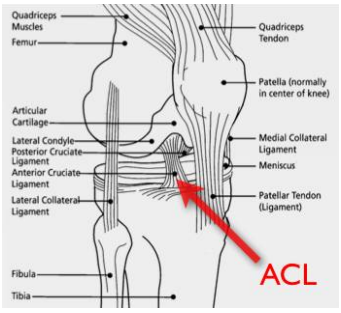
Biomimetic tissue-engineered anterior cruciate ligament replacement

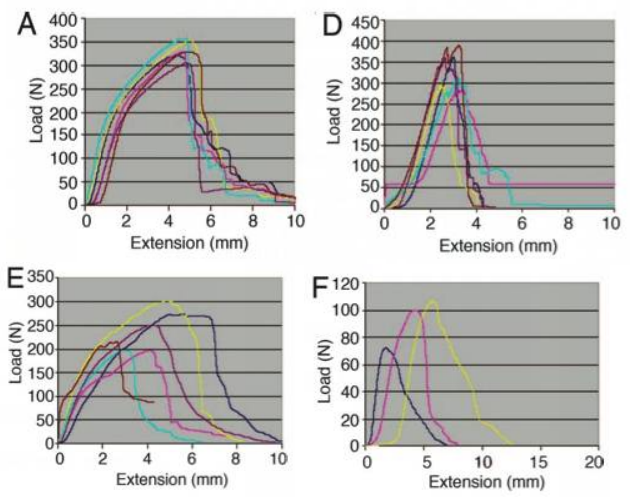
More than 200,000 ACL ruptures occur each year in the United States. Anterior Cruciate Ligament (ACL) is one four major ligaments in the knee. It connects from a posterio-lateral part of the femur to an anterio-medial part of the tibia. These attachments allow it to resist forces pushing the tibia forward relative to the femur. The ACL does not heal on it's own and requires surgical reconstruction with grafting and repair if it has been torn.



There have been many attempts to develop ACL scaffolds with Collagen Fibers, Silk, Biodegradable Polymers, and Composites. All with very limited success of the new ACL tissue growth.

Tissue-Engineered ACL replacement using a 3-D polymeric fiber braiding process. The scaffold is made of FDA Approved bio-compatible polymer, polyL-lactide(PLLA). Which is commonly used for biomedical devices, bone plates, and sutures. Polymer stabilizes the knee while the scaffold promotes regeneration of new ligament tissue.
The absorption rate of PLLA favors biological response.

Using 3D polymeric fiber braiding, a 3D scaffold is made from the PLLA polymer. Scaffold design enables cells to efficiently produce collagen fibers and promotes blood flow. Braiding the ligament provides structure strength.



Load-deformation graphs measured at 2% per second. (a)_5x5 PLLA 3D square braids before implantation (D) Native rabbit ACL (contralateral legs). (E)Four-week seeded TEL.(F) Twelve-week seeded TEL.

Study

Study performed by using 32 rabbits examined at 4 weeks and 12 weeks. The beginning and end of the crucial period of healing. Two types of scaffolds tested: One seeded with Rabbit ACL primary cells and one of only synthetic material. The team replaced the rabbits torn ACL ligaments using the same procedure as would be used on humans. Each scaffold was designed to be slightly smaller than the original ACL to permit tissue generation to take place.

Results

Rabbits that received the seeded scaffolds were walking around normally within 48 hours. At 4 weeks, Collagen and cellular infiltration of the implant. At 12 weeks, cells at the edge of the scaffold had generated collagen fibers for the formation of new ligaments.

Animal model	Implant	Animal native ACL, N	Maximum tensile loads, 4 wk	6 wk	12 wk
Rabbit	Unseeded TEL	314 ± 68	209 ± 74	—	35
Rabbit	Seeded TEL	314 ± 68	239 ± 43	—	93 ± 18
Rabbit	Collagen	251 ± 47	10	—	—
Rabbit	Autograft patellar tendon	418	—	26 ± 5	—
Sheep	PLLA ligament augmentation device	848 ± 529	—	79 ± 51	124 ± 90

Maximum tensile load data (Newtons) comparing the unseeded and seeded TEL replacements with other in vivo studies that performed ACL reconstructions

Future

The team is preparing to perform tests on larger animals and then will proceed to human testing if the results are favorable.

Sources:

"Biomimetic tissue-engineered anterior cruciate ligament replacement" J.A. Cooper, Jr., J S. Sahota, W. Jay Gorum, II, Janell Carter, S. B. Doty and Cato T. Laurencin 2007;104;3049-3054PNAS

Center for Musculoskeletal Regeneration & Repair, Univeristy of Virgina, http://faculty.virginia.edu/laurencin/index.htm

Bordeaux-Mérignac Centre of Orthopaedic and Sports Surgery, Paris, FR "History of ACL Surgery"
http://www.maitrise-orthop.com/corpusmaitri/orthopaedic/

MIT Technology Review, "Restoring Damaged Knees", Mar 22 2007
http://www.technologyreview.com/Biotech/18421/

Wikipedia, ACL reconstructive surgery:
http://en.wikipedia.org/wiki/Anterior_cruciate_ligament_reconstruction