

The Current Evidence for Static Progressive Orthoses for the Upper Extremity

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Static progressive orthoses is a type of mobilization orthosis that therapists use to help their clients regain passive motion in stiff joints and tissues.¹ This type of orthosis incorporates non-elastic components to apply force to the stiff joint or tissue, holding it at end-range position to improve passive motion. The client is instructed to increase the force as the joint or tissue accommodates a new end-range position over time. In this manner, static progressive orthoses permits progressive changes in tissue position.^{1,2}

Reaching Plastic Deformation of Tissue

According to Ulrich et al,³ connective tissue is capable of being stretched due to its viscoelastic qualities. While under tension, it can respond by reaching an either elastic or plastic deformation state. Elastic deformation means that the tissue reverts back to its original length when the force on it is removed, and this is undesirable. Plastic deformation means the tissue will

maintain its new length even when the force is removed, leading to a structural change in the tissue itself.

Dynamic and static progressive orthoses have been used to apply force to tight or shortened tissue to accelerate tissue remodeling. There are two types of loading conditions with the application of mobilizing orthoses, creep based and stress relaxation. In creep-based loading, the force applied is a constant force and the displacement of the limb varies. Creep-based loading is delivered via dynamic orthoses, however, there are disadvantages to creep-based loading. These orthoses may need to be worn for 6–12 hours daily, treatment may be painful and the joint may be damaged by prolonged compression.^{3,4}

In stress relaxation, the displacement is constant and the applied force varies. This is the principle of static progressive orthoses, in which patients are instructed to constantly adjust and readjust the tension on their stiff joints. The tissue reaches the plastic

deformation state more quickly and the effects will last longer.^{3,4}

Static Progressive Orthoses

There are a limited number of studies on the use of static progressive orthoses with a small number of clients enrolled. This review examines the current levels of evidence supporting the use of static progressive orthoses for clients with limitations in range of motion (ROM) of the upper extremity following surgery or trauma (orthopedic pathologies). It also offers relevant information on the types of diagnoses to be treated, wearing schedules, the outcomes affected and the recommended duration of orthotic use.

Key Features¹⁻⁴

1. Non-elastic component places tension on stiff joint/tissue to hold it at its maximum tolerable length.
2. Adjustments to the tension on each joint can be made by the client.

3. The orthotic design maintains the shortened tissue at its maximal tolerable length and does not stress beyond it. It is very important not to exceed the maximal tolerable stress level, which could lead to tissue failure.
4. The longer the tissue remains at its maximum tolerable length, the more it increases in length. This concept is known as total end range time (TERT).^{1,5}
5. Success can be measured by small gains of perhaps 5–10 degrees per week.¹

The Benefits

1. Improved range of motion without pain; high tolerance for orthotic use because the patient can control the force of the tension; higher compliance and higher patient satisfaction result.
2. The patient is able to adjust the tension force gradually, as this type of orthotic intervention takes advantage of small incremental changes in tissue length.
3. The optimum orthotic design allows for small changes in joint motion without remolding of the orthosis each time gains in range of motion are accomplished.

A literature search of the current evidence supporting static progressive orthoses for treatment of stiff upper extremity joints was performed to identify information regarding common diagnoses of patients treated with

this type of orthotic intervention, outcomes achieved, wearing schedules and duration of orthotic use.

It is suggested that we base our therapeutic interventions on evidence-based practice, which requires that we not only seek out the current highest level of research to support our clinical decisions, but that we also incorporate both our expertise and our client's values and judgements into the process. When reading the evidence presented here and doing further research by reviewing the specific studies cited, it is important that you consider how your clients match the subjects detailed in each study, and whether they will agree to the suggested schedule of orthotic wear described.

