Advancing Muscular Skeletal Anatomy towards a Fascial Based Anatomy

By Eli Thompson

The study of human anatomy has been a long road with many exciting revelations and benefits to science and medicine. While our understanding has advanced dramatically, we are still finding errors and entrenched misperceptions from the past. One rather fundamental oversight that has impacted our biomechanical understanding at all levels is the importance of fascia in our bodies and the role it plays in everything we do.

If we look at the origins of the study of human anatomy we find it is not surprising that this oversight occurred. From the first recorded anatomical studies of the Egyptians (1600 BC), through the Greek and Euro-Christian times of Davinci (1452-1519) and Versalias (1514-1564), all the way to the pre-modern medical era (before MRI machines and CAT scans), the main tool of study was a knife. The body was cut into ever smaller and more differentiated parts. This was the very nature of scientific study at the time. I can attest from personal experience that in fresh-tissue cadaver dissections one is confronted with a wet, gooey mess and it’s often hard to find where one part ends and another starts. The body is not neat and tidy as in the text books. Without modern, non-invasive tools the only recourse is to differentiate and cut out. While we have gained a very detailed mapping of all the parts, and have named, cataloged, and studied their function in isolation, it has led us towards a reductionist, Newtonian vision of the body.

Fascia, until recently, has been largely ignored as the body’s packing material. Even today at Gross Anatomy labs in medical schools, the fascia is cut away and discarded to reveal the presumably, *more interesting and important parts*. The same vision of clean cut, fascia-less muscles attaching to white bone is represented in our text books and anatomy courses (Grundy 1983, Netter 1998). It has become a self-perpetuating view, uncontested by the vast majority of professionals.

The body as a machine fits very well into the world view of the past. Muscles work as motors to pull on cable-like tendons which move lever-like bones across joints that function as cantilevers. Our anatomy textbooks illustrate these mechanistic analogies as the main explanation for biomechanical function (Trail Guide to the Body – Andrew Beil 2005, Anatomy of Movement – Clais-Germain 1993). Even Kinesiology, the study of human movement, uses classical Newtonian mathematics to calculate the forces generated in movement. No matter how intricate their analysis and inclusive of neurology and the synergistics of multiple muscle function, it's still based on Newtonian science. There are an increasing number of studies suggesting that these are inaccurate. Graham Scarr writes in his new book BioTenserity, "… such analysis is a gross simplification of joint function, always incomplete and is some cases, absurd." (Scarr, 2014 Pg 37).

Our biomechanical view needs to be updated to a more modern, Einsteinian model. We need to shift from a part-based perspective to a holistic, system-based perspective. Studying the body through the lens of fascia gives us this paradigm shift. Fascia is a protein based, fibrous webbing penetrating throughout the whole body down to the cellular level. It is a strong and dynamic medium that maintains the position of our cells relative to each other, giving them something to grab onto and interact with mechanically. Fascia is what holds every muscle cell in its highly organized pattern and is what muscle cells pull on when they contract. Without it we would be soup, every cell swimming chaotically without the means to interact to produce our miraculous function. It can organize into delicate, viscous webbing that allows layers to slide on each other or it can accumulate to create strong, stable structures such as ligaments and joint capsules. When viewed as a whole it is the system that defines our internal mechanical environment and manages the forces created by gravity and our interactions with our surroundings. It is the fascial system that unifies us into something that is greater than the sum of our parts.

One important misunderstanding that has been perpetuated by the lack of fascial appreciation is that muscles attach to bones. They don't. Muscles, or more accurately, myofascia (bundles of concentrated muscle cells and their associated fascial webbing) attach to the periosteum (the fascial wrapping of bones). To take it a step further, the whole idea of *attaching* is an illusion since there is no beginning or end to the fascia that organizes the *muscle* and *periosteum*. These anatomical names are man-made and representative of fascial zip codes of a seamless whole, not of separate parts. As Tom Myers has shown in his revolutionary theory of the Anatomy Trains, muscles feed directly into other muscles, creating long myofascial chains that run from head to toe (Myers 1998). The body manages strain by distributing it along these myofascial continuities.

We could also say that muscles aren't separate from their side-by-side neighbors either. The fascial wrapping of the muscle (epimysium) has a direct connection to its neighboring muscles' fascial wrapping (Franklin – Miller 2009, Huijing & Baan 2003). It allows some sliding movement but once we reach the end of that slack, the muscle walls lock together and strain gets distributed laterally as well as longitudinally. Thus, not only does strain get distributed widely for more efficient strain management, but work performed by multiple muscles can be focused via these connections for greater power (a relatively new phenomenon called hydraulic amplification).

