Biotensegrity: The mechanics of fascia and the use of a transfer medium in manual therapy.

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Introduction

According to Glossary of Osteopathic terminology, first published in 1981 by the Educational Council on Osteopathic Principles of the American Association of Colleges of Osteopathic Medicine (Seffinger, 2011), the principles of the Osteopathic philosophy are:

1. *"The human being is a dynamic unit of function"*
2. *"The body possesses self-regulatory mechanisms that are self-healing in nature"*
3. *"Structure and function are interrelated at all level"*
4. *"Rational treatment is based on these principles"*

Other principles were later added by common usage (Dowling & Martinkc, 2005):

5. *"The body has the inherent capacity to defend and repair itself"*
6. *"When normal adaptability is disrupted, or when environmental changes overcome the body's capacity for self-maintenance, disease may ensue"*

One common denominator that applies to the above-mentioned principles is the understanding of the body as an indivisible entity. *"All parts of the body are integrated. On an anatomical level, it can be observed that the entire body and its systems are united by means of the fascia. It is continuous throughout the body, uniting system to system, and cell to cell, and by supporting and maintaining these structures enables them to work in harmony"* (Parsons & Marcer, What is osteopathy? Towards a definition, 2006).

From the earliest comprehension and approach from A.T. Still, founder of Osteopathy more than 100 years ago, to the most recent fascia congresses and publications, the journey of understanding the role of fascia has evolved immensely. Besides its understanding as an anatomical and functional element, there have been challenges to create accurate models that reflect its biomechanics. The most accepted model nowadays is the one based on the principles of tensegrity. (Parson & Marcer, 2006).

In this paper, it will be explored the definition of fascia and some basic anatomical and functional considerations; and the main facts about biotensegrity. To translate this knowledge from the theoretical level to the everyday practice as a manual osteopath, the appreciation of the *"hands"* as the primary interface between the patient and the therapist must be clearly understood. To do so, the mechanism of mechanotransduction and the fundamental physical basis of the stress transfer mechanism will be also examined.

Fascia

Fascia forms an uninterrupted tensional network along the human body, covering and connecting every organ, muscle, nerve, artery, among others. It is composed of irregular, interwoven collagenous fiber bundles of different densities. (Willar, Somatic Fascia, 2012). The concept of fascia has evolved immensely from the *"white packing"* envelop that needed to be removed in order to expose a specific structure in any anatomical dissection. (Schleip, Findley, Chaitow, & Huijing, 2012).

Specialists are still debating a common nomenclature to define fascia. In the first Fascia Research Congress held in 2007, they agreed that the term fascia describes the *"soft tissue component of the connective tissue system that permeates the human body"*. This newer concept tries to include the previous concept of fascia profunda and fascia superficialis, including the epi, peri and endomysium and the visceral fascia as well. Altogether, these tissues are part of a bodywide tensional force transmission system. This fascial matrix includes the dense planar tissues sheets like capsules and denser structures like ligaments and tendons, the dura mater, the periosteum, perineurium, the fibrous capsular layer of vertebral discs, bronchial connective tissue and the mesentery of the abdomen. (Schleip, Findley, Chaitow, & Huijing, 2012).

The fascial planes do not have specific well-defined borders, but four layers are commonly described when referring to the somatic fascia, arranged as a series of concentric tubes. These layers are: pannicular or superficial fascia, is primarily composed of loose connective tissue and fat and it covers the axial and appendicular body; the axial or deep investing fascia, that consist of denser and irregular connective tissue investing muscles, tendons, ligaments and aponeuroses; meningeal fascia that surrounds the nervous system and the visceral fascia that encloses the body cavities (pleural, pericardial and peritoneal). (Willar, Somatic Fascia, 2012).

Fibroblasts are the principal cell type of fascia. They are under control of the endocrine system and responsible for the production of collagen and ground substance. They detect the change in tension and react to pressure producing collagen organized along the same stress lines as the direction of force allowing fascia to adapt to external stresses by cross-linking of collagen. (Shiowitz, Brous, & DiGiovanna, 2005). Fascia and its extracellular matrix proteins work as ad three-dimensional scaffolding that supports cellular adhesions and tissue's specific functions. With this tensional network, fascia possesses a true fascial tone, not dependent on the muscular tone, and with it, smooth muscle-like contractions of the fascia are possible. Along with the fibroblast, the connective tissue has also a gel-like ground substance into which the cells and fibers are embedded. (Willard, Fossum, & Standly, 2011).

