A Bledsoe Brace White Paper

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Dynamic Bracing for ACLD and ACLR Knees

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ACL deficient and reconstructed knees share common problems that may not be recognized by many medical professionals.

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Static bracing, muscle strengthening, and other forms of training cannot completely eliminate the symptoms of ACL deficiency

Dynamic Knee Bracing

Dynamic braces use quadriceps power to push the tibia posterior with increasing force as the knee extends to stop anterior tibial translation before foot strike.

Benefits of Dynamic braces

Dynamic braces have several benefits:

1. *Eliminate ACLD Symptoms*
2. *Limit Further Damage*
3. *Protect ACL Reconstructions*

Summary

The benefits can be quickly proven by actual brace use on symptomatic knees.

Introduction

ACL deficient knees and ACL reconstructed knees both share common problems that many medical professionals may not fully realize. The quadriceps contraction forces that cause symptoms in an ACLD patient are still at work against the ligament graft in an ACLR patient. While the reconstructed ligament can prevent much of the motion that causes symptoms of ACL deficiency, unfortunately it does not reduce the forces which lead to graft stretching and failure. Statistics for graft failure in younger patients have been reported from 1% to over 27% [1] with reported laxity in up to 38% of allograft reconstructions.[2] If the failure statistics are further restricted to only those athletes that continue playing high level sports following reconstruction, the failure and laxity rates are alarming. While older bracing studies have demonstrated reductions in anterior tibial translation from 28.8% to 39.1% without stabilizing muscle contractions, and 69.8% to 84.9% with contractions by using functional braces, the data was collected at 30° of knee flexion where the hamstrings can usually control anterior tibial translation.[3] The symptoms of ACLD knees usually occur in a more extended position than in normal knees[4].

Problems of ACLD & ACLR Knees

The quadriceps muscle places considerable strain on the ACL from 45° flexion to full extension according to Renstrom[5], who further stated, *"the hamstrings are not capable of masking the potentially harmful quadriceps contraction on freshly repaired or reconstructed ACLs unless the knee flexion angle exceeds 30°".* [5] Hirokawa showed that translation in ACLD knees can occur at flexion angles of more than 60°, but as hamstrings muscles were co-contracted, tibial translation was reduced in all but the last 15° of extension.[6] Hamstrings co-contraction was ineffective in this range.

> *…as hamstrings muscles were co-contracted, tibial translation was reduced in all but the last 15° of extension.[6]*

In recent years, the presence of a primary ligamento-muscular reflex between the ACL and the hamstrings muscle has been greatly elucidated by researchers such as Solomonow and Sjolander.[7,8,9] Electrical stimulation of the ACL produces a primary reflex in the hamstrings muscles.[10,11] However, the hamstrings latency is twice as slow in ACLD knees as in normal knees.[12] In rapid sport maneuvers, this timing difference can produce symptoms in most ACL deficient knees. The primary reflex arc does not appear to return in ACL reconstructed knees.[13]

There are four activities that ACLD patients have difficulty performing. These are stopping, running downhill, landing from a jump, and lateral maneuvers. There is a common element shared by all four actions. They involve open kinetic chain extension of an ACLD knee in which the tibia translates anteriorly prior to foot strike. Andriacchi[14] (using a multi-camera motion analysis system) and, later independently, Jackson[15] (using his unique ISLD - *Instrumented Spatial Linkage Device*), showed in ACLD knees that the tibia translates anteriorly during extension in the swing phase and is subluxed at foot strike (*fig.1 from Jackson et al*[16]).

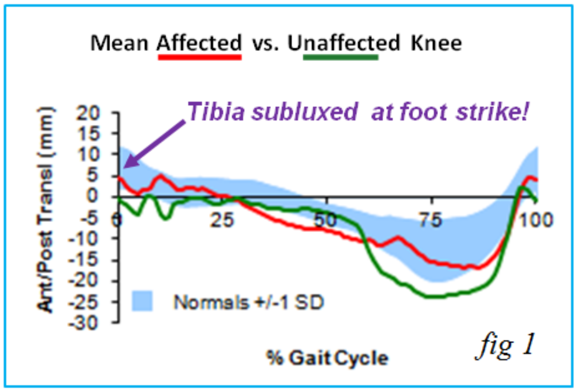

fig 1

According to Solomonow[7], *"The lesson we learned so far tells us that in order to maintain knee stability, weighted posteriorly directed force has to be applied to the tibia in the appropriate range of motion… In order to allow as close a function to normal as possible, any external device, e.g. orthosis, needs to supply such forces."*

Previous Options

Many different strategies have been tried to allow ACLD knees to return to sports play without symptoms. Static shear force bracing is one option in which strap tension is adjusted to create a shear force across the knee pushing the tibia posterior and the femur anterior. On many patients it appears to work to varying degrees. The limitation to static preloading is blood circulation, comfort, and soft tissue deflection. Unfortunately, the amount of force that appears to be required to control the tibia is about 3 times higher than the force that will block circulation.