These and other findings are suggesting a very different myofascial-skeletal organization in our bodies. If we accept the design principle *form follows function and function follows form*, it inherently suggests we should be looking for a different biomechanical function. That search is leading us to a whole new way of thinking: Biotensegrity.

Biotensegrity is a new field of study gaining increasing recognition in the research community. It is the study of how biological systems, from the very smallest (cells, DNA, etc) to the largest (tissue, animals, humans) use a natural self-organizing design principle called tensegrity. Tensegrity is a dynamic system that gains its integrity via the balance of tensional forces and compressional forces. A simple tensegrity model would consist of several struts that are suspended and balanced by the tensional forces in a web of wires connecting them (Thompson 2010). The balance between the wires always pulling inwards and the struts always pushing outwards creates the stable and yet dynamic tensegrity structure. The key to tensegrity is the struts never touch each other but are always floating. Kenneth Snelson has been designing tensegrity based art sculptures since 1954 (Heartney 2009).

The benefits of organizing forces with tensegrity are numerous. First, forces are constantly being distributed as evenly and efficiently as possible through-out the system. Any added forces or impacts are spread widely, as opposed to being absorbed by the individual part. This ensures sustainability and prevents parts from wearing out or breaking. Dr. Amy Sung illustrated how red blood cells use this property of Biotensegrity to distribute strains through the whole cell and thus prevent damage during normal deformation (Sung 2005). Secondly, since tensegrity is so efficient at managing force it becomes very efficient with its material use. One doesn't need massive struts (i.e. bones) like a compression-based system. Nature abhors waist and will tend to use the most efficient means to self-organize. Next, the stability of the system is tensionally dependent so it is not reliant on a specific relationship to gravity (Levin 2002). Unlike a compressional skeletal design, it could be upside down and the system will manage just fine.

In 1998, Dr. Donald Ingber was studying how natural systems self-organize. He wrote in a Scientific American article, "An astoundingly wide variety of natural systems, including carbon atoms, water molecules, proteins, viruses, cells, tissues and even humans and other living creatures, are constructed using a common form of architecture known as tensegrity (Ingber 1998)." Ingber continued his research at Harvard University's Childrens Hospital, discovering several expressions of Biotensegrity in how cells organize, relate to their mechanical environment, and move through their fascial environment (Ingber 1999, 2009). Such understanding of cellular function, though not explained in terms of Biotensegrity, is clearly shown in the Harvard BioVisions animation “The Inner Life of the Cell” (Viel and Lue, 2006).

Dr. Steven Levin has been exploring Biotensegrity as long as Ingber but from the macro perspective. He was a spinal surgeon looking for better explanations of spinal mechanics. He recognized that the law that governs the organization and function of small animals is more than likely the same that governs the very large animals. When calculating the weight of dinosaurs verses the size of their leg bones, mathematically they should not be able to stand. However, if dinosaurs used Biotensegrity to convert the massive compressional forces into widely distributed tensional forces, they wouldn’t only able to stand but run (Levin 2002). Levin continues to be a major proponent for the theory of Biotensegrity and travels internationally introducing these theories to the western medical community.

Over the past decade there has been an increasing amount of supportive evidence from the fascial research community. In 2005, the Fascial Research Congress was formed which offered fascial researchers a venue to present their findings and explore their clinical relevance with fascial clinicians. Since then, the number of papers on fascia indexed in Medline have grown from 200 per year in the 1970s and 80s to almost 1,000 in 2010 (Schleip, Chaitow, Huiging 2013). As the findings accumulate we are gaining a clearer understanding of how the myofascial skeletal system organizes and how the properties of tensegrity naturally manifest through its organization. These ideas are now readily accepted in the Structural Integration and Osteopathic communities. As the field of Biotensegrity continues to grow and gain recognition the insights gained will slowly penetrate the medical community. In time, I hope the outdated biomechanical theories based on century’s old science will begin to evolve and catch up with these new findings. I feel very fortunate to be a part of these exciting advancements.

Bibliography

Biel, Andrew (2004). Trail Guide to the Body. Books of Discover, Boulder, CO.

Another classic musculoskeletal educational text book. Nicely illustrated and well described. Biel has created a whole series of these educational texts, including specialized texts for different modalities. As good as these texts are they are also entrenched in the old model. To Biels credit, his latest edition "Trail Guide to Movement" is attempting to update his work and join the current paradigm shift. He includes a pretty accurate fascial view, as well as, Biotensegrity. I reviewed his introductory chapters concerning fascia pre-final draft. He was a pleasure to work with.

