Case Report

Treatment of a Knee Contracture Using a Knee Orthosis Incorporating Stress-Relaxation Techniques

The subject of this case report was a 67-year-old Caucasian woman who had undergone total knee arthroplasty of the right knee. Postoperative physical therapy and a new orthosis that utilizes principles of stress relaxation (constant displacement) and static progressive stretching were used to reestablish range of motion. The total treatment time (cumulative orthosis wear time) was 32.5 hours over a period of 29 days, and the patient obtained a 17-degree increase in active range of motion. Six months later, there was no measurable loss in range of motion. The results of this treatment may be beneficial for some patients. Researchers and clinicians need to conduct studies to further evaluate this approach to knee contracture management. [Jansen CM, Windau JE, Bonutti PM, Brillhart MV. Treatment of a knee contracture using a knee orthosis incorporating stress-relaxation techniques. *Phys Ther.* 1996;76:182–186.]

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Although bony structures (such as osteophytes) can inhibit motion, a majority of all contractures are attributed to soft tissues such as ligaments, joint capsules, tendons, skin, fasciae, and muscles.[1] Soft tissues behave in a viscoelastic manner.[1–7] Tissue responds to mechanical loads and displacements in both an elastic (time independent) and a viscoelastic (time dependent) fashion. Viscoelastic materials respond differently according to deformation rates (rate of load application) and loading conditions.[8] The most common types of loading used to reduce contractures are those that utilize the properties of creep (constant load, variable displacement[6]) and stress relaxation (constant displacement, variable load[6]).

Creep-based therapies apply a constant load over a prolonged period of time. Examples of creep-based therapies include what is called "dynamic splinting"[9,10] (using devices that apply a constant load to a limb segment on either side of a joint with a contraction for 8–12 hours) and traction. Stress-relaxation techniques apply a constant displacement and allow the stress to decrease as a function of time, presumably as the tissue relaxes. Use of serial casting[11] (using sequentially applied casts), use of turnbuckles[12] (adjustable mechanical devices that increase range of motion [ROM] by altering the position of a contracted joint in incremental steps), and some forms of manual therapy[13] are based on stress relaxation. Progressive stretching techniques, where joints are maintained in positions, are based on stress-relaxation concepts because there are incremental increases in the stretch applied to soft tissues. Physical therapy based on a progressive stretching protocol is one example of a manual approach for restoration of ROM.

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Patients, insurance carriers, employers, and government agencies are asking for the restoration of ROM in a time- and cost-effective manner. When large serial casts are used for contracture rehabilitation, there may be financial consequences if the patient is unable to work.

An approach was developed by Joint Active Systems (JAS)* in 1992 that incorporates the use of an orthosis based on stress relaxation and that follows a progressive stretch-based protocol to produce permanent gains in ROM. The orthosis

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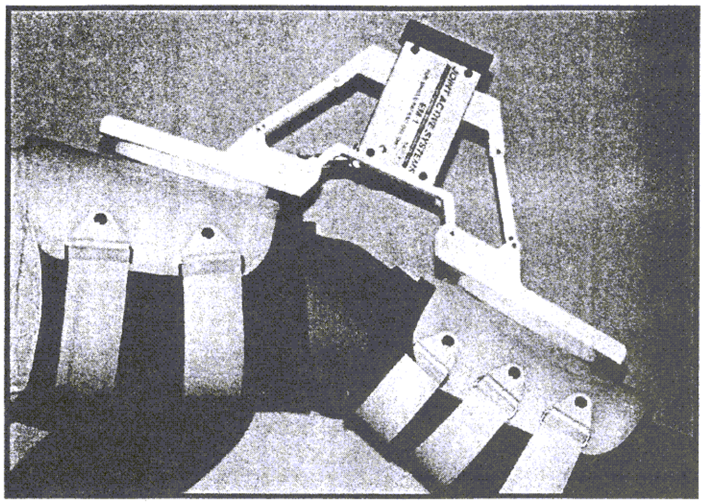

Figure 1.
Orthosis used by patient in this case report.

allows the patient to progressively stretch structures around the knee during 30-minute sessions.

A similar orthosis was used for restoration of ROM in 20 patients with chronic elbow flexion contractures.[14] In that study, a 31-degree average improvement was noted.[14] The total treatment time (or cumulative wear time of the orthosis) was lower (67 hours for the JAS elbow orthosis[14]) than that needed for other approaches to elbow contracture rehabilitation (528 hours for serial casting,[11] 1,110 hours for dynamic splinting,[9,10] and 2,240 hours for turnbuckles[12]).

