

Designing an Anterior Cruciate Ligament from Transgenic Silkworm Silk

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Abstract

It has been estimated that at least 40,000 Anterior Cruciate Ligament (ACL) reconstruction surgeries are performed on a yearly basis^[1]. With a high incidence of ACL surgeries, an adequate and long lasting ACL replacement is needed for ACL reconstruction. Current ACL replacements have certain drawbacks associated with their mechanical and functional properties, as well as surgical and post-op rehabilitation issues.

Spider silk has the potential to replace current ACL reconstruction material due to its unique mechanical properties. The development of an effective spider silk-based ACL matrix could potentially improve current ligament reconstruction design and techniques.

Background

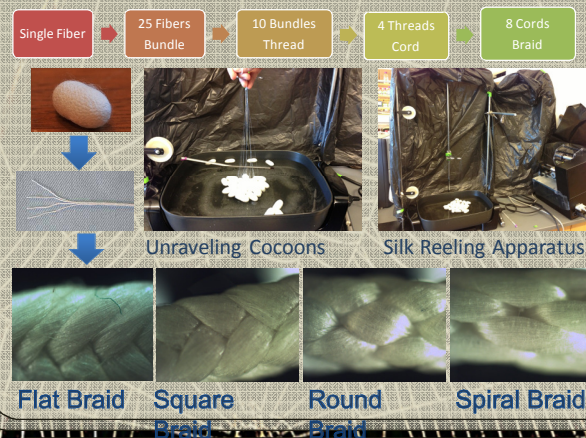
Current replacement disadvantages^[2,3]

- Autografts: Donor site morbidity
- Allograft/xenograft: Foreign body response and need for cadaver/animal donor.
- Synthetic: Foreign body response, implant site abrasion and mechanical failure.

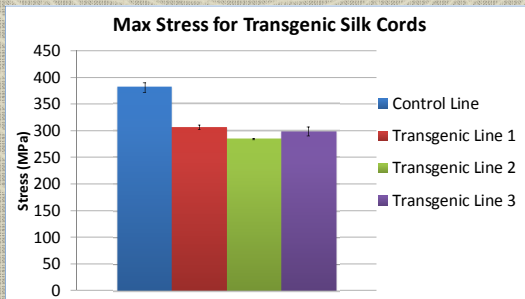
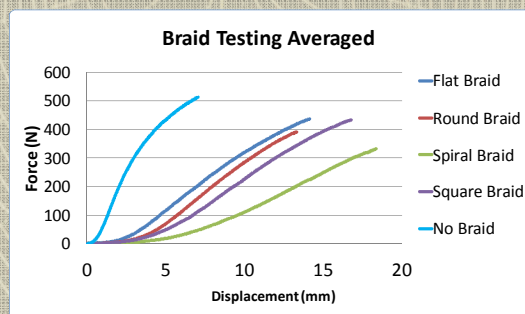
Silk Types

- Spider Silk: Orb weaver spiders spin seven different types of silk with varying mechanical properties used in web creation.
- Silkworm silk: Silkworms (*Bombyx mori*) spin cocoons made of strong fibroins that have been used in fabric and thread for thousands of years.
- Transgenic silkworm silk: Transgenic silkworms produce a hybrid spider/silkworm silk that has been shown to produce silk up to 50% stronger than natural silkworm silk^[4].
- Synthetic silk: Bacteria, goats and alfalfa are being used to produce spider silk proteins which can be lab spun into synthetic threads.

Fiber to Braid



Results



Conclusion

Braid construction does decrease both the ultimate tensile strength and stiffness of the silk. By changing both tension and braiding angles, braids can be customized to match different ligaments, tendons, or any other application necessary.

Analysis of transgenic silk showed the presence of spider silk in small amounts (1%-3%) does not increase the ultimate tensile strength of the silk fibers, however, results have shown that with further optimization of transgenic silk a braid could be constructed to match ultimate failure load and stiffness of a native ACL.

Future Applications

- Implementation research should continue including fixation mechanisms and further abrasion testing
- Tissue engineering applications (transgenic silk scaffold, tissue regeneration scaffold)
- Designs could be constructed for use as different tendons and ligaments as well as medical sutures.

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5. Background image source: http://www.mwallpapers.com/view/delicate_spider_web_sneznik_forest_slovenia-other.html