Effects of Splinting in the Treatment of Hand Contractures in Progressive Systemic Sclerosis

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One of the major factors in the decreasing functional ability of patients with progressive systemic sclerosis is involvement of the patient's hands with secondary immobility and contractures. In a 2-month study of 19 patients, we assessed whether dynamic splinting could decrease proximal interphalangeal (PIP) flexion contractures. Of the eight patients who completed the study, one experienced a statistically significant improvement in PIP range of motion as a result of the splinting. There was no evidence that the use of the splints served to maintain PIP extension when compared with the control hand.

Scleroderma is a disease of unknown etiology and cure for which pharmacologic agents have limited effectiveness. To all involved with scleroderma, the patient's decreasing functional abilities are a significant concern. Causes of this decreasing function are edema, fibrosis, and ulceration in the hand, resulting in contractures and decreased mobility. Characteristic hand deformities that occur in scleroderma are loss of flexion of the metacarpophalangeal (MCP) joints, loss of extension of the proximal interphalangeal (PIP) joints, and loss of thumb abduction, opposition, and flexion resulting in a decreased web space (see Figure 1). Flexion contractures of the PIP joint may limit tip-to-tip prehension or complete grasp and lead to weak lateral pinch, resulting in decreased dexterity. As a result, patients are frequently limited in performing those activities of daily living that require grasp or pinch.

Review of the Literature

Although the literature frequently includes recommendations regarding the use of exercise, modalities, and splinting to alleviate the problem of soft tissue contractures (LeRoy, 1981; Melvin, 1982; Swartz, 1978), studies of the efficacy of the range of motion and stretching treatment programs are few and poorly documented (Entin & Wilkerson, 1973; Lehmann & DeLateur, 1969; Rudolph, Leyden, & Berger, 1974). Surgical approaches to the hand problems have also met with limited, short-term success (Entin & Wilkerson, 1973).

Several authors have stated that an overgrowth of collagenous connective tissue and fibrosis of the skin are responsible for the contractures and decreased joint mobility, and that joint changes are not a major contributing factor in scleroderma (LeRoy, 1981; Rodman, 1979; Rodman & Schumaker, 1983). Physiological studies dealing with connective tissue (LaBan, 1962; Smith, 1954; VanBrocklin & Ellis, 1965), as well as observations of clinical investigators (Kottke, Pauley, & Patak, 1966), indicate that dynamic splinting is theoretically an appropriate approach to the treatment of these connective tissue contractures.

For example, in vitro studies conducted by Smith (1954), using a rabbit cruciate ligament model, and LeBan (1962), using canine calcaneal tendon, confirmed that sustained constant stress applied to connective tissue elongated the tissue over time. VanBrocklin and Ellis (1965), using human foot extensor digitorum tendons, confirmed these observations. They further observed that the elongation of connective tissue is not only a function of stress but also of the application of that stress and that if the stress is increased rapidly in some ranges there is a corresponding resistance to elongation. Consequently, elongation is more likely to occur with less resistance.
applied over a longer period. However, none of these investigators developed specific parameters for the use of this information in the therapeutic setting, and no studies in patients were done.

Kottke, Pauley, and Patak (1966) noted that collagen and connective tissue exhibited a quality of "plastic elongation" when constant or prolonged tension was applied. They alone among investigators extended their experimental work on collagen to direct clinical application, developing treatment programs for stretching the hip flexors, knee flexors, and ankle plantar flexors in 10 patients with a variety of nonrheumatic diseases. The use of their stretching techniques resulted in greater restoration of motion of the hip, knee, and ankle joints (within the limits of pain and without evidence of tearing of tissues) than did the use of other methods. The authors, however, did not apply their techniques to the upper extremities. Other clinicians also have made use of the elastic properties of the connective tissue in splinting of the hands (Boyes, 1970; Flatt, 1974; Kaminetz, 1969).

In this study, we attempted to determine whether or not the proximal interphalangeal (PIP) joint contractures in patients with progressive systemic sclerosis (PSS) can be reduced, modified, or reversed through a regimen of dynamic splinting designed to stretch connective tissue.