Calais-Germain, Blandine (1993). Anatomy of Movement. Eastland Press, Seattle, WA.

A useful muscular skeletal anatomy text book with nice sketches illustrating the anatomy. This anatomy text is especially nice in its illustration of the function of each muscle through sketches of nudes going through that muscles movement. As nice as this anatomy text is (and helpful for a beginners study of anatomy) it is centrally rooted in the traditional musculoskeletal view of the body and a single muscle analysis.

Franklin-Miller (2009). Strain transmission during straight leg raise (compared to strain of posterior thigh). Fascial Research Congress.

A simple and well-designed study illustrating the body's ability to distribute strain globally. Five cadavers had digital strain gauges glued onto the musculature at various locations in the leg and back. Then strain measurements were taken as a straight leg raise was performed. This typical hamstring stretch was expected to create clear strain measurements in the hamstrings, perhaps also the calf and low back but strain was measured in many other places suggesting a global strain distribution system.

Grundy, John Hull (1983). Human Structure and Shape. Nobel Books.

Grundy is a wonderful anatomical artist with interesting insights into anatomy and spatial organization in the body. Very much an artistic representation of classic anatomy.

Heartney , Eleanor (2009). Kenneth Snelson: Forces Made Visible. Hudson Hills, Easthampton, MA.

A beautiful coffee table picture book full of examples of Snelsons Tensegrity sculptures. A pretty good description of Tensegrity but not of BioTensegrity.

Huijing & Baan (2003). Lateral Myofascial Force Transition. Vrije Universiteit, Amsterdam.

A simple study showing how a forces are transmitted form one muscle laterally to its neighbor, even if its neighbor is supposed to perform the opposite function.

Myers, Tom (2013). Anatomy Trains, 3rd edition. Elsevier, Edinburgh.

The ground breaking exploration of the myofascial meridians for the manual and movement therapist. It was one of the first books to bring together many of the modern myofascial biomechanical theories into one cohesive story. It incorporates fascial anatomy, physiology, chronic patterning, neurology, and culminates in myofascial Biotensegrity. It helps therapists understand how symptoms can have distant causes and how to track them down using the map of the ATs. This book advanced fascial theory and played a big role in bringing it to prominence.

Netter, Frank H. (1998). Atlas of Human Anatomy. 2nd Ed. East Hanover, New Jersey.

This is one of the most recognized anatomy atlases used internationally. It illustrates hand painted plates of human anatomy in all its glory. The images are a generalization of hundreds of dissections and will show the common variations of anatomical structures.

Scarr, Graham (2014). Biotensegrity: The Structural Basis of Life. Handspring Publishing, Scotland.

The first published book focusing on the new field Biotensegrity. It explores why nature would choose to use tensegrity as an organizing principle and the benefits of it. It is well written, well-illustrated, and well referenced. Overall a giant leap forward in the accessibility of the information and a wonderful contribution to the Biotensegrity community.

Schleip, Findley, Chaitow, Huiging (2013). Fascia: The Tensional Network of the Human Body. Elsevier, Edinburgh.

A great collection of research articles and essays exploring the increasing knowledge base of fascia. Written from the view point of many different modalities and researchers, including manual therapy, movement therapy, physiology, and many others. Quite technical at times but very informative.

Sung, Amy (2005) UCSD. Protofilament and Hexagon: A Three-Dimensional Mechanical Model for the Junctional Complex in the Erythrocyte Membrane Skeleton. Annals of Biomedical Engineering.

Clear presentation of the Biotensegrity (cytoskeleton) organizing the structural stability of a red blood cells membrane. Suggestion of the mechanism of membrane deformation and stress / impact management.

Thompson, Eli (2010). Benchworks and Tensegri-Teach. Brookline, MA.

Tensegri-Teach is the second product my company Benchworks has developed and distributes internationally. There are two tensegrity models. A six dowel and a twelve dowel model, both made of wooden dowels, black bands, and black end caps. These are simple models that demonstrate the properties of tensegrity making it much easier to describe and teach.

www.Tensegri-Teach.com

Viel, Alain and Lue, Robert A (2006). The Inner Life of a Cell. Harvard BioVisions.

A spectacular animation showing the most cutting edge understanding of the internal workings of a white blood cell. It describes the internal physiology and the cascading structural (Biotensegrity) transformation that occurs when it reaches a site of inflammation. It changes from a spherical cell to a flat cell that can squeeze out of the capillary walls. It then reforms back to spherical to go fight the inflammation (not shown).

http://multimedia.mcb.harvard.edu/