The Use of Low-Load Prolonged Stretch Devices in Rehabilitation Programs in the Pacific Northwest

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Key Words: contracture • occupational therapy (treatment) • orthotic devices

Objective. This retrospective study examined the use of low-load prolonged stretch (LLPS) orthoses for contracture management.

Method. The records of 17 patients from skilled nursing facilities, hand clinics, and hospitals were reviewed. There was a total of 18 contractures (2 wrist, 12 elbow, 4 knee) secondary to neurological and orthopedic pathologies. Chart review focused on patient demographic information, range of motion (ROM) and functional outcomes, and wear schedules.

Results. The use of LLPS orthoses significantly increased ROM for the whole sample, which in turn significantly improved the subjects' functional outcomes. When the sample was divided into two pathology groups to compare a predominately geriatric population with neurological pathologies to a somewhat younger population with a history of musculoskeletal pathology, both groups showed a significant gain in ROM with the use of the LLPS orthoses.

Conclusion. Use of LLPS orthoses for contracture management can mediate the losses in ROM and function that occur with joint contractures.

Joint and muscle contractures are secondary conditions that can be attributed to musculoskeletal and neurological disorders such as cerebrovascular accident, arthritis, spinal cord injury, head trauma, Parkinson's disease, and Alzheimer's disease. Fibrous muscle contractures can result from loss of motor cortex inhibition, which causes flexor muscles to spasm. Muscle fibers are then gradually replaced by fibrous connective tissue (Souron, Franssen, & Reisberg, 1995). Joint contractures resulting in shortening of the capsular or periarticular tissues occur from structural damage to the joint caused by degenerative joint disease, trauma, inflammation, or prolonged immobilization (Souren et al., 1995). Common complications associated with contractures include soft tissue breakdown, pain, and decreased mobility. For example, functional activities such as transfers, which require both upper-extremity and lower-extremity function, can be severely affected by elbow and knee contractures (Packer, Wyss, & Costigan, 1994; Potter, Kirby, & MacLeod, 1990), thus impairing performance of activities of daily living (ADL).

In rehabilitation, therapists use stretch to elongate the muscle tissue that has been shortened by contractures (Frank, Akesson, Woo, Amiel, & Coutts, 1984; Gossman, Sahrmann, & Rose, 1982). Controversy exists as to the most efficacious means of producing a lasting elongation (Bonutti, Windau, Ables, & Miller, 1994). The cost of
therapist-assisted therapy versus the cost of an orthotic device, the permanence of the elongation, the potential injury related to passive motion (e.g., excessive trauma to the tissues, undesired mobility of a joint) (Frank et al., 1984), and the lack of appropriate feedback with the use of mechanical equipment (Mukherjee & Mokashi, 1987) are issues still being debated.

One method used to reduce contractures is low-load prolonged stretch (LLPS), and one means of providing LLPS is the use of an orthotic device that holds the joint in a position of stretch. The tension across the joint can be varied with two spring-loaded adjustable cuffs (MacKay-Lyons, 1988). The orthosis is worn briefly at the start of treatment and for progressively longer periods as the treatment advances. In this study, patient records were reviewed to gain more information about the use of this type of device for elbow, wrist, and knee contractures.

Background

Range of motion (ROM), or the extent to which a joint is capable of moving, can be affected by any of the structures surrounding it. These structures may include muscles, joint surfaces, capsules, ligaments, fascia, blood vessels, or nerves (Kisner & Colby, 1990). Alterations in the viscoelastic properties of muscles surrounding a joint can result in adaptive shortening of muscle tissue, which may lead to a limitation of motion or joint contracture. Joint contractures due to adaptive shortening of the surrounding muscles can occur as a result of immobility or abnormal muscle tone secondary to various musculoskeletal and neuromuscular conditions. The functional impact of a limitation of motion due to joint contractures can be loss of functional mobility (Berg, 1989; Falconer, Hayes, & Chang, 1992; Kirby, Price, & MacLeod, 1986; Mahar, Kirby, & MacLeod, 1985), increased energy output due to the increased muscle activity required when walking with knee flexion contractures (Cerny, Walker, & Perry, 1988), and pain (Fleckenstein, Kirby, & MacLeod, 1988).

Functional limitations such as those caused by joint contractures can result in a loss of community mobility, which affects social environment, self-concept, self-expression, and self-control (Bachelder, 1994; Cutler, 1994; Souren et al., 1995; Tesch & Whitbourne, 1981). Each of these instances provides an opportunity for occupational therapy intervention to minimize the losses and, thus, increase independence and improve quality of life.