Elbow Range of Motion — A total of 11 studies examine the role of static progressive orthoses for treatment of elbow stiffness.^{3,4,6-14} One of the more recently published articles is a systematic review by Veltman et al⁶ and includes eight elbow studies (one randomized clinical trial and seven retrospective studies). Six of these elbow studies incorporated the use of a static progressive orthosis for the treatment of elbow stiffness. Two studies incorporated the use of a dynamic orthoses. Both types of orthoses were commercially available models. While the recommended wearing schedule for the dynamic orthoses was eight hours a day for two months, most patients used their dynamic orthoses much less than prescribed. On the other hand, patients receiving a static progressive orthosis were

instructed to wear it either 30 minutes four times a day (four studies) or 15–20 hours a day (two studies). Despite the difference in wearing schedules in the static progressive treatment protocols, an equal amount of progress was demonstrated with shorter time frames in the four studies.⁶ As clinicians, we have to ask ourselves, “Which instructions are your patients more likely to follow?”

Lindenhovius et al⁷ published the results of a randomized clinical trial comparing dynamic orthoses to static progressive orthoses for elbow stiffness. Thirty-five patients used a static progressive orthosis and 31 patients used a dynamic orthosis. This study also utilized commercially available orthoses. The authors examined whether the outcomes of improvements in range of motion and Disabilities of the Arm, Shoulder and Hand (DASH) scores differed whether patients used static progressive or dynamic orthoses for the treatment of elbow stiffness. Elbow ROM was measured initially, and at three, six and 12-month time frames. Patients also completed the DASH questionnaire initially, and at the 6-month and 12-month time frame. The authors found little difference in the improvements between the types of orthoses. Elbow range of motion improved on average 47 degrees in the dynamic orthosis group versus 49 degrees in the static progressive orthosis group at the final evaluation. DASH scores improved from 50 points versus 45 points (dynamic group versus static progressive group) to 28 points versus 26 points (dynamic group versus static progressive group). The authors stated the choice for one type of splint or the other could be made by patient and physician preference. In addition, they recommended that gains could continue to be made even over 6–12 months with either splinting option.⁷

Both of these studies conclude that patients with stiff elbow joints benefit from both types of orthoses, dynamic and static progressive, and can improve over longer duration of use than previously prescribed.^{6,7} Research by Veltman et al and Lindenhovius et al^{6,7} also suggest that patients continue to use these orthoses for 12 months, or until a plateau in gaining range of motion is reached.

| Static Progressive Orthoses | Four Studies | Two Studies |
|-----------------------------|---|----------------------------------|
| Protocol of wear Duration | 30 minutes, 4 times per day for 14 months | 15–20 hours per day for 5 months |

| Dynamic Orthoses | Two studies (Recommended) | (In Reality, Varied Use) |
|---------------------------|------------------------------|--|
| Protocol of wear Duration | 8 hours per day for 2 months | 1–4 times per day for 2–8 hours per session for 2 months |

Chart modified from Veltman ES et al.²⁴



Forearm Range of Motion — Research by Parent-Weiss & King¹⁵ and McGrath et al¹⁶ looked at static progressive orthoses for patients lacking forearm rotation. One study used a commercially available orthosis and the other study used a custom-made orthosis. Both groups of patients (a total of 66 from both studies) did well, gaining supination and pronation with similar wearing schedules of several hours a day for 3–4 months duration.

Wrist Range of Motion — Studies by Lucado et al¹⁷, Lucado et al¹⁸ and McGrath et al¹⁹ looked at static progressive orthoses for the wrist. A total of 80 patients were included in these three studies, and all three used commercially available orthoses with a similar wearing schedule of 30–60 minutes, three times per day. All patients gained increased wrist range of motion in both flexion and extension. The McGrath study included 47 patients who wore their orthosis for 30–60 minutes, 1–3 times a day

for an average of 10 weeks. The total arc of wrist motion increased by a mean of 35 degrees (range, 5 degrees to 100 degrees). Average gains in wrist flexion were 18 degrees (range, 1 degree to 50 degrees) and average gains in wrist extension were 17 degrees (range, 3 degrees to 50 degrees). Lucado et al¹⁷ described increased motion for patients following distal radius fractures, but also reported on improved DASH scores and improved grip strength as well. This study looked retrospectively at 19 patients using a static progressive orthosis for wrist

range of motion for an average duration of use of 75 days. Wrist extension increased on average 19 degrees and wrist flexion increased on average 12 degrees. McGrath et al¹⁹ also reported that patients had improved satisfaction scores as a result of orthotic usage.

