

Case report

Dynamic splinting for pronation contracture following a spinal cord injury

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Abstract

Background. This report discusses the success of using multiple protocols/modalities to reduce forearm contracture in a 34-year-old, African American man who had suffered a spinal cord injury (SCI) over 2 years before this treatment. The patient's initial maximal active range of motion (AROM) in supination was -85° left and -60° right, and his initial passive range of motion (PROM) was $+12^{\circ}$ left and $+50^{\circ}$ right.

Methods. Intervention included occupational therapy five times per week and the protocols employed included manual AROM and PROM training, isometric strength training, handwriting, self-feeding and grooming training. Electrical stimulation for shoulder flexion and elbow extension, and a unique new modality, the Supination Dynasplint[®], was also used for 45 min on each arm, twice daily.

Results. After three months, the patient regained over 40° AROM of supination in each arm. This benefitted the patient's ability to use utensils for eating, improved his handwriting skills and he regained the ability to use a urinal at night while in bed.

Keywords: Contracture reduction, Dynasplint[®], electrical stimulation, forearm, passive stretching

Introduction

Over 250,000 Americans have suffered spinal cord injuries (SCIs) and the incidence rate is approximately 11,000 new cases each year.^{1–3} Spasticity and excessive neuromuscular tone in the upper extremities often impair the SCI patient's functional abilities.² This is due to complex agonist and antagonist hyperactivity, particularly in the pronator teres and/or quadratus muscles. Tone management and spasticity reduction often require multiple treatment methods for continual efficacy.^{3–5}

Contracture is common in SCI patients and a retrospective analysis of 482 SCI patients showed that over 30% of these patients suffered from contracture in at least one joint within 60 days from the injury.⁶ Dalyan *et al.*⁶ also observed that the incidence rate of contracture was twice as high when associated with spasticity and pharmaceutical treatment compared with patients without spasticity. The standard of care in treating SCI contractures often includes manual, occupational therapy for contracture reduction^{4–6} and botulinium toxin (BTX) for tone management.

Stretching is considered one of the most integral treatments in reduction of contracture^{7–14} and this often requires the greatest amount of time from the therapist. Passive stretching is commonly used for patients with excessive pronation,^{3,5,7,9,10} and a recent case reported by Susan Denham¹⁰ showed how beneficial passive stretching with functional activity training could be for a stroke patient. Denham used protocols that included three sets of 10 minutes of passive stretching (at end range) for each joint while the other hand was held neutral by a resting hand splint. After only 12 weeks her patient gained 90° passive range of motion (PROM) in supination, 50° pronation, and the patient regained independence in wheel-chair transfers, cutting meat and opening jars that were previously inhibited by tone and contracture before this treatment.

Dynamic splinting has been shown to increase the total duration of time in stretching, while freeing the therapist's time for higher therapeutic endeavors such as fine motor skills.^{3,10,11} The modality in this report uses calibrated, changeable torque in a circular frame mechanism to keep the patient's forearm at end-range for prolonged durations; this can be directly beneficial in contracture

reduction. The purpose of this report is to show the benefits of a multifaceted programme which included dynamic splinting for reduction of forearm contracture in an SCI patient.

Case report

The 34-year-old, African American man had suffered an SCI two years, eight months before treatment began. His initial functional limitations can be seen in Box 1. He presented with pronation contracture and his initial active range of motion (AROM) in supination was -85° in his left and -60° in his right forearm. Initial PROM was $+12^\circ$ left and $+50^\circ$ right. The patient gave his consent to use any information of his treatment and outcomes in this manuscript.

Intervention

The treatment included occupational therapy five times per week for three months. In these sessions the patient was treated with multiple modalities that can be seen in Box 2: manual PROM and AROM training, isometric strength training, handwriting, self-feeding and grooming training, and electrical stimulation (E-stim) to enhance shoulder flexion and elbow extension. A muscle strengthening E-stim protocol was used for 20 min, five times per week. He was also treated with alternate (left versus right) supination dynamic splinting (SPDS) 45 min, twice daily, (Supination Dynasplint[®] System, Severna Park, MD, USA).

