Prospective PLG 82-18 Use in Anterior Cruciate Ligament Reconstruction

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Kellogg Honors College Capstone Project

Background:

There are 200,000 anterior cruciate ligament (ACL) injuries in just the United States each year, which makes it the most common ligament to be injured. Since 94% of these injuries require reconstruction it is important to have safe and effective materials and techniques during surgery. Currently the most common ways to reconstruct an ACL are replacing the torn ligament with a piece of tendon from another part of the knee or replacing the ligament with one from a donor. The purpose of the graft is to provide a scaffold for the new ligament tissue to grow on.

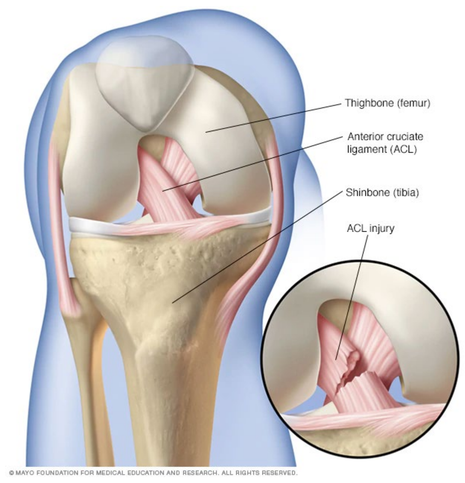

Figure 1: Uninjured and Injured ACL

Bioabsorbable polymers are polymers that break down over time into compounds that can be absorbed by the body. They have uses in the medical field such as drug delivery and stents.

This project is a continuation of Peter Kuetzing's Capstone project with Dr. Mehrdad Haghi as a mentor where he explored the use of PLG 10/90 as a scaffold for ACL repair.

Objective:

The objective of this experiment is to find viable alternatives to tendon grafts in ACL surgery by exploring the use of bioabsorbable polymers as a scaffold. This is done through measuring the mechanical properties of one bioabsorbable polymer poly(lactic-co-glycolic acid) or PLG 82/18 as it degrades within body-like conditions.

Material Comparisons:

Ligaments are made from dense bands of connective tissue that connect two or more bones. The purpose of a ligament is to provide stabilization of joints both in action and at rest. For a polymer to be able to replicate the function of an ACL during the recovery there are several mechanical properties that must be assessed. I compared three different bioabsorbable polymers for their use in ACL reconstruction: PLG 82/18, Poly(L-lactide-co-D,L-lactide) or PLDL 70/30, and PLG 85/15.

The first property to consider is the Young's modulus of the material. Young's modulus is a measure of how stiff a material is. It is typically represented with an E and in SI system the unit is in pascals. The second property to consider is ultimate tensile strength or UTS. Ultimate tensile strength is a measure of how much tensile stress a material can withstand before breaking. Figure 2 is a representation of how a ligament will react to a load. Point 5 on the figure is the point that represents the ultimate tensile strength.

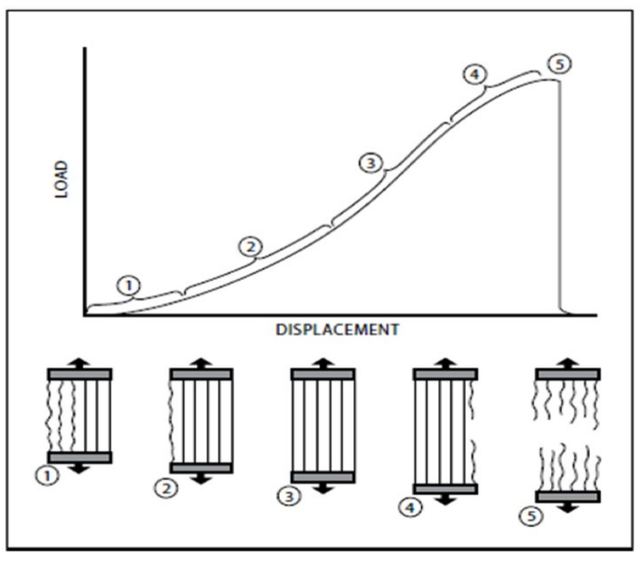

Figure 2: Strength Graph of Ligaments

The final property to consider is the degradation time of the polymer. Since the recovery time from an ACL surgery is 6-9 months, the degradation time of the bioabsorbable polymer must be at least that long to avoid complications in the patient's recovery.

Given these mechanical properties that must be considered Table 1 was created to compare each of the candidate's properties. Since PLG 82/18 has the closest Young's modulus and degradation time to an actual ACL, it was chosen for further testing.

Material	Young's modulus, E (MPa)	Ultimate tensile strength, UTS (MPa)	Degradation time (Months)
ACL	278	35	6-9
PLG 82/18	2000-4000	60	12-16
PLDL 70/30	3200-4000	60-70	18-24
PLG 85/15	3300-3800	60-70	12-18

Table 1: Comparison of Polymers to ACL

Testing:

In order to test the mechanical properties of PLA 82/18 as it would behave in the body, the material will be tested at different stages of degradation. These tests will be conducted when the material is new and dry and then again after it has been in a saline solution. The test will be a tensile test until failure on an Instron 3360. These tests will be able to determine how the properties of the polymer will change over the course of the healing process.

Another important test is a fatigue test. This is achieved by subjecting the material to a cyclic load that represents the repeated load of a person walking or running on the injured leg. Cyclic loads can cause progressive damage that results in the growth of cracks and eventually failure. This information is critical in determining the abilities of a person who has PLG 82/18 as a scaffold.

Future Work:

This work can be continued with better testing of polymers that have already been picked out, such as testing at more intervals during degradation or letting the polymer degrade in a solution closer to that in our bodies. Future researchers can also find different bioabsorbable polymers to test as candidates for the procedure.

References: "ACL Injury." *Mayo Clinic*, Mayo Foundation for Medical Education and Research, 30 Mar. 2019, www.mayoclinic.org/diseases-conditions/acl-injury/symptoms-causes/syc-20350738.

Hauser, Ross, and Erin Dolan. "Ligament Injury and Healing: An Overview of Current Clinical Concepts." *Journal of Prolotherapy*, 25 Feb. 2019, journalofprolotherapy.com/ligament-injury-and-healing-an-overview-of-current-clinical-concepts/.