Hand Range of Motion — Two studies examined the use of static progressive orthoses for joints in the hand. A small scale study by Beanglia et al²⁰ describes treatment of proximal interphalangeal (PIP) joint contractures in four volleyball players. Even though this was a small sample size, the authors were able to use a custom-made static progressive orthosis to achieve significant improvement in range of motion. A more recently published study by Wang et al²¹ looked at metacarpal-phalangeal (MCP) joint contractures in 31 patients. This study actually included TERT as an outcome measure and suggests that all clients keep

a journal of orthotic wear. This is a great suggestion! These two studies about finger joints are particularly relevant and important to us as hand therapists because the orthoses included were custom-made, original designs utilizing low-temperature thermoplastic materials.

Other — Two systematic reviews, rated level one evidence, also include studies using static progressive orthoses. Farmer and James²² reviewed nine studies on splinting for contracture management in their systematic review of all therapeutic interventions to treat contractures resulting from muscle weakness, spasticity and immobilization. Two studies looked specifically at static progressive orthoses. The authors noted the benefits of mobilization orthoses of both dynamic and static progressive orthoses — they can be used for longer periods of time and removed to allow for stretching of the antagonist muscles and active range of motion.

Another systematic review, authored by Michlovitz et al,²³ included 26 studies that examined different therapeutic techniques to improve range of motion. The authors cite a total of nine studies that describe orthotic intervention, including the use of static progressive orthoses. Four of the studies utilized static progressive orthoses to help increase range of motion in contractures, while the other five studies included serial casting or dynamic orthoses. The authors noted that more evidence is needed to determine the best practice of orthotic usage and type.

Types of Orthotic Designs and Treatment Protocols

Many of the studies utilize the commercially available Joint Active System (JAS) orthoses. The JAS system makes specific recommendations for the wearing schedule, so all of the studies using JAS orthoses followed a similar schedule. The recommended schedule started with one 30-minute session per day for the first week, increasing up to three times per day by the third week.^{2-4,6,7,16-19} In addition, patients were instructed to increase the tension on the affected body part every 5 minutes while

wearing the orthotic device. The general approach was 30 minutes in each direction (flexion and extension for example) three times a day.

Custom-made static progressive orthoses was fabricated for the elbow in one study, for forearm motion in one study and for the finger joints in the two aforementioned studies. Patients using the custom-made orthoses were instructed to wear for long sessions throughout the day and night. The instructions for the turnbuckle orthoses (for the elbow) were to wear it for as long as possible, even up to 15–20 hours per day.^{6,10} The orthosis could be removed for meals and for a minimum of exercise.

Outcome Measures

The researchers from all studies^{2-4,6-19} looked at patients with a wide variety of diagnoses, including elbow fractures (radial head, ulna and distal humeral fractures), wrist fractures (distal radius and ulna fractures), fracture dislocations, lacerations, tenosynovitis, sprains, crush injuries, general stiffness after surgery or trauma and joint contractures. They used an assortment of outcome measures, including active and passive range of motion, function, grip strength and patient satisfaction in reporting their results.

Suggestions for the Future

There is moderate evidence to support this orthotic intervention. Everyone can contribute here by recording range of motion measurements and functional scales prior to using these orthoses and evaluating these outcomes at client discharge. Help grow the evidence by reporting your own retrospective studies or case series from your clinic.

There are no set parameters on wearing schedules and/or duration of orthotic intervention. Have your clients keep a journal of wearing times to evaluate whether they are wearing the orthosis enough to make a difference and help determine the optimal wearing schedule.

There is a wide selection of designs for custom orthoses available. It is worth taking a

look at recent and past issues of the practice forum in the *Journal of Hand Therapy* to get inspiration and ideas for creative orthotic fabrication!

Longer wearing times with frequent adjustment of tension appears to be a commonly employed protocol. Increase expected duration of use until a plateau in gains is reached. ♦

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