Tensioning a Soft Tissue ACL Graft

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The method of tensioning a soft tissue ACL graft is controversial, because surgeons do not agree on how much tension to apply, whether the structural properties of the fixation method should be considered, and whether or not to use a tensioning device. The goal of a tensioning method is clear, which is to restore anterior stability to the knee.

For a tensioning method to be effective the initial tension should be transferred and maintained in the intraarticular portion of the graft. Our recent study of four fixation devices showed that tensile force applied to a soft tissue ACL graft is not transferred intraarticularly and is not maintained during graft fixation. Friction in the tibial tunnel causes a loss in tension. The insertion of the tibial fixation device changes the intraarticular tension, and the direction and magnitude of the change in tension is unpredictable. Slippage of the graft at the site of fixation during cyclic loading causes an additional loss in tension. The amount of tension loss after inserting and cycling the knee is sufficient to increase anterior laxity (Figure 1) {Grover, In Press #168}.

One technique that compensates for the inevitable loss in graft tension on anterior stability with a soft tissue ACL graft is the use of a high-stiffness graft construct {Karchin, 2004 #167}. The formation of a high-stiffness soft tissue ACL graft construct requires high-stiffness fixation devices. High-stiffness fixation devices are placed distal or at the end of the tunnels in cortical bone that has 30 times the strength of cancellous bone

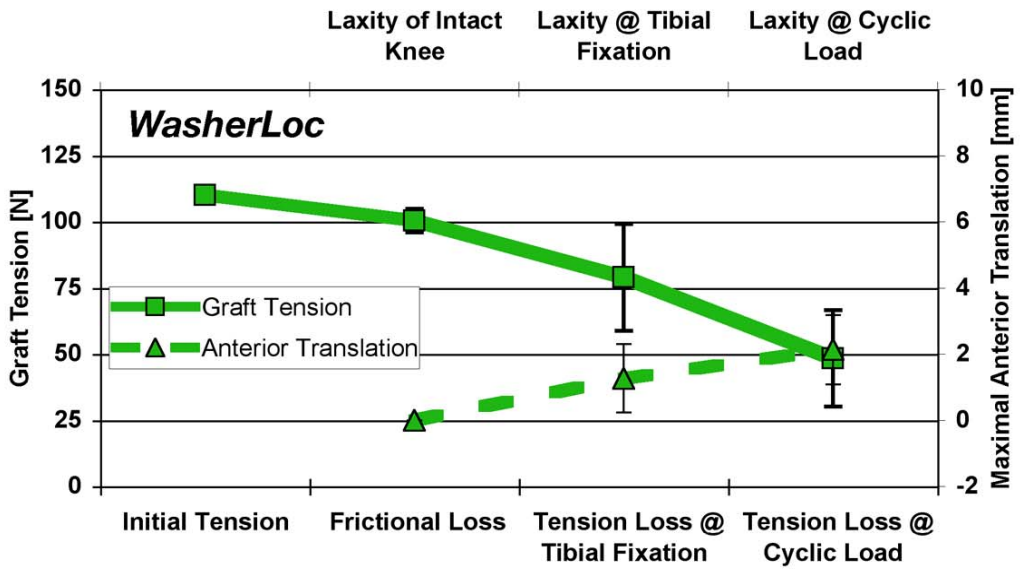
{Coleridge, 2004 #178; To, 1999 #173; Magen, 1999 #176}. Because the stiffness of the construct is determined by the stiffness of the fixation devices, a graft fixed with high-stiffness fixation devices is still stiffer than joint line fixation with interference screws even though the graft is a few centimeters longer {Kousa, 2003 #174; Magen, 1999 #176; To, 1999 #173}. The initial tension required to restore anterior stability for a high-stiffness graft construct is more than three times less than that for a low-stiffness construct (Figure 2). Because a high-stiffness graft construct requires less initial tension than a low-stiffness graft construct, the tension pattern in a high-stiffness graft construct better matches the pattern in the intact anterior cruciate ligament {Karchin, 2004 #167}.

Some surgeons prefer to use a tensioning device attached to the tibia because the amount of tension can be dialed-in and the need for an assistant is eliminated. Others contend that the joint reaction forces produced by the tensioning device improve anterior knee stability. We studied the effect of the three joint reaction forces and showed that the anterior stability was the same whether the graft was tensioned with a device attached to the tibia that produced joint reaction forces or tensioned by hand without a joint reaction force. The most likely explanation that the joint reaction forces do not improve anterior stability is that the compressive force negates the displacement effect of the posterior force, a finding confirmed by many other studies {Thompson, 2004 #172}.

In summary, we have learned that the initial tension is lost, the slippage and stiffness of the fixation determines the tension needed to stabilize the knee, and that the use of a tensioning device does not affect anterior stability. We now try to maintain of stability after tensioning and cylic loading of the knee by using fixation methods that resist lengthening at the site of fixation and provide high-stiffness. We pay close attention to

the technique for inserting the tibial fixation device as this step induces the greatest change and variability in the intraarticular tension. We are equally comfortable tensioning the graft by hand or with a tensioning device attached to the tibia since the joint reaction forces do not affect anterior stability.