Fascia provides protection and lubrication for the elements of the musculoskeletal system and it plays a crucial role in force transmission, as the muscles distribute a large portion of their contractile or tensional forces onto fascial sheets. (Schleip, Findley, Chaitow, & Huijing, 2012). It serves as a body-wide mechanosensitive signaling system playing a substantial role in the process of proprioception (Langevin, 2006). Due to the ability to distort and to tolerate stretch in multiple planes, the fascia layers provide a distensible cushion that allows organs to glide by each other while protecting them. These layers are abounding with a well-organized blood supply and lymphatic drainage system, contributing to the tissue repair mechanism. (Willard, Fossum, & Standly, 2011).

Fascia influences directly or indirectly the health of the body, by being synchronized with the musculoskeletal system, by assisting in the circulation of the body fluids and in the arrangement of the nerves. (Shiowitz, Brous, & DiGiovanna, 2005)

Biotensegrity

The understanding of fascia as the scaffold of the body leads us to the concept of biotensegrity.

The word *"tensegrity"* refers to an architectural principle, where structures are stabilized by continuous tension with discontinuous compression. Also known as tensional integrity or floating compression is a *"structural principle based on the use of isolated components in compression inside a net of continuous tension, in such a way that the compressed members (usually bars or struts) do not touch each other and the prestressed tensioned members (usually cables or tendons) delineate the system spatially"*. (Jáuregui, 2005). This model differs from the conventional architecture based on Newtonian mechanics that uses the compressive force of gravity to maintain structures based on columns, beams, levers and fulcrums.

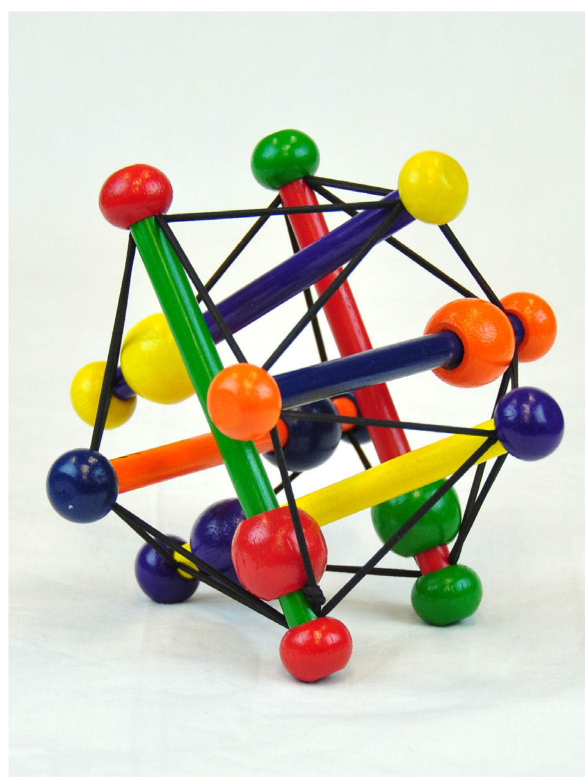
Tensegrity structures behave differently from the classical compressional architectural model because they act as whole systems. They have the property known as *"prestress"* when even before the application of any external load, members of the structure are already in compression or tension. The combination of tensional and compressional elements is called synergy. Tensegrities are self-stabilizing structures meaning that when the external force is removed, they recover their original shape. (Parsons & Marcer, Tensegrity, 2006).

Tensegral structures keep their integrity by balancing the tensile forces. This concept is crucial when trying to explain the motion, interconnection, responsiveness and strain patterning of the body. (Myers, 2009). This model was imported into a biological model to better recreate living organisms, from viruses to vertebrate, their systems and subsystems, and named biotensegrity. (Levin S. M.).

