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A bigger suture diameter for anterior cruciate ligament all-inside graft link preparation leads to better graft stability: An anatomical specimen study

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Background: In anterior cruciate ligament reconstruction, different suture types are used for graft link preparation. Thus the aim of this study was to determine whether differences in the diameter of the suture used influence biomechanical stability of the prepared graft. We hypothesized that the use of a greater suture diameter leads to a higher load to failure rate in tested graft links.
Methods: In an anatomic specimen study, ligament preparation was enrolled in 15 cadaveric knees. The material used was the semitendinosus/gracilis tendon, which was fresh frozen (−80°) after harvesting for four weeks. The grafts were then defrosted, randomized into two groups and prepared with the same technique: 12 with a suture; FiberWire No. 2 and 12 with a FiberWire No. 0.
Results: Overall, the group using FiberWire No. 2 presented with a mean load to failure rate of 730.67 N, mean overall final elongation of the graft was 5.98 mm. In the FiberWire No. 0 group mean load to failure was with a mean overall elongation of the graft of 6.96 mm. Significant differences ($P = 0.006$) between the two groups with regard to the load to failure rate were found, with FiberWire No. 2 withstanding forces better. There was no difference in elongation of the grafts or mode to failure between the two groups.
Conclusions: Graft preparation with a bigger suture type is recommended to gain better load to failure rates, also in smaller-diameter grafts. Regarding the elongation rate, different suture types did not influence the outcome.
Level of evidence: Anatomical specimen study, Level III.

1. Introduction

The type of graft used for anterior cruciate ligament (ACL) reconstruction still remains controversial. Despite numerous studies, there is till today an ongoing debate on this topic [1]. For the past decades the most common practice was to use patellar tendon grafts for ACL reconstruction [2]. Due to the increasing number of other successful minimal invasive ACL reconstruction techniques, the choice of graft has gradually changed. Nowadays, the use of the semitendinosus ± gracilis tendon, in combination with more accurate preparation techniques allows minimal invasive ACL reconstruction. However, these techniques bring their own problems including saphenous nerve injury, harvest-site haematomas or even tunnel widening [3].

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The all-inside technique is an ACL reconstruction technique using the semitendinosus ± gracilis tendon described by Wilson et al. in 2013 [4]. ACL reconstructions using tibial tunnels with a continuous diameter have been a common orthopaedic technique, while, the ACL all-inside reconstruction technique changes this to a tibial socket which is the biggest advantage of this technique. A femoral “socket” and a tibial “socket” are used, whereby a tunnel is made which is wider where the graft is placed and narrower at the cortex. This preserves a cortical bone bridge through which the graft link is shuttled and fixed [5]. Previous clinical evaluations of patients that underwent all-inside ACL reconstructions presented with less pain and good functional outcomes [5,6].

However, the all-inside technique requires a specific graft-preparation technique with special consideration of the graft source, graft length, fixation method and surgical technique [7]. Regarding this development, the hamstrings are widely used and accepted for ACL reconstruction today [7–10], however, the technique comes with considerable difficulties in graft preparation. Several different techniques for hamstring graft preparation have been described in the literature with regard to the material used, the different sutures, etc. [7,10–12]. To this day there is no study investigating suture diameter in graft link preparation and testing the entire tendon construct. The suture is of great importance, particularly in the first six months during the re-modelling phase of the graft, as it binds the graft together and plays an important role for early stability. The forces affecting the graft during implantation and healing can lead to clinical failure, which needs to be considered. Several factors affecting graft construct elongation are described in the literature, including tissue quality, stitching technique, and number of suture throws [13–16] as well as suture diameter.

Therefore the aim of this study was to determine whether a difference in suture diameter influences biomechanical stability of a graft link. We hypothesized that utilizing a bigger suture diameter leads to a higher load to failure rate for the graft link.

2. Material and methods

This study was performed as an anatomical specimen study at the Department of Trauma Surgery Medical University of Vienna in cooperation with the Center of Anatomy and Cell Biology of Medical University of Vienna and the Institute of Material Science and Technology of the Technical University of Vienna.

2.1. Graft harvesting

In 15 anatomical specimens of the lower extremity (eight males and seven females, mean age 68 years, range 61–78 years) the semitendinosus and gracilis tendon were harvested via a medial incision directly over the tendons and a sharp dissection. The tendons were followed over their entire length and released at the pes anserinus and at the insertion of the respective muscle, leaving a total of 30 tendons for possible inclusion. Following macroscopic inspection of the tendons and final measurement of the tendon length, six tendons were excluded: four due to an insufficient length and two because of macroscopic changes. A total of 24 tendons, 12 in each group of equal length ±1.5 mm and without any signs of degenerative or pathological changes (macroscopically) were finally obtained and randomly allocated to one of two groups.

All harvested grafts were measured and only grafts with a minimum length of 270 mm were used to enable quadruple folding for graft link preparation. Finally, only grafts with a minimum diameter of eight millimetres (in their quadrupled form) were used for mechanical testing. Tendon length was measured with a standard ruler; the final diameter of the tendons (quadrupled) was measured using a tendon-measuring block by Arthrex®, (Naples, FL).

2.2. Graft preservation

All harvested grafts were fresh frozen at −20 °C after measuring. For final testing the tendons were defrosted at room temperature (21 °C) over 36 h.

2.3. Graft preparation

All graft link preparations were performed by two authors TT and MW for each specimen, who are both experienced in graft link preparation for ACL reconstruction.

The tensioning apparatus by Arthrex (Naples, FL) was used for preparing the grafts. All grafts were prepared according to the continuous loop technique as described by Arthrex (Figure 1) [17]. For graft link preparation, two different suture diameters were used: (1) FiberWire® No. 0; and (2) FiberWire® No. 2. Twelve randomized hamstrings were each prepared with one of the two FiberWire strengths. The TightRope by Arthrex (Naples, FL) was used for fixation in all graft links. During preparation the tendons were dampened with 0.9% NaCl as it is routinely performed at our department during graft preparation. The final testing procedure was carried out at room temperature as it is usually performed in standard biomechanical procedures [1,18].

2.4. Biomechanical testing

A researcher specialized in material science carried out the biomechanical testing. The graft link preparation and mechanical testing procedures were performed at the Institute of Material Science and Technology of the Technical University of Vienna.

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