FIGURE 1


Laxity of Intact Knee
Laxity @ Tibial Fixation
Laxity @ Cyclic Load
WasherLoc
Graft Tension [N]
Maximal Anterior Translation [mm]
150
125
100
75
50
25
0
10
8
6
4
2
0
-2
Graft Tension
Anterior Translation
Initial Tension
Frictional Loss
Tension Loss @ Tibial Fixation
Tension Loss @ Cyclic Load

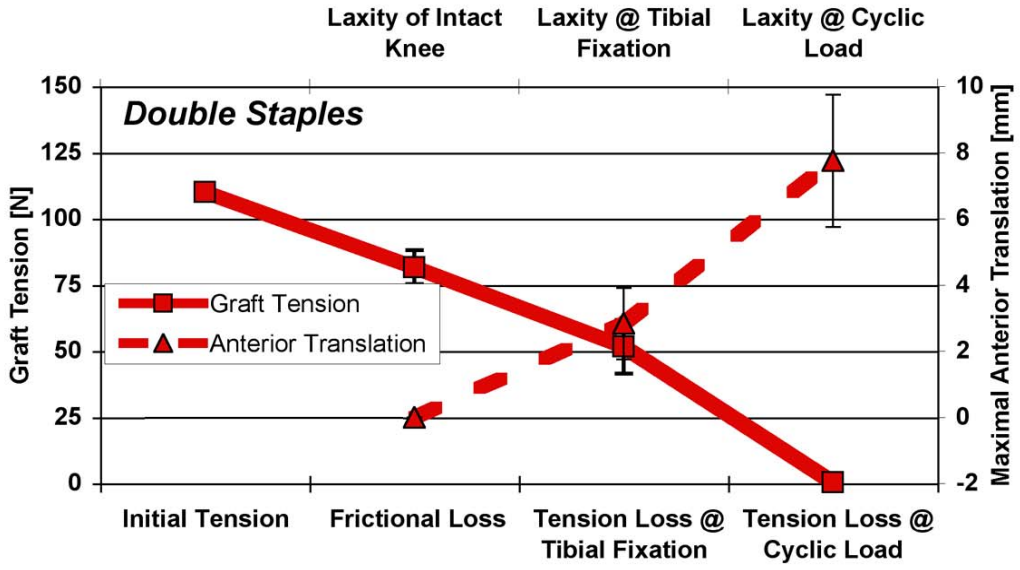
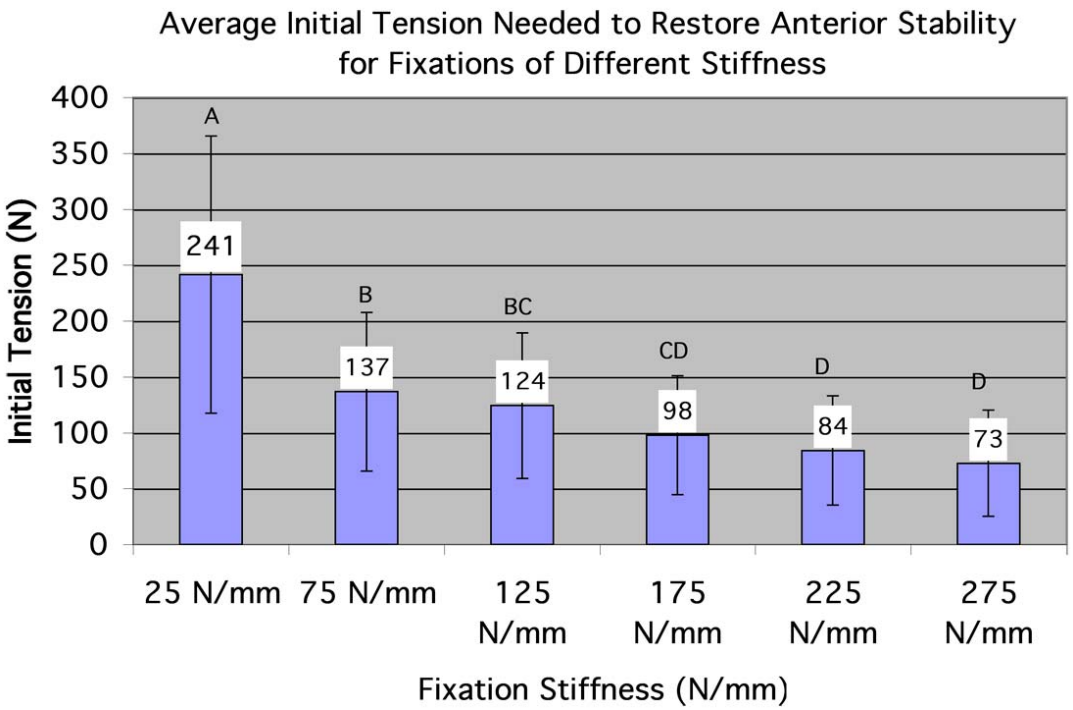

Laxity of Intact Knee
Laxity @ Tibial Fixation
Laxity @ Cyclic Load
Double Staples
Graft Tension [N]
Maximal Anterior Translation [mm]
150
125
100
75
50
25
0
10
8
6
4
2
0
-2
Graft Tension
Anterior Translation
Initial Tension
Frictional Loss
Tension Loss @ Tibial Fixation
Tension Loss @ Cyclic Load

FIGURE 2


Average Initial Tension Needed to Restore Anterior Stability
for Fixations of Different Stiffness
Initial Tension (N)
400
350
300
250
200
150
100
50
0
A
241
B
137
BC
124
CD
98
D
84
D
73
25 N/mm
75 N/mm
125 N/mm
175 N/mm
225 N/mm
275 N/mm
Fixation Stiffness (N/mm)

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