Biotensegrity antitheses the centuries-old concept of the skeleton as the frame of the body. It sets the concept of triangulated structures, as the only stable structures with flexible joints, suggesting that the icosahedron is the most suitable for biological modeling. (Levin & Martin, 2012). The bones of the skeleton are considered the discontinuous compression components held within the continuous soft tissue tensional network (the fascial system). The muscles and ligaments are pre-stressed and the different body cavities and their visceral content work on the fascial compartments allowing the stability of the body, as if they were inflatable balloons holding it. The biotensegrity principle is also visible at the cellular level, where the cells are hard wired intracellularly and also connected to the extracellular matrix forming that immense ground substance that permeates the body. (Parsons & Marcer, Tensegrity, 2006)

Under the biotensegrity model, forces are distributed instead of localized, so the concepts of levers become obsolete. There is no shear, torque or bending. Movement is not the angular bending of a specific joint, but expansion, repositioning, and contraction of tensegrities. The systems react as a whole, being more energy efficient. (Levin & Martin, 2012).

This model aligns perfectly well with the osteopathic principles of that the structure and function are reciprocally related and that changes applied in one area will also have effects distally. (Parsons & Marcer, Tensegrity, 2006).



Mechanotransduction and the hands as the fundamental source of mechanical stimulation

Another important concept to understand is mechanotransduction. Characteristic of fibroblasts, chondrocytes and osteoblast, it refers to the cellular changes that occur in response to the external mechanical forces. The stress and strain placed on the fascia can be transmitted to the cell membrane and cell cytoplasm. This process plays a crucial role in normal development, health maintenance, the origin of diseases and aging. (Willard, Fossum, & Standly, 2011).

It is not intended in this paper to deeply examine the mechanism of mechanotransduction, but to highlight the fact that the therapeutic effects of any manual therapy are based on it.

As manual practitioners, our hands are the main source of mechanical stimulation to the body. Comprehending the concepts of fascia and tensegrity, should improve and enrich the way *"manual treatment"* is delivered. What follows, is based on the work done by Leonid Blyum and Mark Driscoll, Eng. Ph.D. in their efforts to mathematically model the "guided-mechanical -stress-transfer principle" and to simplify physical concepts that should be internalized by any manual therapist while practicing.

First, we need to realize how complex the analysis of the mechanical interaction between provider and recipient is (therapist/patient). It stems from knowing the difference between force and stress. When applied to living bodies, forces and stress differ significantly.

From our very basic high school physics studies of movement, we learned that a force is a pull or a push upon an object resulting from the object's interaction with another object. Force is measured in Newton (amount of force required to give to 1-kg mass acceleration of 1 m/s/s). It is a vector quantity, so it has magnitude and direction. The effect of an individual force upon an object is often canceled by the effect of another force, but if another force is applied the balance is lost and the resultant is motion. (Henderson, 1996).

After understanding the concept of tensegrity, it makes more sense to talk about stress, which is the force per unit area (N/m2). Different forces transferred to a living-tensegral body (an area), do not cancel, they add. The response of that area where the stress is transferred will vary depending on the type of the material the body is built of. So the mathematics to analyze it is much more sophisticated.

For many years, Blyum and Driscoll have been studying the properties of different materials that could be used as *"stress transfer mediums"* or tools, and their effects and reach on the different body layers:

"Between these two systems – Stress Transfer Source (a therapist as a Stress Transfer Inducer) and a client's body as a Stress Transfer Recipient – there is a Stress Transfer Interface, which represents all the variables of how the Stress Transfer Inducer can deliver his impact at the Stress Transfer Recipient: intensity, force magnitude, direction, sequencing, velocity, acceleration, area of contact, the use of additional tools and materials to reach the desired tissues and organs and of course plenty more factors. It's important to keep in mind the essence of what defines your therapeutic efficiency or inefficiency – a specific Stress Transfer Outcome that takes place within the body of a Stress Transfer Recipient". (Blyum & Driscoll, 2012).

Their study *"Mechanical stress transfer – the fundamental basis of all manual therapy techniques"*, presented at the Third International Fascia Research Congress, suggests that the use of soft stress transfer mediums like rubber or weak foams allow deeper reach in the layers of the body.

Based on this experience, when soft tools are used while performing osteopathic mobilization and soft tissue techniques, the patients describe the session as *"more pleasant" and the practitioner refers an increase in the "ability to listen"* to their bodies, where the tactile exploration gets much more amplified hence more informative.

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