The Fixation Strength of Tibial ACL Press-Fit Reconstructions: A cadaveric study

1Ettinger, M; 1Haasper, C; 1Liodakis, E; 2Breitmeier, D; 1Krettke, C; 2Hurschler, C; M Jagodzinski

1Hannover Medical School (MHH), Orthopaedic Trauma Department, Hannover, Germany; 2Hannover Medical School (MHH), Laboratory for Biomechanics and Biomaterials, Hannover, Germany; 3Hannover Medical School (MHH), Institute of Legal Medicine, Hannover, Germany.
jagodzinski michael@mhh hannover.de

ABSTRACT

INTRODUCTION

A secure tibial press fit technique in anterior cruciate ligament reconstructions is an interesting technique because no hardware is necessary. This study compares the biomechanical properties of four press fit fixation techniques to an interference screw fixation.

METHODS

The knees of 14 human cadavers (28 knees) were used for acquisition of the hamstring tendons. The age of the cadavers from which the tissue was obtained was 49.2±18.5 years (range: 23-75). The harvesting of the tendons was performed an average 1.7±0.76 day post mortem. We used tendons from 15 men and 5 women with a mean body size of 175.7±10.3 cm (range: 154-183) cm for this investigation. There were no visual signs of ligament degeneration. For the tibial drill holes, we used the femurs of 28 German Landrace pigs. The pigs were 1 year old, fully grown, and had a weight between 100 and 120 lbs. The tibial neck was cut off and the shaft of the tibia cemented into an aluminum holder using cold-curing methacrylate resin (Technovit 4071, Heraeus Kulzer GmbH, Wehrheim, Germany). In the T group (Fig.3) the graft was fixed over a bone bridge using 4-mm tape (Mersilkene; Ethicon Inc., Somerville, NJ, USA). In the TS group (Fig.3) the graft was fixed over a bone bridge using Fiberwire #2 (Arthrex, Naples, Florida), the S group (Fig.3) was fixed over a bone bridge as well (Mersilkene No.3 metric, USP6; Ethicon Inc.). In the F group an additional bone block was sutured into the tendon (Systor® [Poly(D,L-Lactid) (PDLLA)]; Centerpulse Medical AG, Winterthur, Switzerland).

MECHANICAL TESTING

The constructs were thawed at 4°C for 24 hours prior to mechanical testing and kept moist using saline spray during the entire procedure. A material testing machine (Mini Bionix 858, MTS Systems Co., Minneapolis, USA) was used for the mechanical evaluation of the constructs. The potted tibias were rigidly fixed in a base platform at 0°, there was a distance of 30mm between the grafts and the clamp, the total length of all constructs. The potted tibias were rigidly fixed in a base platform at 0°, there was a distance of 30mm between the grafts and the clamp, the total length of all constructs.

MECANICAL TESTING

The constructs were thawed at 4°C for 24 hours prior to mechanical testing and kept moist using saline spray during the entire procedure. A material testing machine (Mini Bionix 858, MTS Systems Co., Minneapolis, USA) was used for the mechanical evaluation of the constructs. The potted tibias were rigidly fixed in a base platform at 0°, setting the bone tunnel-force direction angle to 30°. There was a distance of 30mm between the grafts and the clamp, the total length of all tendons was trimmed to 50mm, leaving 20mm for fixation in a custom made s-shaped clamp. The constructs were pre-tensioned with 60N for 30 sec. prior to testing. Then, 500 cycles of mechanical loading in between 60 and 260N were applied at a repetition rate of 1Hz. The increase in construct length was recorded. Length changes are reported between the minimum of the first (15th, 20th) and to the maximum of the 5th (20th, 500th) cycle. After a decreasing preload from 60N to 1N, and passing for 30 seconds, a failure test with a ramp speed of 1mm/sec was performed. The maximum failure load, failure mode, and stiffness of the constructs were analyzed. The tests were recorded with a digital video camera (frame rate: 25 pictures/sec). Constructs were photo- optically marked at intervals of 10mm starting at the ridge of the tibial drill hole. One marker was attached to the bone and three markers within the tendons with a distance of 10mm in between each marker. Markers A and B were used to investigate length changes within the tendon, markers C and D to analyze changes between tendon and bone (Fig. 1). An image analyzing software (ImageJ, NIH) was used to determine length changes. The measurements are reported in percent of the initial length.

We analyzed the length change in between tendon - bone and tendon - tendon markers. The procedure was executed from the smallest length observed during the 1st (15th) (20th) loading cycle to the maximum length attained during the 5th (20th) (500th) loading cycle. Moreover, lengthening in between the beginning and end of failure testing was evaluated. This data was compared with the length changes that were recorded by the mechanical testing machine. All mean values are reported with standard deviations, such as maximum and minimum. The three groups were compared using a One Way ANOVA. Normality and Equal Variance Tests were conducted. If Normality Test failed, a Kruskal-Wallis ANOVA on Ranks was executed with a post-hoc Scheffe Test. If Normality Tests were passed, an Equal Variance Test was conducted. Comparison of two groups was conducted using a non-parametric T-Test. All operations were performed using Sigma Stat 15.0 (SPSS-company, Chicago, IL 60606, USA). A significance level of p<0.05 was assumed.

RESULTS

Maximum failure loads observed were 970±38N (853-1087N) for the T fixation, 572±151N (777-324 N) for group TS, 544±109N (440-756 N) for technique I, 402±77N (303-485 N) for the S fixation and 290±74N (250-432 N) for the F technique. The load reached by the T group was significantly higher compared to all other techniques (ANOVA on Ranks, P<0.01; Fig.2). The stiffness was 78±13 N/mm (59-95 N/mm) for group T, 108±18N/mm (88-145 N/mm) for group S, 162±27N/mm (129-207 N/mm) for group I, 76±14N/mm (55-93 N/mm) and for the TS technique. The stiffness of the group I was significantly larger. (ANOVA on Ranks, P<0.01; Fig.3). The cyclical loading elongation, determined by the testing machine in between the 1st to 5th cycle, was significantly larger for the F fixation compared to the S, T and I group. (P<0.05). The cyclical loading elongation in between the 15th to 20th was significantly larger for the F group compared to all other techniques (P<0.001). In between the 15th to 500th loading cycle the loading elongation was significantly larger for the F group compared to all other groups (P<0.001).

CONCLUSION

The present study compared the “time 0” properties of 4 press fit fixations and one interference screw fixation. The press fit fixations showed equal properties compared to the interference screw fixation and other hardware fixations in the literature. Clinical trials are necessary to evaluate the performance and incorporation of a tibial press fit fixation. The results of this study suggest that a tibial press fit fixation does not hamper the biomechanical properties and such techniques can be applied similar to hardware fixation techniques. Hence, the results of this study indicate that a tibial press fit fixation is an alternative to interference screw tibial ACL reconstruction fixation.