Contractures resulting from adaptive shortening of muscle have traditionally been managed by a combination of interventions, such as passive range of motion (PROM) and manual stretching techniques. Several studies have reported the use of various devices designed to produce LLPS for the purpose of decreasing contractures. For example, Hepburn and Crivelli (1984) described a case in which the use of a Dynasplint™, a device designed to produce LLPS, resulted in the complete resolution of a 43° elbow flexion contracture secondary to immobility after fractures of the humerus, radius, and ulna in a 13-year-old boy. In a similar case study, MacKay-Lyons (1988) reported a 55° decrease in an elbow flexion contracture of a 22-year-old man with head trauma after the use of a Dynasplint for 7.5 months. In a larger study, Hepburn (1987) used a Dynasplint on 13 subjects with nonosseous elbow or knee flexion contractures and reported an average of 61% increase in ROM after use of the device for an average of 13 weeks.

Light, Nuzik, Personius, and Barstrom (1984) compared high-load brief stretch (HLBS) and exercise in the form of proprioceptive neuromuscular facilitation (PNF) diagonals with LLPS produced by skin traction in 11 nonambulatory nursing home residents with knee flexion contractures. Their results suggested that LLPS was superior to HLBS and exercise for decreasing contractures. In a more recent study of nursing home residents with knee flexion contractures due to a variety of musculoskeletal and neuromuscular disorders, Steffen and Mollinger (1995) compared the use of a Dynasplint with a regimen of PROM and manual stretching. They found no significant differences in knee ROM between joints treated with LLPS (provided by the Dynasplint) and PROM combined with manual stretching. These results seem to contradict earlier studies done on LLPS with use of a Dynasplint.

Other studies have examined the effects of LLPS through devices other than a Dynasplint, with promising results. For example, Hill (1994) compared the effects of LLPS via serial casting with traditional forms of contracture management (i.e., PROM, prolonged stretch, splinting, PNF, neurodevelopmental treatment) in patients with upper-extremity contractures secondary to brain injury. She found significant increases in PROM from the casting intervention compared with the traditional interventions. Bonutti et al. (1994) used a modified progressive stretching procedure with an LLPS splinting device on patients with contractures due to upper-extremity fractures. They reported an average 31° increase in ROM after a 1-month to 3-month treatment program with the device.

In summary, there appears to be support in the literature for the use of LLPS devices in the management of contractures. Differences in diagnoses, progression of the disease processes, and treatment protocols may account for the inconsistencies in results. Treatment variables such as the length of time the LLPS was used before dis-

1Manufactured by Dynasplint Systems, Inc., 6655 Amberton Drive, Baltimore, Maryland 21227.
charge, prescribed wearing schedules, and tension settings either are often not well described or differ significantly between studies. Although these studies have attempted to describe the usefulness of various methods of using LLPS devices for the management of joint contractures, the differences in treatment protocols and results make it difficult to ascertain just how these devices are actually being used in clinical practice. Furthermore, there is presently only limited information available as to the functional outcomes associated with the use of such devices. Therefore, the purpose of this study was to document the use and functional outcomes of LLPS orthotic devices in rehabilitation settings in the Pacific Northwest.

Method

Subjects

A retrospective descriptive study was undertaken that used data collected from the charts of 20 patients who had had an LLPS orthotic device applied. The inclusion criterion for this study was the previous (within the past 5 years) or current application of an LLPS orthotic device for contracture management. Charts were excluded from consideration if they did not contain beginning and ending ROM measurements and treatment protocol data about the prescribed wearing schedule, tension settings, and length of treatment.

Procedure

Snowball sampling (Portney & Watkins, 1993) was used to identify facilities and therapists who had used LLPS orthoses for treatment of contractures. Hospitals, rehabilitation facilities, hand therapy clinics, skilled nursing facilities (SNFs), major therapy providers, and LLPS device representatives in the Pacific Northwest were solicited by telephone. One therapist responded to an advertisement that was placed in the Washington Occupational Therapy Association’s newsletter. In some instances, SNF regional managers contacted their various facilities to identify those that had used LLPS orthoses. Therefore, the number of facilities actually queried is not known. Of the 15 facilities that were identified as having placed orders for LLPS orthoses, therapists from 8 responded that they could provide data meeting the inclusion criterion.

Permission was obtained from the university, rehabilitation research review committees, and facilities to review chart histories of the 20 patients who were treated with an LLPS orthosis. The charts were reviewed, in most cases, by the first author as well as by the clinician who performed the treatment. On the basis of the chart review, 3 subjects were eliminated because the orthoses used were not LLPS devices, leaving a sample of 17 (6 women, 11 men) for analysis (see Table 1).

