Instrumented Implant for Self-healing of the Anterior Cruciate Ligament

Subject: Sensor technologies
Thesis advisor: Prof. Dr. Bertrand Dutoit
Expert: Dr. Janosch Häberli (Mathys AG Bettlach)
External project partner: Mathys AG Bettlach, Bettlach

Anterior cruciate ligament (ACL) ruptures are very common within athletes. Ligamys® is a novel implant for the treatment of ACL ruptures. Currently there is little information available about the in vivo forces acting on the implant during the healing period of the ACL. The goal of this project is to find magnetic methods to measure and analyse the forces acting on Ligamys® corresponding to the ACL self-healing over time.

Initial Situation

Ligamys® includes several mechanical pieces, in particular a mobile part which supports the anterior cruciate ligament (ACL) during the healing period. The aim of this project is to develop a system based on magnets, which allows to measure the absolute forces acting on the implant, in order to analyse the regeneration of the ACL. The measurement methods should be wireless, which means they should be positioned outside the human body. As there is no knowledge about absolute values of spring forces during the regeneration phase of the ACL, the main challenge was to find a reference point on graph (fig.1), which depicts qualitative information about how the ACL regenerates with Ligamys®.

System Design

The instrumented Ligamys® allows measuring the force provided by the implant. It comprises a moving magnet within the implant and a magnetic sensor located in an external reader.

The first step was to locate one or several rare-earth permanent magnets into Ligamys®. These magnets are known for producing very strong magnetic fields, which should be measured outside the skin tissues. In order to be biocompatible, the magnets are encapsulated into the implant with a biocompatible two-components glue and surrounded by a nanometric film, to insulate the magnet from the synovial liquid, which flows into the implant. The second step was the FEM (Finite Element Method) analysis. FEMM is a FEM software dedicated to magnetic problems. It gives a precise appreciation of the magnetic field values at some determined distances. Finally a test bench was created, which allows real-time measurements of the magnetic field produced by the mobile magnet. These measurements are made by a 3D Hall sensor.

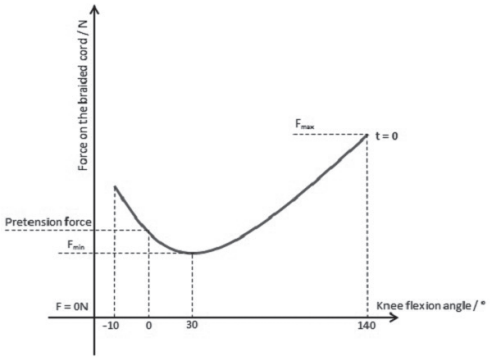

Fig.1 Schematic of the forces acting on Ligamys® in function of the patient's knee flexion angle

Results and Conclusions

It has been determined that a real-time force measurement gives indications about the healing process. A Hall effect sensor oriented along the magnet axis can return the measured magnetic field value when the patient bends his or her knee from extension to complete flexion, by displacing the mobile element into the implant. In fact, the forces acting on Ligamys® decrease over time, which means that the ACL progressively recovers its functions. Until the end of this Bachelor Thesis, the system will be tested on a test bench and finally implanted into a pig's knee, which is physiologically similar to human's (see fig.2).

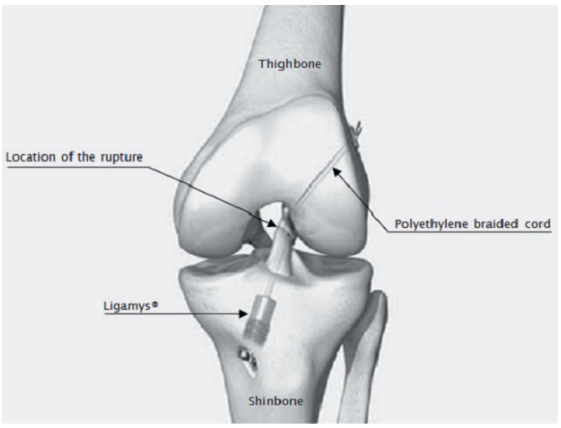

Fig.2 Schematic of the Ligamys® Implant in the knee joint while healing phase.

Maxime Paul Genilloud
maxime.genilloud@outlook.com