Working towards the digital twin of the knee

Top-notch decisions in knee surgery

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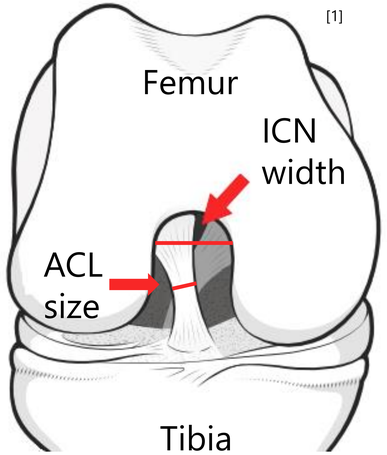


Anterior cruciate ligament reconstruction

Rerupture of the anterior cruciate ligament (ACL) after reconstructive surgery is reported to be between 3.9% and 11.1%[2]. As the incidence rate of ACL rupture is increasing under younger patients, this treatment needs to be more durable.

Anatomical features play a role in graft failure, as is the case with impingement of the ACL. The risk of this failure mode depends on the intercondylar notch (ICN) width and ACL size (cross-sectional area), which varies between patients.

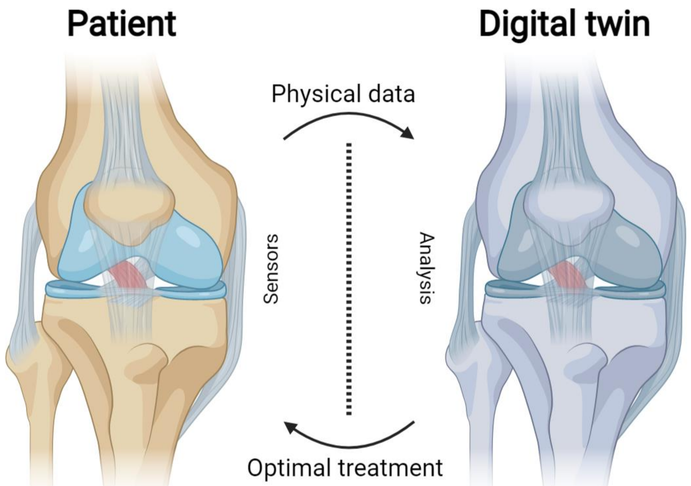
Decellularized ACL allografts

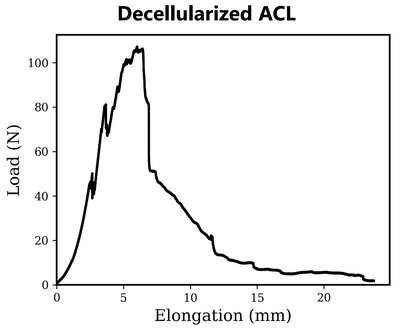
A protocol has been developed at Biointerface Science (BiS) that is suitable for the decellularization of ligaments[3]. This opens up the possibility for developing an off-the-shelf allograft, giving the surgeon the possibility to choose a specific graft size for the patient.

Digital twin

Developing a digital twin for each patient can bring this anatomical problem and the off-the-shelf allografts together to provide durable, personalized healthcare. This digital twin approach has already been applied in healthcare, showing a great improvement in precision cardiology[4].

By creating a virtual model of a patient's knee based on their personal data, analysis of the injury and environment can be done while also being able to suggest the optimal graft properties for the patient.

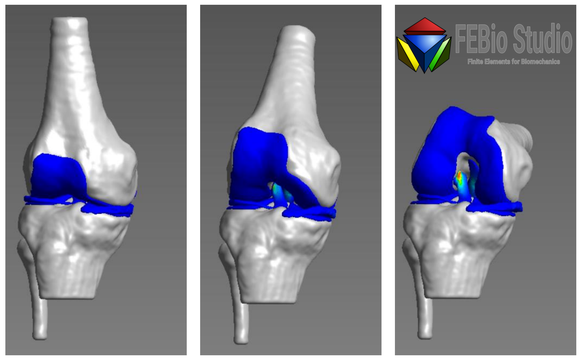




Project:

Tensile testing

The mechanical properties of ACLs and decellularized ACLs are determined through uniaxial tensile testing. This data is used to characterize the different grafts in the next step.



Simulations

Finite element analysis is performed on 8 patient-specific knee models from the OpenKnee project[5] database. ACL size and mechanical properties are varied to determine the effect on each individual knee. Local stress distributions are used as a marker for rupture risk.

Future outlook

This project will be a proof of concept for developing an assessment tool to support surgeons in the decision for graft selecting. After ACL injury, a digital twin can be created based on an MRI scan of the patient's knee. By analyzing this virtual knee, or digital twin, rupture risk can be assessed for each graft type and size, thereby aiding the surgeon in their decision to select the graft with lowest rupture risk.

Injury | MRI scan | Digital twin | Graft prediction | Surgeon

References
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