Data Analysis

Descriptive statistics were used to characterize the sample. Means and standard deviations for age and degree of change in ROM were computed for group analysis. Paired $t$ tests between the ROM measurements before and after the application of LLPS treatment were performed. The sample was divided into two groups on the basis of whether the primary diagnosis was orthopedic or neurologic. Independent sample $t$ tests were then computed for pre-LLPS and post-LLPS ROM measurements between the two groups, and paired $t$ tests were computed for within-group differences.

Functional outcomes were individually described, and a sign test was used to determine the probability of obtaining a difference in functional outcomes by pure chance. For the purpose of this study, function was described as any positive outcome noted by the treating therapist. Subjects whose function had increased after treatment were assigned a 2, those whose function had remained at baseline received a 1, and those who lost function received a 0. The Statistical Package for the Social Sciences (Norusis, 1990) was used for all statistical analyses.

Results

The use of LLPS orthoses significantly increased ROM for the whole sample, $t(17) = 4.99, p<.001$. No significant difference in ROM was found between the orthopedic and the neurological groups either before or after the LLPS treatment (see Table 2). The orthopedic group had a significant gain in ROM, $t(7) = 3.61, p = .009$, as did the neurological group, $t(9) = 3.35, p = .008$.

The number of hours orthoses were worn ($M = 6.47, SD = 3.14$) and the corresponding tension settings as noted in the individual charts are presented in Table 3. Orthoses were worn for an average of 10 weeks; nine subjects wore their orthoses for less than 3 months, six for 3 months; two for 4 months, and one for more than 1 year.

Table 4 lists the functional gains that the treating therapists attributed to the use of LLPS orthosis intervention. Eight subjects experienced some improvement in ADL; three demonstrated increased reach, and three returned to work. Two subjects’ skin integrity improved, and two other subjects’ comfort improved. Two subjects were able to resume leisure activities. A sign test of functional outcomes revealed that a significant number of subjects experienced increased function after the application of LLPS orthoses ($p = .0001$).

The Appendix summarizes the therapists’ comments associated with LLPS orthosis use, which were obtained during chart-review interviews. Issues and concerns related to the fit and application of the orthoses, discomfort, and skin integrity were the most frequently raised concerns.
Table 1