Dynamic splinting uses a hypoallergenic cuff that allows flexion of the elbow but not beyond -30° elbow extension. The wrist cuff and hand piece are attached to the torque chamber which mimics a hand-therapist's action in end-range stretching, and also employs calibrated, dynamic tension (Figure 1). This device was used alternately on the right versus left extremity, which allowed the therapist to achieve higher level protocols such as electrical stimulation and functional training on the non-SPDS arm. Donning of the SDS was initially performed by the therapist. The patient's arm was placed into the SDS frame and then hypoallergenic straps were used to secure the patient's arm and hand in the unit. The dynamic tension was then released allowing the low load stretching to begin. After one month the staff and

Box 2 Modalities used in treatment

- Passive stretching
- Active range of motion training
- Isometric strength training
- Functional training
 - Handwriting
 - Self-feeding
 - Grooming
- Electrical stimulation
 - Shoulder flexion
 - Elbow extension
- Dynamic splinting (prolonged end-range stretching in supination)

caregivers were taught how to don and doff the equipment, so that the patient could use this modality for home therapy after completing the 12-week rehabilitation described in this report.

The SPDS was used twice a day on each forearm, in 45-min periods. This gave the patient over 90 total hours of low load, end-range stretching while enrolled in this programme. The progressive tension settings used were 1 (5.3 kg/cm) to 3 (30.7 kg/cm).

Results

After three months of this multiple modality programme the patient had the following changes: his AROM improved by 43° in his left forearm (from -85° supination to -42°) and improved 40° AROM in his right

Box 1 Initial functional limitations

- Maximal assistance required to drink from cup
- Feeding required swivel spoon and enlarged grip
- Fine motor skills limited (writing and Q-tip)
- Inability to manipulate clothing
- Inability to hold urinal



Figure 1 Supination Dynasplint[®] system

forearm (from -60° supination to neutral 0°). His PROM improved 40° in his left forearm (from $+12^\circ$ supination to neutral $+52^\circ$) and 25° in his right (from $+50^\circ$ supination to $+75^\circ$). All functional skills improved, which included the use of utensils for eating, improved handwriting skills, and he regained the ability to use a urinal at night while in bed.

Discussion

After the contracture reduction was accomplished, the unique feature of this modality is that it can also be worn nightly as adjunct therapy for continued benefits in tone management and retaining the range of motion that was achieved. This accomplishes a structured, daily home therapy as recommended by Denham¹⁰ and she recommended a resting hand splint to maintain the gains in ROM. The SPDS accomplishes both the passive stretching and the dynamic tension maintains the gained end range while worn which also has been shown to complement the effect from BTX injections.³

Progressive tension is important because as the end range changes, the tension must be adjusted to challenge a new end range. Stretching used in another study by Harvey *et al.*¹¹ did not achieve results, which may have resulted from a lack of increasable tension to adapt to changes in ROM. After the end range was met with the initial stretching, the tension was not changed so progression did not continue as it did with the SCI patient in this report. Increased tension was used in this modality to maximize the end-range stretching time as accomplished in other studies.^{4,13,14}

Spasticity is common in SCI^{1-3,5,10} and prolonged stretching with the SPDS may have also contributed to the decreased spasticity. Avela *et al.*¹² found that prolonged, passive stretching decreased reflex sensitivity, and the amplitude of peak-to-peak reflex decreased by 84.8%. The consistent stretching employed in this case was for 45 min, twice per day, for each forearm, totaling 90 hours for each arm.

This modality is also commonly used as home therapy. The patient or care-giver is trained on donning and doffing the unit which is worn while the patient sleeps, achieving 6–8 hours of range of motion therapy. The difference between the therapists' use versus home therapy is that the therapist has the ability to judge the changes and tension used more frequently. For example in this case the therapist increased the tension from setting 1 to 7 in 12 weeks, but as home therapy the progression of tension would be more conservative (one increment per month). The therapist's daily attention in the use of this modality is beneficial, but even in home therapy, the prolonged end-range stretching is what is considered integral to the contracture reduction.^{12,13} On a scale of 1 to 10 (10 being the highest score) the patient gave this modality a 10 for benefit and ease of use, and he has written a letter of recommendation to the manufacturer.

Conclusion

This report described the multifaceted programme to reduce forearm contracture in an SCI patient. The benefit of this programme which included SPDS for contracture reduction and tone management was that this patient regained over 40° in AROM of supination in each arm and regained 40° and 25° PROM of his left and right arms. The continued use of the SPDS in home therapy will allow the patient to retain both functional abilities and the improvements in range of motion.

Competing interests: TSK has not received or will not be receiving benefits in any form from a commercial party related directly or indirectly to the subject of this article. BW has received or will receive benefits for personal or professional use from a commercial party related directly or indirectly to the subject of this article.

Accepted: 11 September 2009

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