Muscle strengthening and training to control ACLD knees has been tried by numerous researchers with varying degrees of success.[7,17,18,19,20,21] Hamstrings strength alone will not completely solve the problem, which involves a complex series of timing phenomena. The hamstrings reaction time in ACLD knees is too slow for rapid sport maneuvers.[22,23] Braces can decrease hamstrings latency (earlier muscle activation), thus improving symptoms.[24] A point in favor of muscle training is that it improves the ability to detect motion thus increasing joint position sense, an important part of proprioception.[25] Electrical muscle stimulation used during early rehabilitation of ACLR knees is effective in maintaining muscle size and strength, and in speeding the recovery time.[26]

Dynamic Knee Bracing

Dynamic knee braces use the power of the muscles that cause tibial translation as a source of power to work against this pathological movement. In the case of Dynamic ACL knee braces, some of the quadriceps extensor force is used to provide a progressively increasing force to push the tibia posterior relative to the femur as the knee moves into terminal extension. Force is reduced as the knee flexes back into the ready position. As the knee extends to less than 30° flexion, the force rises more quickly. The resulting force is sufficient to prevent the tibia from subluxing prior to foot strike.[7] As the knee joint is compressed in the proper position, it gains much more stability.[27] This normal tibial position enhances joint position sense and maintains a more normal knee flexion angle.[4] The rapid rise in strap force is often enough to elicit a tonic reflex co-contraction in the hamstrings which further stabilizes the knee and decreases hamstrings latency.[24] An added benefit of using dynamic braces after several days is the muscle re-learning that occurs providing "spontaneous hamstrings coactivation" that is elevated to prevent subluxation even if the brace is removed.[7]

Benefits of Dynamic Braces

There are three key benefits resulting from the use of dynamic knee braces as opposed to passive or static type braces. The biggest benefit is the reduction in or elimination of ACLD symptoms.

1. *Eliminating ACLD Symptoms*

Preventing tibial translation before foot strike is the key to stopping the remaining elements in the chain of events that lead to symptoms. Without tibial translation, there is no subsequent pivot shift or joint reduction. This stops the giving way episodes, quadriceps inhibition, and other symptoms.

In a 1995 study by Acierno et al[28], it was shown that ACL deficient patients using dynamic braces could generate maximal voluntary isokinetic extension effort throughout the full range of motion with significantly increased quadriceps activation and without any knee subluxation. One of the paper's authors, Solomonow, later commented that "A noticeable decrease in hamstrings co-activation was also noted, as it was not required".[7]

> *ACL deficient patients (using dynamic braces) could generate maximal voluntary isokinetic extension effort throughout the full range of motion with significantly increased quadriceps activation and without any knee subluxation.*[28]

2. *Limiting Further Damage*

There have been extensive articles published on the damage to the menisci and articular cartilage after ACL injury.[14] The existing literature seems to share a consensus of opinion that limiting tibial translation is the most important element to successfully preventing further damage to articular cartilage and the menisci. Since tibial translation is effectively controlled using dynamic ACL braces it is reasonable to assume that this will reduce or limit further damage to these structures.[28] One of the key uses of such braces is on individuals who cannot undergo reconstruction such as adolescents where potential risk to growth plates exists if an ACL reconstruction is performed too early. Dynamic bracing is also of great use in preventing further injury to non-surgically treated adults that can perform daily activities without symptoms, but occasional weekend sports produces some symptoms which are easily handled with a Dynamic brace. ACLD patients are not the only ones that can benefit from such a brace. One of the most important but least understood uses is for ACL reconstructed patients.

3. *Protecting ACL Reconstructions*

When ACL reconstructed patients perform the same four maneuvers (involving open kinetic chain extension) that cause symptoms in ACLD knees, a high degree of stress is placed on the reconstructed ligament graft. One of the functions of the original ACL is a neuro-sensory role that not only elicits a primary hamstrings reflex to protect the ACL, but also inhibits the quadriceps from applying too much force that might damage the ACL under certain circumstances.[9, 10] Both the primary hamstrings protective reflex, and the quadriceps inhibition reflex are absent or reduced in ACL reconstructed knees. Subjecting the knee ligaments to even mild cyclic loading can cause “ligament creep”, laxity, and some neuromuscular disorder.[29,30] This may be why we see progressive stretching and failure in such a high percentage of ligament grafts in the 2 to 5 year period. Dynamic braces can apply a force which reduces the strain on the reconstructed ligament helping to protect it from subsequent stretching. [7, 28]

Summary

Bracing has been shown to significantly reduce the risk and incidence of reinjury to ACL injured athletes in certain sports.[31] Dynamic braces add an additional dimension to this protection. These braces are an effective tool to eliminate symptoms of ACL deficiency and to help protect ACL reconstructed knees. While extensive research articles support this as an effective alternative for patients, it can also be demonstrated very effectively on symptomatic ACLD knees and on ACLR knees that might still have residual problems such as quadriceps inhibition, poor proprioception, or a sensation of instability. The difference in performance level and the decrease of or the lack of symptoms clearly demonstrates the principles outlined in the research, and the benefit to patients.

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