Subject Demographic Information and Outcomes

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age (Years)</th>
<th>Gender</th>
<th>Pathology</th>
<th>LLPS Device</th>
<th>Facility</th>
<th>Contracture Location</th>
<th>Time Used</th>
<th>°ROM</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>90</td>
<td>F</td>
<td>R hip fx, dementia</td>
<td>Dynasplint™</td>
<td>SNF</td>
<td>R knee</td>
<td>3 days</td>
<td>0</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>79</td>
<td>M</td>
<td>L CVA, R hemiplegia</td>
<td>Turn bucke</td>
<td>SNF</td>
<td>R elbow</td>
<td>6 weeks</td>
<td>10</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>61</td>
<td>M</td>
<td>Aneurysm, closed head injury</td>
<td>Dynasplint</td>
<td>SNF</td>
<td>L elbow</td>
<td>&gt; 1 year</td>
<td>65</td>
<td>Yes</td>
</tr>
<tr>
<td>4a</td>
<td>32</td>
<td>M</td>
<td>TBI</td>
<td>Dynasplint</td>
<td>Hospital</td>
<td>R elbow</td>
<td>3 months</td>
<td>16</td>
<td>Yes</td>
</tr>
<tr>
<td>4b</td>
<td></td>
<td></td>
<td></td>
<td>Dynasplint</td>
<td>Hospital</td>
<td>L elbow</td>
<td>3 months</td>
<td>8</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>67</td>
<td>M</td>
<td>R CVA, L hemiplegia</td>
<td>Ultraflex</td>
<td>SNF</td>
<td>L elbow</td>
<td>3 months</td>
<td>55</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>85</td>
<td>M</td>
<td>L CVA, R hemiplegia</td>
<td>Ultraflex</td>
<td>SNF</td>
<td>R elbow</td>
<td>3 months</td>
<td>10</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>78</td>
<td>F</td>
<td>L CVA, R hemiplegia</td>
<td>Ultraflex</td>
<td>SNF</td>
<td>R knee</td>
<td>4 months</td>
<td>10</td>
<td>No</td>
</tr>
<tr>
<td>8</td>
<td>78</td>
<td>F</td>
<td>R CVA, L hemiplegia</td>
<td>Dynasplint</td>
<td>SNF</td>
<td>L knee</td>
<td>1 month</td>
<td>40</td>
<td>Yes</td>
</tr>
<tr>
<td>9</td>
<td>69</td>
<td>M</td>
<td>L &amp; R CVA, Parkinson's disease</td>
<td>Dynasplint</td>
<td>SNF</td>
<td>R knee</td>
<td>4 days</td>
<td>25</td>
<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>24</td>
<td>M</td>
<td>R radial ulnar fx</td>
<td>Ultrasex</td>
<td>Hand clinic</td>
<td>R wrist</td>
<td>2 months</td>
<td>42</td>
<td>Yes</td>
</tr>
<tr>
<td>11</td>
<td>62</td>
<td>M</td>
<td>R radial and ulnar fx</td>
<td>Ultrasex</td>
<td>Hand clinic</td>
<td>L wrist</td>
<td>1 month</td>
<td>6</td>
<td>Yes</td>
</tr>
<tr>
<td>12</td>
<td>13</td>
<td>M</td>
<td>Congenital R elbow flexion contracture</td>
<td>Dynasplint</td>
<td>Hand clinic</td>
<td>R elbow</td>
<td>2 months</td>
<td>25</td>
<td>Yes</td>
</tr>
<tr>
<td>13</td>
<td>50</td>
<td>F</td>
<td>L suprascapular palsy</td>
<td>Ultrasex</td>
<td>Hand clinic</td>
<td>L elbow</td>
<td>3 months</td>
<td>10</td>
<td>Yes</td>
</tr>
<tr>
<td>14</td>
<td>36</td>
<td>M</td>
<td>L unstable fx dislocation</td>
<td>Ultrasex</td>
<td>Hand clinic</td>
<td>L elbow</td>
<td>2 months</td>
<td>44</td>
<td>Yes</td>
</tr>
<tr>
<td>15</td>
<td>46</td>
<td>F</td>
<td>L elbow arthroscopy and anterior capsule release</td>
<td>Ultrasex</td>
<td>Hand clinic</td>
<td>L elbow</td>
<td>1 month</td>
<td>66</td>
<td>Yes</td>
</tr>
<tr>
<td>16</td>
<td>58</td>
<td>F</td>
<td>R severe distal humeral fx</td>
<td>Ultrasex</td>
<td>Hospital</td>
<td>R elbow</td>
<td>4 months</td>
<td>38</td>
<td>Yes</td>
</tr>
<tr>
<td>17</td>
<td>48</td>
<td>M</td>
<td>R CVA, L hemiplegia</td>
<td>Dynasplint</td>
<td>Hand clinic</td>
<td>R elbow</td>
<td>3 months</td>
<td>55</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note. Active range of motion figures were reported for subjects 14, 15, and 16; all others were passive range of motion. CVA = cerebrovascular accident; fx = fracture; °ROM = degrees range of motion change; SNF = skilled nursing facility; TBI = traumatic brain injury.

Discussion and Limitations

This retrospective study supports the effective use of LLPS orthoses to achieve ROM and functional gains in contracture management. However, the low statistical power of our small sample must be taken into account before universal claims are made about the benefit of these orthoses. Our study supports the findings of Hepburn and Crivelli (1984), MacKay-Lyons (1988), and Hepburn (1987) who found improved ROM with the use of LLPS orthoses; however, it contradicts Steffen and Mollinger's (1995) findings that LLPS was not effective for decreasing knee flexion contractures in an SNF population. This difference could have been a result of the difference in wear times. The 6.83-hour mean wear time in Steffen and Mollinger's study was more than twice as long as the 3-hour mean wear time in our study.

The division of patients into two groups on the basis of orthopedic or neurological pathologies allowed for a comparison of a predominantly geriatric population with neurological pathologies to a somewhat younger population with a history of musculoskeletal pathology. There were no significant differences in ROM gains between the two groups.

The variability and lack of wear schedule data make it difficult to establish any one best combination of time and tension for the orthoses. In addition, the lack of detailed notes within some charts made it impossible to reconstruct the treatment, which may make it difficult to obtain similar results with future patients. This inconsistency leads to learning the same lessons over at the expense of future patients.

The quality and quantity of functional outcomes varied widely within the sample. For example, in addition to functional improvements noted in ADL, work, and leisure, caregivers also reported increased ease in assisting subjects with tasks such as dressing and personal hygiene because of increases in ROM. One may postulate that if dressing or hygiene is made easier, caregivers would be more likely to pursue this activity than when it is difficult, thereby indirectly benefiting the patient.

