Effects of suture choice on biomechanics and physeal status after bio-enhanced ACL repair in skeletally immature patients – a large animal study

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Introduction: Recent studies have introduced the groundwork for a new treatment option for anterior cruciate ligament (ACL) ruptures: bio-enhanced ACL repair (1). Briefly, this procedure is a primary suture repair of the ACL augmented by the implantation of a collagenous biomaterial soaked with platelet-rich plasma into the ACL defect along with a “suture stent” to initially protect the healing ligament (Figure 1). Our first hypothesis was that suture choice, using either absorbable suture (Vicryl, Ethicon, Somerville, NJ) or non-absorbable suture (Ethibond, Ethicon, Somerville, NJ), would have an effect on physeal function. The second hypothesis was that the biomechanical outcomes of repairs performed with absorbable would be inferior to those with nonabsorbable sutures after 15 weeks of healing.

Methods: 16 pigs underwent unilateral ACL transection and bio-enhanced ACL repair with either absorbable (Vicryl, Ethicon, Somerville, NJ) or non-absorbable sutures (Ethibond, Ethicon, Somerville, NJ). At 15 weeks suture tunnel and growth plate healing were assessed by microCT and structural properties of the knees were measured.

Figure 1 Schematic of bio-enhanced ACL repair. In the knee undergoing enhanced ACL repair, one set of sutures was passed from the Endobutton on the femur through a tunnel in the femur, through the collagen scaffold, tibial tunnel and secured in place with an extracortical button (red sutures). A second set of sutures from the Endobutton were tied to a Kessler suture placed in the tibial stump (green sutures) to reduce the torn ACL. The collagen scaffold is saturated with 3cc of autologous blood as a source of platelets, which release an abundance of growth factors.

Micro-computed Tomography
Knees were scanned in a MicroCAT II (Siemens, USA) micro-CT scanner at a resolution of 50 microns with a slice thickness of 0.09 mm to assess tunnel integrity. The scanner was set at 300ms exposure, 72 kVp, and 500uA in 1° increments for 360°. Scans were aligned such that the bone tunnel was along the vertical axis using the free medical imaging software AMIDE (www.amide.sourceforge.net). Size and density of the suture tunnels were taken in six anatomical locations (proximal tunnel opening, third of tunnel, proximal growth plate, distal growth plate, distal third of tunnel, and distal tunnel opening) using circular or elliptical regions of interest (ROI) at a right angle to the tunnel axis. Bone mineral density (BMD) was calculated as milligrams of hydroxyapatite per cubic centimeter.

Biomechanical testing
For failure testing, the knee flexion angle was initially set at 30°. The tibia was mounted to the base of the MTS via a sliding X-Y platform with the femur unconstrained to rotation. Before initiating the tensile test, the femur was lowered until the load across the joint surface was +5N of compression. A ramp at 20 mm/min was performed and the load-displacement data were recorded at 100Hz. The yield load, failure load, linear stiffness, yield displacement and failure displacement were calculated from the MTS load-displacement tracing. Biomechanical testing was done by an individual blinded to the surgical condition.

Results:
No intact suture material was found in any of the knees during testing.

Micro-computed Tomography
The non-absorbable group showed significantly larger bone tunnels (p<0.001) and physeal defects (p<0.001) and a lower bone mineral density within the tunnels (p<0.001).

Discussion:
We found evidence for more growth plate disruption in the non-absorbable suture group (Ethibond), which had larger tunnels, and lower bone mineral density within the tunnels at the 15 week time point compared to the absorbable group (Vicryl). We also found that the use of non-absorbable suture material produced significantly improved outcomes in structural properties. The fact that all sutures were disrupted at the time of biomechanical testing rules out that these differences in testing are attributable to the suture material itself, but rather supports the assumption of an underlying difference in biological response.

Significance:
Non-absorbable sutures improved the structural properties of the healing ligament, but may also jeopardize the growth plate. We suggest the use of non-absorbable sutures with an intraphyseal placement, similar to recommendations for suture fixation of tibial eminence avulsions.

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