Introduction

The doubled hamstring tendon graft has been commonly used in anterior cruciate ligament (ACL) reconstruction. This graft, however, has a few disadvantages, which involves low stiffness of the femur-graft-tibia (FGT) complex (1). In order to increase the stiffness of the FGT complex with the hamstring tendon graft, a new fixation procedure with the BoneMulch Screw/WasherLoc (BMSW) system has recently been developed by Howell et al. The static biomechanical characteristics were reported by To et al (2). No studies, however, have been conducted to evaluate dynamic behaviors of the FGT complex with this system using cyclic loading. The purpose of this study is to compare biomechanical behaviors of the FGT complex reconstructed with the flexor tendon (FT) graft and the BMSW system to the FGT complex reconstructed with the two clinically standard procedures, the bone-patellar tendon-bone (BTB) graft-interference screw procedure and the doubled FT graft-Endobutton procedure.

Materials and Methods

Based on our previous study (1), a porcine ACL reconstruction model was used in this study. In this model, a pair of digital FT was trimmed so that their cross-sectional area became 7 and 14 mm², respectively. Forty-two porcine knees were randomly divided into three groups of 14 specimens each. For each group, ACL reconstruction was performed with one of three different procedures. In Group A, each end of the doubled FT was fixed with BMSW system (Arthrotek, Naples, FL). In Group B, each end of the BTB graft was secured with an interference screw. In Group C, the femoral end of the doubled FT was tethered to an Endobutton (Smith & Nephew Inc) using a polyester tape, and the tibial end was tethered to a screw-post with four #2 Tevdek sutures. In each group, seven specimens underwent 5000 cycles of cyclic elongation (0.2 Hz) with constant amplitude of 2 mm, after initial tension of 20N was applied. Finally, each FGT specimen underwent the tensile failure test at a crosshead speed of 50 mm/min. The remaining seven specimens were examined in the same tensile failure test without cyclic elongation being applied. Statistical comparisons were made using the ANOVA with the post-hoc Fischer PLSD test for multiple comparisons.

Results

1) At the first cycle, the peak load value in Group A was significantly higher than that in Group C, while there were no significant differences between Groups A and B (Fig. 1). The peak load rapidly decreased during the first 1000 cycles in each group. At the 5000th cycle, the peak load in Group A was significantly lower than that in Group B, while the value in Group A was significantly higher than Group C. 2) Before cyclic loading, there were no significant differences in the initial stiffness (the slope of the toe-region in the load-displacement curve) between Groups A and B, while these values were significantly higher than that of Group C (Fig 2). Cyclic loading significantly decreased the initial stiffness values of all groups. After cyclic loading, the initial stiffness of Group A was significantly lower than that of Group B, although the value of Group A was still significantly higher than that of Group C. 3) Cyclic loading did not significantly affect the linear stiffness or the ultimate failure load in each (Fig. 3). Regardless of cyclic loading, the linear stiffness of Group A was significantly higher than that of Group C, while there were no significant differences between Groups A and B. There were no significant differences in the ultimate failure load among three groups.

Discussion

The present study demonstrated that, in ACL reconstruction with the FT graft, the peak load measured at the 5000ᵗʰ cyclic displacement was significantly greater in the FGT complex with the BMSW system than in the FGT complex with the suture-Endobutton system. In addition, the initial stiffness of the former complex was significantly higher than that of the latter complex before and after cyclic loading. These results suggested that the BMSW system reduces the degree of the biomechanical disadvantage in ACL reconstruction with the flexor tendon graft. However, this study also showed that the peak load and the initial stiffness of the FGT complex with the BMSW system were significantly less than those of the FGT complex with the BTB-screw system after 5000 times of cyclic loading, although there were no significant differences in these parameters between the two groups before cyclic loading. As for the clinical relevance, orthopaedic surgeons should take this information into consideration when they decide an initial graft tension during surgery and rehabilitation protocol after surgery.