SOFT TISSUE LIMITS CONTROL!

The greatest factor that limits control of the leg by any external device is soft tissue deflection. The skin, fatty tissue, flaccid muscles, or muscles which lack proper tone, place a limit on the control which can be provided by any external device. Soft tissue deflection occurs in three ways. The first soft tissue deflection is rotation. As an example, perform an isometric contraction of the quadriceps and hamstring muscles with your leg at about 35° of flexion. Then firmly grasp the skin on each side of the knee with your hands and roll the tissues around the leg. Next roll the tissue around with the muscles flaccid. This should demonstrate that considerable rotation is possible. Repeat the same maneuver at the middle of the thigh. It is virtually impossible for an external device to control all of this rolling soft tissue.

The second soft tissue deflection is translation. Repeat the previous example by grasping the middle of the thigh or calf with both hands and move the tissues proximal and distal on the leg. Even if a brace were bonded to the skin with skin adhesive, translation would still occur. This translation is partially caused by the thickening and thinning of moving muscles. As an example, place your hand into the fold behind the knee from the medial side. Permit your hand to move with the skin over the hamstring muscles as you flex and extend your leg. How much translation exists at this point? This forced movement is the very reason why the two posterior straps that are closest to the knee on a functional brace must pivot freely.

The final soft tissue deflection is compression. Press the end of your thumb into the middle of your quadriceps muscles and see how much indentation occurs. Now, using the same compressive force, press your entire hand into the same muscle. There is much less indentation. This demonstrates that force per unit area is the important factor. Therefore maximizing surface contact area is important. Maximizing length or leverage is also important. These are the two factors that provide the greatest enhancement to control.

Each end (thigh and calf) of every hinged brace is a three-point lever system. These two levers share a common third point at the hinge that does not contact the leg. The remaining two points on each arm of the brace where the brace straps attach to the leg form a four-point force system. Every brace with a hinge is a four point brace. Maximizing the length or leverage is important to brace control. However, the market continues to ask for shorter and lighter braces. In fact, braces need to be longer to gain better control. This is particularly true on those portions of the lever arms that compress into a lot of soft tissue. The point on the leg where the least compression occurs, is the anterior tibia. There is very little soft tissue present to deflect. Therefore, the overwhelming majority of brace manufacturers have chosen to use a pre-tibial shell on their functional braces as a center fixation point coupled with some type of suspension on the slightly smaller circumference of the gastrocnemius and soleus muscle just below the knee.

As long as the anterior shell of a brace is held firmly in contact with the front of the tibia, it will move as the tibia moves. For instance, if the tibia subluxes anteriorly (as with a missing ACL), it will carry the tibial shell of the brace with it. This leaves only the posterior distal thigh strap and the proximal anterior shell of the brace to indent into the skin, fat, and muscles in an attempt to limit the subluxation motion. Most tibial subluxation occurs as the leg is rapidly extended in preparation for foot strike in maneuvers such as stopping, running downhill, landing from a jump, or moving laterally. These are open kinetic chain maneuvers that involve quadriceps contracture before foot strike. Due to the slow hamstring reflex arc after loss of the mechano-receptors that were present in the original ACL, the hamstring muscles are flaccid and slow to react. This permits the posterior distal thigh strap of the brace to compress easily into the flaccid tissue resulting in very little resistance to anterior subluxation. This previous example demonstrates why most braces offer little resistance to anterior tibial subluxation.

Simply tightening the straps of a brace does not eliminate soft tissue compression, translation, and rotation. Strap tension is limited by patient comfort and blood circulation. Obviously, those patients with more soft tissue will experience less control from any external device. It is easy to brace the patient that is 6 ft. tall and weighs 95 pounds. It is almost impossible to brace the patient that is 5 ft. tall and 250 pounds. It is difficult to control the position of the bones and joints through the Jello-like soft tissues of the leg. This places an upper limit on the required strength and stiffness of a functional brace. Once this limit is reached no additional control is gained by making the brace stronger or stiffer. Even a one inch thick solid stainless steel cylinder cast would run into these same soft tissue limits.

As muscles contract the stiffness increases. This permits braces to control the leg more easily. However, nothing can be done about the amount or thickness of the fatty tissue. It does not change its resistance to compression with muscle contraction. Therefore, on excessively overweight patients it may not be possible to control their legs with any external device. It must be remembered that muscles contract at different rates on different parts of the leg according to the activity performed. Certain brace straps may be over muscle areas that are not contracted during a particular maneuver resulting in excessive soft tissue deflection and lack of control. During extension, for example, the quadriceps muscles may be completely contracted while the hamstring muscles are totally flaccid.

In summary, braces are limited by the amount of soft tissue that is present on the leg. The required brace strength and stiffness reaches an upper limit based upon the amount of soft tissue. Adding brace strength or stiffness adds weight. The changing shape of the leg during movement forces the brace to have some flexibility. Some types of movements may be virtually impossible to control with any external device unless special dynamic or active mechanisms are added to the brace that compensate for the soft tissue deflection. Bledsoe Braces Systems manufactures special dynamic braces for certain pathological conditions for this very reason. It is necessary to pre-compress all of the soft tissue before a pathological movement occurs. Soft tissue compression requires force. The force can be obtained from the muscles during leg movement. If it is mechanically necessary to contain certain pathological movements, dynamic braces or smart braces with muscle stimulators may be necessary.

There is a difference!

The difference is in the details!