VISCOELASTIC BEHAVIOR OF ACL GRAFTS WITH AND WITHOUT PRETENSIONING

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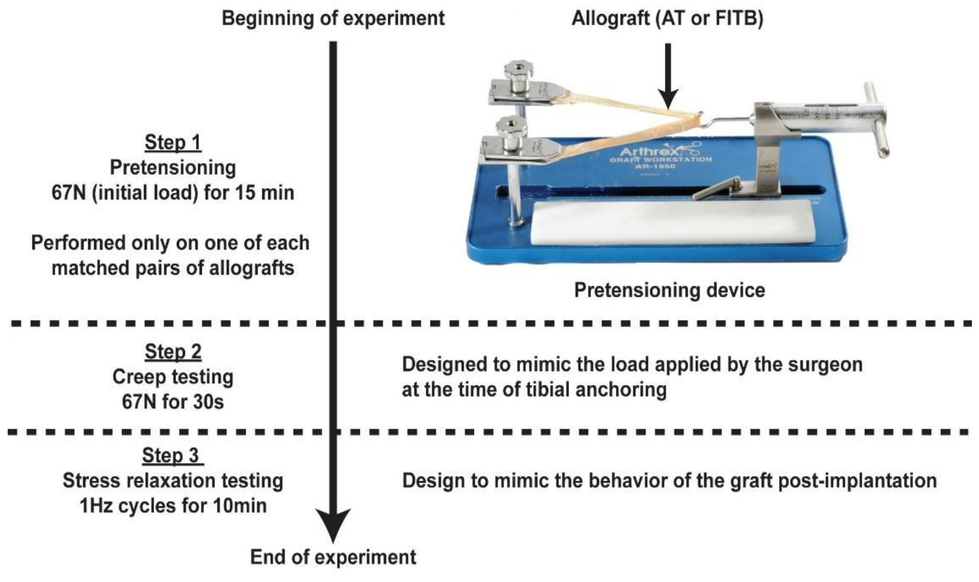
INTRODUCTION

Intra-operative preconditioning graft material in a tensioning device is intended to minimize laxity at the site of the reconstruction after ACL surgery. Previous studies have shown that pretensioning ACL grafts at high levels of strain resulted in alteration of the collagen fibrillar ultrastructure.[1] The most stressful post-op activity for the graft replacements is the isometric seated knee extension causing about 4.4% strain[2,3] and about 300 N force[4] on the ACL.

The purpose of this study is to determine ex-vivo whether pretensioning of ACL replacement grafts at the low levels of load typically used intra-operatively has an effect on the stress relaxation and creep properties of the graft during mechanical loading at the expected early post-operative levels.

METHODS

Five pairs of grafts were prepared by the surgeon investigator with sutures to both anterior tibialis (AT) and fan-folded iliotibial band (FITB) grafts. One of each matched pair of allografts was pretensioned under a load of 67 N (15 lbs) for 15 minutes, mimicking the average procedure performed by the SI in the operating room (Step 1).



Each group (pretensioned and non-pretensioned) was then mounted in the tensile grips of the MTS machine. Creep was performed by loading in load control to 67 N for 30 seconds to mimic the load applied by the surgeon at the time of graft fixation onto the patient's tibia (Step 2). This 67 N load was determined using a tension transducer attached to a synthetic graft in a Sawbones knee. The average measures from 3 surgeons were recorded as they manually simulated their tensioning and ROM cycles prior to anchoring the graft to the tibia.

After the creep test, the graft was subjected to a stress relaxation test to mimic the behavior of the graft early post-implantation. The MTS machine was changed to stroke control and the grafts were cyclically extended (+1.5mm from their initial position, to simulate the 4.4% strain on the ACL expected at the first physical therapy post-op visit) for 10 minutes at 1 Hz (Step 3).

RESULTS

The results of the creep testing, which was designed to mimic the load applied by the surgeon onto the graft at the time of tibial anchoring, demonstrated a tendency for the pretensioned grafts to creep more than their non-pretensioned counterparts (A, B).

However, statistical analysis performed on the final value of the creep testing demonstrated that this increase in creep was significant only in the case of the pre-tensioned FITBs (P=0.019), with an average creep increase from 5.0±2.9mm to 8.5±4.0mm, when comparing the non-pretensioned and pretensioned FITBs (B).

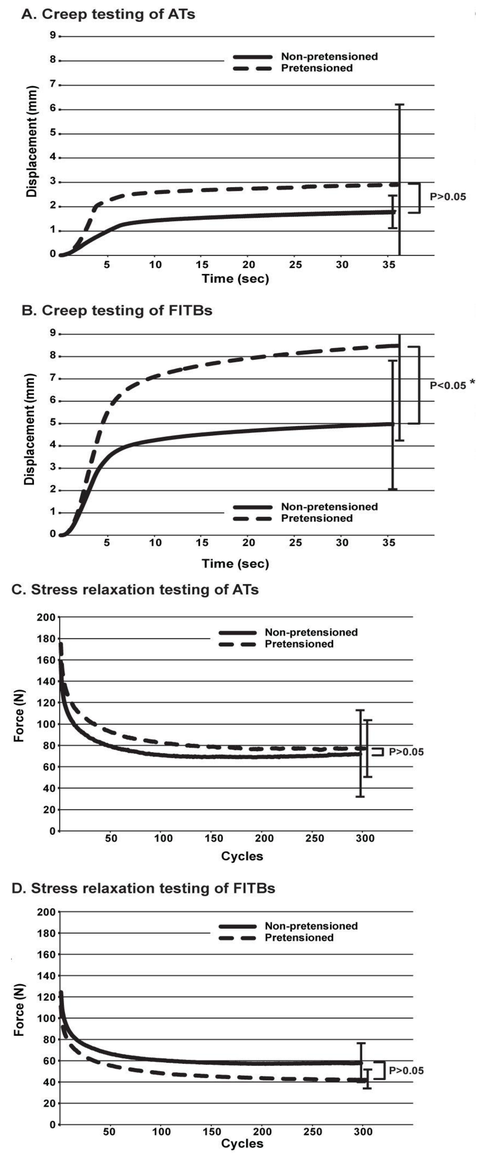
Indeed, ATs only slightly increased from 1.8±0.7mm to 2.9±3.3mm upon pretensioning, which was not a statistically significant difference (P=0.61) (A).

We also noticed more variability in the creep behavior of pre-tensioned ATs compared to non-pretensioned. The stress relaxation testing was designed to mimic the behavior of the graft early post-implantation.

Pretensioned and non-pretensioned allografts, either ATs or FITBs, did not exhibit any significant difference during the stress relaxation test (C, D).

In the AT stress relaxation test, the mean force following relaxation was not significantly modified (P=0.55) with final values of 71.8±41.0N and 77.1±26.6N for the non-pretensioned and pretensioned ATs, respectively.

In the FITB stress relaxation test, we observed a non-significant (P=0.062) decrease in the mean force following relaxation, from 57.7±18.2N to 41.9±8.8N for the non-pretensioned and pretensioned FITBs, respectively.



DISCUSSION

Under these study parameters, pretensioning of ATs and FITBs appeared to have no obvious mechanical advantage. Since alteration of collagen structure has been shown to occur at much higher levels of strain than used by these surgeons, it may be worth investigating the level of strain during pretensioning that is effective at improving the immediate postoperative properties.

SIGNIFICANCE

Since the stress relaxation test was designed to simulate the behavior of the graft after implantation, pretensioning at the low strain levels used in this study is of no apparent mechanical advantage immediately after implantation, thereby questioning the utility of the practice with the parameters applied in this study.

REFERENCES

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