Influence of Mechanics on Tendon and Muscle Development

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Tendons are essentially parallel fibers of collagen, ~70% of the dry weight, interspersed with fibroblasts that are responsible for the development and maintenance of tendon physiology. Tissue engineering of collagen structures involves the interaction of cellular and collagen mechanics and growth, providing a challenge to tendon development models. Our attempts to elucidate these interactions are based on the alignment of collagen either by physiological or mechanical means.

Tendon fibroblasts in culture attempt to align isotropic collagen gels, constrained only by cross-links, and when grown alone will spontaneously form macroscopic tendon-like structures that are under cell-mediated tension.[1, 2] We are currently reproducing these results with fibroblasts obtained from rat Achilles tendon to generate aligned collagenous structures. Aligned collagen gels may also be formed by creating a double network.[3] The collagen network is allowed to partially crosslink under an imposed deformation, it is then placed under additional deformation during further crosslinking.

The overall goal in creating these tendon structures is to combine them with self-assembling 3-dimensional muscle constructs, termed myooids, that have already been created in our lab.[4] These myooids generate force spontaneously and upon the application of an electrical stimulus. Unfortunately, this force is on the scale of developing muscle, a result of a physiology that resembles muscles of embryonic and neonatal mammals. It is well known that mechanical stimuli are an important factor in muscle and tendon development. The anchors currently used with the myooid do not form a strong interface with the muscle and do not allow for the application of cyclic mechanical strength of physiological intensity. The most suitable anchor for muscle is tendon. We will next explore the bioengineering of myotendonous junctions along with a quantitative description of their mechanical function.

REFERENCES

[1] K. J. Doane, D. E. Birk, *Fibroblasts retain their tissue phenotype when grown in three-dimensional collagen gels*, Exp. Cell Res., 195, (1991), 432-442.

[2] C. E. Evans, I. A. Trail, *Fibroblast-like cells from tendons differ from skin fibroblasts in their ability to form three-dimensional structures in vitro*, J. Hand Surgery Br., 23B, (1998), 633-641.

[3] P. H. Mott, C. M. Roland, *Mechanical and optical behavior of double network rubbers*, Macromolecules, 33, (2000), 4132-4137.

[4] R. G. Dennis, P. Kosnik, *Excitability and isometric contractile properties of mammalian skeletal muscle constructs engineered in vitro*, In Vitro Cell. Dev. Biol. Anim., 36, (2000),327-335.