Because the JAS orthosis appeared to be effective in restoring elbow ROM and because the same principles of progressive stretch and orthosis design are incorporated in the JAS knee orthosis, we believed that similar results could be observed in treating knee contracture. The purpose of this case report is to describe a treatment using the JAS knee orthosis.

Case History

The patient was a 67-year-old Caucasian woman with osteoarthritis in the right knee. A conservative nonsurgical treatment path was followed for a duration of 2 months that included prescribed anti-inflammatory medication followed by injections of steroids. The patient's pain persisted throughout this 2-month period, and she ultimately underwent total knee arthroplasty.†

The patient intermittently used a continuous passive motion device for 3 weeks postoperatively in an attempt to reestablish motion. The device was 94 cm (37 in) in overall length and was used for 2 hours three times daily. During this time, the patient also performed exercises with resistance that included quadriceps femoris muscle sets, hamstring muscle curls, short-arc quadriceps femoris muscle contractions, and straight leg raises. After 3 weeks, the patient's active ROM was measured at 110 degrees of flexion and she could not fully extend her knee. Goniometric techniques were used to obtain all ROM measurements. Knee extension was observed to be lacking 25 degrees of extension (25° from 0° or full extension) when the patient was positioned prone and her hip was in 0 degrees of abduction, adduction, flexion, extension, and rotation. Use of the continuous passive motion device was discontinued at this time.

The patient was referred to outpatient physical therapy to regain ROM. The initial physical therapy evaluation included assessment of active and passive ROM, manual muscle testing, and examination for edema. Flexion was measured at 110 degrees for active ROM and 126 degrees for passive ROM, and extension was observed to be lacking 25 degrees for active ROM and 10 degrees for passive ROM. The manual muscle test score was 5/5 for the hamstring, quadriceps femoris, and hip adductor muscles,[15,16] and approximately 2.5 cm (1 in) of swelling was observed in the lateral and medial aspects of the knee between the femoral condyle and the condyle of the tibia during the examination for edema. The initial physical therapy examination also revealed a 5-degree lack of extension in the contralateral knee. Flexion of the contralateral knee was measured at 120 degrees for both active and passive ROM. Physical therapy that included the exercises already being performed along with sessions on a stationary bicycle was prescribed by the physical therapist. Additionally, twice weekly the patient received passive stretching therapy in flexion and extension, administered by a physical therapist for 20 to 30 minutes per session, with mobilization in both directions. Mobilization consisted of a physical therapist manually applying passive traction and gliding movements to attempt to allow normal glide mechanics to occur. After 1 week of this program, knee ROM was measured at 115 degrees of flexion, but the patient still lacked 25 degrees of extension. Therapy was continued for an additional 7 weeks, at which point the patient's progress plateaued at 130 degrees of flexion with a 2-degree loss of extension. At this time, the patient was satisfied with the results and discharged from physical therapy.

Over the next 3 months, the patient progressively lost ROM. Measurements taken 3 months after discharge from physical therapy showed that a 5-degree loss of flexion (125° of flexion) and a 21-degree loss of extension had occurred since discharge. These losses of ROM were attributed to the patient's lack of activity. The patient was unable to climb stairs, had difficulty walking, could not get in and out of bed without assistance, and had trouble with weight bearing on the right leg after sitting or lying down.

At this point (3 months after discharge), use of a knee orthosis designed to provide progressive stretch and stress relaxation was initiated by the patient's physical therapist in

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an attempt to restore ROM in a lasting fashion, with a strong emphasis on recovering lost knee extension.

Materials and Methods

The orthosis used by this patient is shown in Figure 1. The orthosis is designed to facilitate permanent (plastic) deformation of soft tissue through incremental increases in displacement. By controlling displacement (not load), stress relaxation should take place. A progressive stretching protocol was followed by creating an incremental series of stress-relaxation states, or stretches. Thus, the principles on which this orthosis is based are similar to those used in manual stretching therapy.

Cuffs designed to eliminate tissue entrapment, maximize contact area, and stabilize tissue were used to attach the device to the patient's lower extremity. The cuffs are allowed to travel in a controlled manner (cuff motion is directly related to the angular position of the orthosis) along the axes of the femur and tibia. The orthosis also is designed to displace the fulcrum of the applied force away from the center of rotation of the joint. Shifting the fulcrum away from the joint line reduces compressive bending stresses.

