network?

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FROM ABSTRACT:

Unspecialized "loose" connective tissue forms an anatomical network throughout the body.

This paper presents the hypothesis that connective tissue also functions as a body-wide mechanosensitive signaling network.

Three categories of signals are discussed: electrical, cellular and tissue remodeling, each potentially responsive to mechanical forces over different time scales.

It is proposed that these types of signals generate dynamic, evolving patterns that interact with one another.

Such connective tissue signaling would be affected by changes in movement and posture, and may be altered in pathological conditions (e.g. local decreased mobility due to injury or pain).

Connective tissue thus may function as a previously unrecognized whole body communication system.

Since connective tissue is intimately associated with all other tissues (e.g. lung, intestine), connective tissue signaling may coherently influence (and be influenced by) the normal or pathological function of a wide variety of organ systems.

Demonstrating the existence of a connective signaling network therefore may profoundly influence our understanding of health and disease.

THIS AUTHOR ALSO NOTES:

Research and consequent medical specialization has broken the human body into systems (e.g. respiratory, digestive, musculoskeletal), and this is unfortunate.

The musculoskeletal system does not physiologically function in isolation from the rest of the body. **[Key Point]**

The musculoskeletal tissues (bones, muscles, cartilage, tendons) are strongly associated with posture and movement.

An extensive global physiological role for connective tissue has been suggested over 2000 years ago by the ancient practice of acupuncture.

Evidence now suggests that there is a "body-wide network formed by connective tissue."

Unspecialized "loose" connective tissue is part of the musculoskeletal system, and participates in movement and posture control.

"Unspecialized connective tissue not only forms a continuous network surrounding and infiltrating all muscles, but also permeates all other tissues and organs." **[Very Important]**

"Within individual organs, the extracellular interstitium and connective tissue matrix play a well-recognized role in integrating the function of diverse cell types existing within each tissue (e.g. lung, intestine)."

The connective tissue matrix is a key participant in the "mechanisms allowing cells to perceive and interpret mechanical forces."

"The continuous interplay between cells, matrix and mechanical forces is also known to control long term sculpting of the connective tissue matrix." **[Very Important]**

Connective tissue proteins convey information stability and tissue "memory".

"Since connective tissue plays an intimate role in the function of all other tissues, a complex connective tissue network system integrating whole body mechanical forces may coherently influence the function of all other physiological systems." **[Most Important]**

There are 3 categories of signals that are responsive to mechanical forces that allow connective tissue to function as a complex body-wide mechanosensitive system:

1) Electrical signals generated by mechanical forces may propagate through the extracellular matrix.

"The idea that electronic mobility and charge transfer across biological polymeric molecules may be a fundamental mechanism in living organisms was first proposed by Szent-Gyorgyi in 1941."

A number of proteins including collagen display semiconductive, piezoelectric and photoconductive properties.

"If such electronic currents do occur within connective tissue, the tissue's electrical conductance would be expected to be affected by various external influences (e.g. mechanical stress, illumination, heating)."

2) At the cellular level, fibroblasts in "loose" subcutaneous tissue are linked together in a cellular network.

These connective tissue fibroblasts exhibit active cytoskeletal responses following tissue stress that "are accompanied by some type of cell-to-cell signaling."

"One can envisage a whole body web of connective tissue involved in a dynamic, body-wide pattern of cellular activity fluctuating over seconds to minutes reflecting all externally and internally generated mechanical forces acting upon the body."

3) "The third category of signals concerns long term connective tissue responses to changing levels of overall movement patterns."

"A well-recognized property of connective tissue is its plasticity in response to varying levels of mechanical stress. These changes take place over the course of days to weeks following a change in posture or activity."

"Known physiological connective tissue responses involve remodeling of the collagenous matrix, with changes in collagen fiber density and orientation with resultant changes in tissue viscoelastic properties."

Remodeling responses in unspecialized loose connective tissue "would suggest the existence of a slowly evolving global pattern of connective tissue plasticity reflecting an individual's overall movement patterns."

These 3 categories of signals (extracellular, cellular and tissue remodeling) interact with one another.

Local connective tissue fibrosis following an injury may affect both electrical conductivity as well as fibroblast-to-fibroblast communication. Therefore, local pathology can affect whole-body connective tissue signaling. **[Important]**

There is both direct communication between the connective tissues of the matrix, and also indirect communication via the nervous system. **[Very Important]**

"Exciting new developments in the field of neuroplasticity indicate that a two way 'conversation' exists between sensory neural pathways and target organs."

Connective tissue is richly innervated with mechanoreceptors and nociceptors.

Sensory information from connective tissue is integrated in the central nervous system, and there is an interplay between both systems. **[Important]**

“Understanding the temporal and spatial dynamics of connective tissue bioelectrical, cellular and tissue plasticity responses, as well as their interactions with other tissues, may be key to understanding how pathological changes in one part of the body may cause a cascade of “remote” effects in seemingly unrelated areas and organ systems.” **[Key Concept]**

“For example, a patient presenting with a flare-up of ulcerative colitis preceded by a two week exacerbation of knee osteoarthritis would probably be thought to have two distinct problems, one in the gut and one in the knee. Establishing the presence of a connective tissue “bridge” between these two medical problems would potentially have important repercussions on both diagnosis and treatment of these conditions.”