Subject discomfort or problems with skin integrity were consistent themes in therapists' concerns about using LLPS orthoses. Discomfort could be mediated by the therapist when the patient is able to indicate the presence

Table 2

Comparison of Age and ROM Outcomes for Orthopedic and Neurologic Subject Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>M</th>
<th>SD</th>
<th>Range</th>
<th>°ROM</th>
<th>M</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurologic</td>
<td>9</td>
<td>64.12</td>
<td>19.04</td>
<td>32-85</td>
<td>28.40</td>
<td>26.78</td>
<td>-10-65</td>
<td></td>
</tr>
<tr>
<td>Orthopedic</td>
<td>8</td>
<td>47.38</td>
<td>23.95</td>
<td>13-90</td>
<td>28.88</td>
<td>22.65</td>
<td>6-66</td>
<td></td>
</tr>
<tr>
<td>All subjects</td>
<td>17</td>
<td>56.24</td>
<td>24.50</td>
<td>13-90</td>
<td>28.61</td>
<td>24.31</td>
<td>-10-66</td>
<td></td>
</tr>
</tbody>
</table>

Note. °ROM = degrees range of motion change.
of pain; however, skin breakdown is more likely to occur with patients with lower cognitive functioning. The results suggest that consistent monitoring is necessary to protect skin integrity with patients who are confused or have dementia. The therapists who participated in the data collection were asked whether they would use these orthoses again. All replied that they would; however, some gave qualifying circumstances under which they would use them again (see Appendix).

The reported success of LLPS in patients with spasticity runs counter to comments received during the initial search for charts for this study. Therapists initially indicated that they did not believe that these orthoses were indicated in a geriatric population or for use when spasticity was present, which may be one reason why the use of these orthoses is not more widespread in SNFs.

As with all retrospective chart-review studies, this study had several limitations. The detail of documentation varied for each case, depending on the therapists' skill and consistency. Most charts did not include documentation of the number of days per week the orthosis was worn. In addition, the treating therapists also reported a variety of other treatment interventions before and during the time that the orthoses were being applied. Therefore, the benefits gained may be attributed to a combination of interventions. Each therapist interviewed, however, believed that the benefits were due to the orthosis because it was the final technique introduced after all other treatment interventions had been tried. Another drawback to this study was the lack of follow-up data regarding the permanence of improved ROM and functional gains made during treatment after discharge. Such information is crucial for determining the long-term effects of LLPS orthosis use. The lack of a control group for comparison was another limitation.

**Summary**

The purpose of this study was to document the use and functional outcomes obtained from the application of LLPS orthoses within rehabilitation settings in the Pacific Northwest. The records of 17 subjects with wrist, elbow, or knee contractures showed significant improvement as a group in ROM and in functional outcomes after an intervention of LLPS. When the sample was divided into two groups on the basis of musculoskeletal or neurological pathologies, no significant difference in beginning or ending ROM measurements between the groups were found.

Further research is needed that uses a stringent treatment protocol on a larger sample of patients, including a
control group, to determine the efficacy of LLPS orthoses for the treatment of contractures. Prospective studies that document functional outcomes, baseline, discharge, and follow-up PROM and active ROM measurements are needed to establish the overall value of LLPS orthoses. Single-subject designs may prove easier to initiate and may provide a basis for further study.

Appendix

Therapists’ Concerns and Comments Associated With Low-Load Prolonged Stretch Orthosis Use

Concerns

- Numbness or burning sensation when tension was increased
- Painful to sleep
- Uncomfortable straps
- Compression on ulnar nerve by straps
- Pain at lateral epicondyle and elbow joint
- Discomfort
- Uncomfortable
- Hygiene with patients with incontinence
- Breakdown of pads
- Skin integrity
- Hook-and-loop cuffing does not contour to arm
- Orthosis slips out of position on arm
- Bulky
- Must be ordered for each patient, or fit is poor
- Does not cross shoulder joint
- Too hard to teach positioning to others
- Patient or caregiver is noncompliant
- Cognitive level of patient
- Difficult to apply

Comments

- Use of orthosis was less therapist intensive because monitoring outcomes of orthotic use required less time than the therapist-assisted exercises, such as passive range of motion, PNF patterns, or neuromotor treatment, even if applied only by the occupational therapist and not an aide.
- Sheep skin between cuffs and skin helped protect skin.
- Orthoses worked well because restorative staff members consistently applied orthoses as prescribed.
- Manufacturer’s level of support influenced choice of orthoses in only two cases.

References


