**The Effect of Initial Graft Tension on Mechanical Behaviors of the Femur-Graft-Tibia Complex During Submaximal Cyclic Loading is Different Between Bone-Tendon-Bone and Flexor Tendon Grafts**

*Nakano, H; +**Yasuda, K; **Tohyama, H; ***Yamanaka, M; *Kaneda, K*

*Department of Orthopaedic Surgery, Hokkaido University School of Medicine, Sapporo, Japan. +**Department of Medical Bioengineering, Hokkaido University School of Medicine, Sapporo, Japan. Department of Orthopaedic Surgery, Hokkaido University School of Medicine, Kita-ku Kita-15 Nishi-7, Sapporo 060-8638, 81-11-706-7211, Fax: 81-11-706-7822, yasukazi@med.hokudai.ac.jp*

**Introduction** The graft after anterior cruciate ligament (ACL) reconstruction is inevitably exposed to submaximal repetitive loads in the early rehabilitation phase. Our previous studies have demonstrated that submaximal cyclic loading significantly changes biomechanical properties of the femur-graft-tibia (FGT) complex after ACL reconstruction under a constant initial graft tension [1]. However, orthopaedic surgeons commonly apply various degrees of initial graft tension during ACL reconstruction. Therefore, we should clarify the effect of initial graft tension on mechanical behavior of the FGT complexes during and after cyclic submaximal loading. No studies, however, have dealt with this issue. The purpose of this study is to compare the effect of initial graft tension on biomechanical behavior of the FGT complex with ACL reconstruction during and after submaximal cyclic loading between the bone-patellar tendon-bone (BTB) and doubled flexor tendon grafts.

**Materials and Methods** Based on our previous biomechanical study [1,2], a porcine ACL reconstruction model was used in this study. In this model, the bone-patellar tendon-bone (BTB) and flexor digitorum profundus tendon grafts harvested from the fully mature LWD pigs were used as substitutes for the human BTB and hamstring tendon grafts, respectively. A pair of flexor tendons was trimmed so that the cross-sectional area became 14 and 7 mm², respectively [2]. Twenty porcine knees were randomly divided into four groups of five specimens each. For each group, after the ACL was resected, ACL reconstruction was performed with one of the two procedures. The femoral and tibial tunnels were drilled through the anatomical insertions of the ACL. The diameter of the tunnels was matched to the graft diameter in each knee. In the first and second groups (Groups B20 and B80), each end of the BTB graft (10-mm wide) was secured without any initial graft tension using a interference screw (Kurosaka screw, Depuy Inc.) having a diameter of 9 mm and a length of 25 mm. In the third and forth groups (Groups F20 and F80), a pair of the flexor tendons was doubled, and each end of the tendons was tethered without any initial graft tension using 4 Tevedek sutures (#2) to a plastic button. The FGT complex was attached to a tensile tester at 45 degrees of knee flexion so that the femur and the tibia were positioned to allow tensile loading aligned with the long axis of the bone tunnel. Then, a tensile load of 20 N was applied to the graft for 2 minutes as an initial graft tension in Groups B20 and B80, while a tensile load of 80 N was applied to the graft for 2 minutes in Groups B80 and F80. After preconditioning, submaximal cyclic loading was started. The stiffness during cyclic loading was recorded throughout the experiment. Then, tensile failure tests of FGT complexes were performed at a cross-head speed of 50 mm/min. Statistical comparison was made using the two-way ANOVA with the Bonferroni's post-hoc multiple comparison.

**Results** For the BTB graft fixed with interference screws, an increase of initial graft tension from 20 N to 80 N increased the peak load from 68 N to 123 N and the average peak load from 135 N to 278 N and the average valley load from 9 N to 42 N at the 1st cycle (Fig. 1-a). For the FT graft, an increase of initial graft tension of 80 N significantly increased the peak and valley loads at each cycle. For the FT graft secured with sutures, the initial graft tension did not significantly affect the linear stiffness or the ultimate failure load of each FGT complex after cyclic loading in each group (Fig. 2). Linear stiffness and ultimate failure load in Groups B20 and B80 were significantly higher than those in Groups F20 and F80.

**Discussion** The mechanical conditions in this study simulated those in continuous passive motion exercise for the knees during approximately 2 weeks after ACL reconstruction. For the BTB graft fixed with interference screws, an increase in initial graft tension of 80 N significantly increased the peak and valley loads even at the 5000th cycle. For the FT graft secured with sutures, however, the effect of the increase in initial graft tension on the peak and valley loads disappeared by the 1000th cycle. This study demonstrated that the effect of initial graft tension on biomechanical behavior of the FGT complex with ACL reconstruction during and after submaximal cyclic loading is significantly different between the BTB graft fixed with interference screws and the FT graft secured with sutures. However, an increase of initial graft tension of 80 N did not significantly affect the biomechanical properties of the FGT complex with each graft in failure tests. As to clinical relevance, when surgeons determine the initial graft tension in ACL reconstruction using the BTB graft and interference screws, they should take it into consideration that the effect of an increase in initial graft tension on the peak and valley loads continues for a relatively long period, because excessively high tension may give adverse effects to remodeling of the graft. In addition, when surgeons use the FT graft in ACL reconstruction, they should recognize that graft tension applied intraoperatively decreases rapidly in the rehabilitation phase. Initial graft tension of 20 N may be too low because not only the valley load but also peak load become close to zero immediately after surgery.