“One of the greatest problems of modern medicine is its fragmentation.”

“Connective tissue may be a key missing link needed to improve cross-system integration in both biomedical science and medicine.” **[Key Point]**

KEY POINTS FROM DAN MURPHY

- 1) Unspecialized “loose” connective tissue forms an anatomical network throughout the body.
- 2) Connective tissue functions as a body-wide mechanosensitive signaling network that is separate from the nervous system, yet it also influences and is influenced by the nervous system.
- 3) Connective tissue signals include electrical, cellular and tissue remodeling. Each of these are responsive to mechanical forces that occur subsequent to changes in movement or posture, and to pathological conditions such as injury or pain.
- 4) Connective tissue function as a whole body communication system.
- 5) Since connective tissue is intimately associated with all other tissues, including the viscera, connective tissue signaling may influence the normal or pathological function of a wide variety of organ systems.
[This is extremely important for chiropractors. Traditional chiropractic teaches, and our research documents, that our mechanical care improves visceral function. This author, from the Department of Neurology, University of Vermont, College of Medicine, is giving us a viable explanation to support chiropractic teachings, research, and clinical observations.]
- 6) The existence of a connective signaling network may profoundly influence our understanding of health and disease.

- 7) Dividing the human body into separate systems for research and medical specialization is a mistake because all of the systems are integrated through the nervous system and connective tissue.
- 8) The musculoskeletal system does not physiologically function in isolation from the rest of the body. **[Key Point]**
- 9) "Unspecialized connective tissue not only forms a continuous network surrounding and infiltrating all muscles, but also permeates all other tissues and organs." **[Very Important]**
- 10) The connective tissue matrix allows "cells to perceive and interpret mechanical forces."
- 11) "Since connective tissue plays an intimate role in the function of all other tissues, a complex connective tissue network system integrating whole body mechanical forces may coherently influence the function of all other physiological systems." **[Most Important]**
- 12) Mechanical forces generate electrical signals that propagate through the connective tissue extracellular matrix because proteins, including collagen, have semiconductive, piezoelectric and photoconductive properties.
[The piezoelectric properties explain in part the mechanism by which chiropractic adjustments and postural changes work. Piezoelectric current science is integrated into the academics of various chiropractic techniques, including Chiropractic Biophysics.]
[The photoconductive properties explain in part the mechanism by which low level lasers work].
- 13) Tissue electrical conductance is affected by various external influences, including mechanical stress and illumination.
[Again, the "mechanical stress" explains in part a mechanism by which chiropractic adjustments and postural improvements help patients; the "illumination" explains in part a mechanism by which low level lasers work].
- 14) A whole body web of connective tissue is involved in a dynamic, body-wide pattern of cellular activity reflecting all externally and internally generated mechanical forces acting upon the body.
- 15) Connective tissue plasticity means that connective tissues will change in response to mechanical stress. These changes take place over the course of days to weeks following a change in posture or activity.
[This is important because it indicates that the joints and tissues that chiropractors influence with spinal adjustments and modes of rehabilitation will ultimately result in desirable tissue adaptation.]

16) Local connective tissue fibrosis following an injury may affect both electrical conductivity as well as fibroblast-to-fibroblast communication. Therefore, local pathology can affect whole-body connective tissue signaling. **[Important, this suggests that all local injuries have systemic manifestations.]**

17) There is direct communication between the connective tissues within the matrix, and also indirect communication via the nervous system. **[Very Important]**

18) Connective tissue is richly innervated with mechanoreceptors and nociceptors.

19) Sensory information from connective tissue is integrated in the central nervous system. **[Important: this supports that every connective tissue injury or problem and the chiropractic management of the connective tissue injury or problem, will influence the central nervous system.]**

20) "Connective tissue bioelectrical, cellular and tissue plasticity responses, as well as their interactions with other tissues, may be key to understanding how pathological changes in one part of the body may cause a cascade of 'remote' effects in seemingly unrelated areas and organ systems." **[Key Concept]**

21) Musculoskeletal dysfunction can initiate remote visceral disease. The example used by the author is knee osteoarthritis initiating a flare-up of ulcerative colitis.

22) "Connective tissue may be a key missing link needed to improve cross-system integration in both biomedical science and medicine." **[Key Point]**

COMMENT FROM DAN MURPHY

The concept of the connective tissue creating a bioelectric tensegrity matrix that has the ability to alter our genetic expression when we have altered alignment in a gravity environment is not new. It is expertly reviewed in the book [Energy Medicine, The Scientific Basis](#), by James Oschman, Churchill Livingstone, 2000. Chapter 11 on gravity and spinal alignment is particularly applicable to chiropractors.