The following protocol[14] was adhered to for this patient. The orthosis was adjusted to a position matching the angle of the contracture and applied to the patient. The knee was then positioned in the orthosis, with the center of the device body placed over the patella, and the straps were fastened. Orthosis placement over the center of the patella is intended to ensure that the device properly follows the anatomical mechanical motion of the knee joint. Neoprene wraps were used to assist with containment of tissue in the cuff area and to ensure that maximal cuff/skin contact was maintained throughout the therapy sessions.

The patient increased extension by rotating the ratchet on the orthosis until resistance was met. The resistance point is similar to the "RI" point (or point at which first resistance is met) used in manual therapy.[13] The patient maintained the position for approximately 5 minutes to allow for tissue stress relaxation to occur. The duration of 5 minutes was selected based on the use of this approach to rehabilitate patients with elbow contractures.[14] After 5 minutes had elapsed, the patient then increased the joint position further into extension until new resistance was met. This cycle was repeated six times during each 30-minute treatment session.

The settings on the orthosis are patient directed; thus, the patient and not the device determines the maximum stretch imparted during each step of therapy. The patient is actively integrated into the rehabilitation program. The use of stress-relaxation conditions also makes it possible to incrementally advance the joint in 5-minute stretch-and-hold steps, because relaxation of the tissue is allowed to occur.

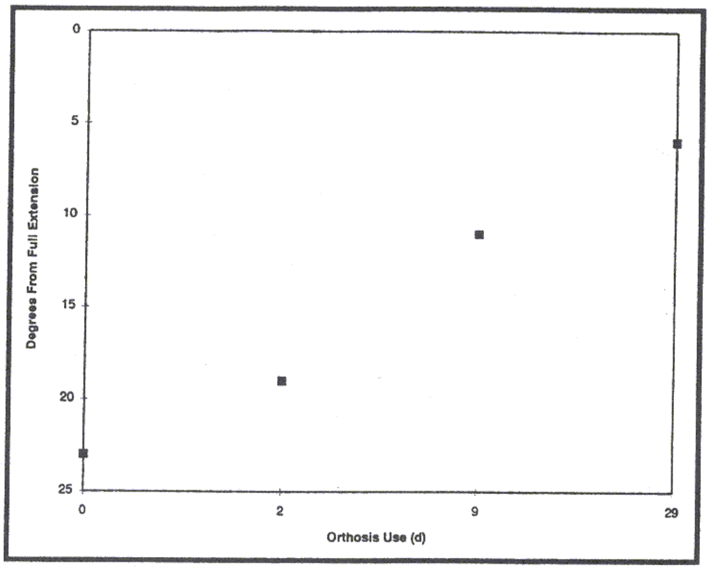

Figure 2.
Graph of knee extension as a function of time during JAS orthosis usage.

Therapy sessions were conducted at home and twice weekly at the therapy center. Patient progress was monitored biweekly by three independent athletic trainers and two physical therapists for compliance and correct use of the device. The patient used the orthosis for 29 days. One 30-minute session was completed on each of the first 7 days. The patient used the orthosis for two sessions on each of the next 7 days. During the last 15 days, the patient used the device three times per day.

Figure 2 shows a plot of the lack of extension versus time. After 29 days (4.1 weeks) of orthosis use, the patient gained 17 degrees of extension. This gain resulted in a final 6-degree lack of extension, which was similar to the motion of the contralateral knee. At this point, the patient was able to climb stairs, had no difficulty when walking or getting in and out of bed, and was able to bear weight on the right leg immediately after sitting or lying down. Because the patient had achieved symmetric extension in both knees, physical therapy was discontinued. Throughout therapy, there were no reports of pain or discomfort that would cause the patient to discontinue orthosis use.

The patient achieved gains in knee extension after a total treatment time of 32.5 hours. The total treatment time is the cumulative wear time of the orthosis, which is a measure of the amount of time that the patient is limited in activities due to therapy.

There were no reports of complications, nor were there any reports of loss of motion following completion of therapy. Follow-up was once per month for the 6 months after device usage was discontinued. Although many researchers believe that a long-term stretch[9,10] is necessary to reestablish ROM, it appears that for this patient and in results reported elsewhere,[14] 30-minute therapy sessions can be effective in increasing ROM.

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