A Model of Forces on Fascia from Muscle Contraction and Fascial Manipulation

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BACKGROUND Fascia accepts and concentrates forces; fascia delivers these forces through tendons to the skeleton for motion. Therapists apply forces to fascia; fascia transmits these forces to muscles and pain receptors. Forces on fascia are transmitted by three types of geometrical vectors.

APPROACH Four types of vectors are involved in fascia: 1) linear, 2) planar, 3) multi-planar, 4) multi-linear. A **vector** is an arrow vector (linear); a **covector** (planar) is a flat area formed from an arrow-arrow cross-product. A **stack** is multi-planar areas (covectors) in a 3-D (3-axis) coordinate system [1]. A **sheaf** is multi-linear arrows (vectors) at the crossing points of stacks [2]. Muscle fibers are linear; endomysium is planar; muscle fascicles contain multi-linear vectors. A vector (**force**) acts across a covector (**area**) to produce a **pressure** (force/area).

RESULTS (1) Muscle contraction: Endomysium is the fascia around the muscle fiber. The muscle fiber (**vector**) contracts and pulls on the endomysium (**covector**). The endomysium in the muscle fascicle forms a honey-comb pattern separating muscle fibers; the crossing points of the fascia between adjacent muscle fibers concentrate the forces linearly (a sheaf of arrow vectors) [3]. (2) Fascial manipulation produces a strain that causes a stress in tissues. A **strain tensor** (vector and covector) causes an angular deformation of a body subjected to an external force. A normal strain tensor is a perpendicular external arrow **(vector)** compressing a surface **(covector)**. A **shear strain** tensor is an external arrow **(vector)** causing parallel surfaces of a body to slide over each other without a change in volume **(covector over covector)**. A **stress tensor** (vector and covector) is an internal reaction of a body outward due to an external force. A normal stress tensor is an internal arrow **(vector)** perpendicular to an internal surface (**covector**). A **shear stress** tensor is an internal arrow **(vector)** parallel to an internal surface (**covector**).

CONCLUSIONS (1) **Vector|covector** types account for the forces of muscular contraction on fascia. (2) The crossings of endomysium of muscle fiber units integrate the forces of multiple contracting muscle fibers. (3) **Vector|covector** types illustrate the normal and shear forces applied by therapists to fascia. (4) Acupuncture may involve needle (vector) impinging on fascia (covector) with its pain receptors modifying the pain response.

REFERENCES

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