Methods

Subjects

Subjects in this study came from the UCLA Outpatient Scleroderma Clinic, where they had been evaluated by a physician using history, physical examination, and appropriate tests to establish their diagnosis. Study requirements were a diagnosis of symmetrical and progressive systemic sclerosis by American Rheumatic Association criteria (Rodman & Schumaker, 1983) and involvement of the hands with contractures of the fingers (PIP flexion contractures had to be greater than 15° in each digit of each hand), while the status of the MCP joints was not a determining factor in eligibility for the study. Patients with skin ulcers of the fingers or hands severe enough to interfere with proper and safe splinting were excluded from the study. Nineteen patients met the criteria and were entered in the study.

Procedure

A random table was used to determine which hand was to be splinted, and the unsplinted hand served as a control. The splinting schedule was 8 hours per day for the 2-month study period.

To establish the baseline range of motion, each subject’s hands were measured with a goniometer by the same investigator on two occasions prior to splinting. Repeat bilateral measurements were done by the same evaluator who was blind to the study at 1- and 2-month intervals in both active and passive extension of the PIP joints of digits 2 through 5. The MCPs were maintained in the 0° position for the initial and all subsequent PIP evaluations.

A dorsal thermoplastic hand splint that maintained the wrist in approximately 15° extension, the MCPs in 0°, and had a dynamic PIP extension outrigger was fabricated for each subject. The splint provided gentle, persistent extension to the PIPs of digits 2 through 5 (see Figure 2). The PIP extension pressure was maintained at the individual’s maximum tolerance.

Week 1 of the 2-month study did not start until the subject was able to wear the splint daily for 8 hours. During the duration of the study, subjects were checked weekly, and the tension on the rubber bands was adjusted. The splint checked for fit and comfort.
Table 1
Comparison of Patients Completing and Not Completing Study

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Completed Study (n = 8)</th>
<th>Did Not Complete Study (n = 11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>8 females, 0 males</td>
<td>9 females, 2 males</td>
</tr>
<tr>
<td>Age range</td>
<td>31-61 years (avg. = 48 years)</td>
<td>23-61 years (avg. = 45 years)</td>
</tr>
<tr>
<td>Disease duration</td>
<td>15-25 years (median = 2 years)</td>
<td>0.5-14 years (median = 2 years)</td>
</tr>
<tr>
<td>Skin involvement</td>
<td>Indurative/classic*</td>
<td>Indurative/classic*</td>
</tr>
</tbody>
</table>

* Rodnan/LeRoy classifications: hidebound, hyper-hypopigmentation, telangiectasias.

and the subject's weekly splint wearing log was reviewed for compliance. Statistical analysis was based on the paired Student's t test.

Results

Only 8 of the 19 subjects in the study completed the 2-month splinting program. Those completing it were no different from those not finishing it with respect to gender, age, disease duration, or extent of skin involvement (see Table 1). Thus, it was not possible to predict from any baseline subject characteristics who would and who would not complete the study.

Of the 11 dropouts, 4 experienced iatrogenic, splint-exacerbated Raynaud's phenomenon, 3 had exacerbation of their systemic disease, and 4 dropped out for reasons not related to the disease (2 had transportation or work conflicts, and 2 were dropped for noncompliance).

Of the 8 subjects who completed the study, passive and active extension yielded similar measurements among individual joints on a hand. Therefore, the data were analyzed based on the sum of extension of these four digits (index, middle, ring, and little finger PIPs).

Repeated determinations prior to splinting indicated that the measurement error was 11 ± 7° for passive extension and 10 ± 7° for active extension. Consequently, we chose to consider a change of 18° or greater as significant.

Neither the splinted nor the control hands of the 8 subjects, when evaluated as a group, changed significantly in active PIP extension at 1 or 2 months (see Table 2).

In 7 patients evaluated as a group (the first patient entered into the study was not measured pass-sively), passive PIP extension also changed very little at either the 1-month or 2-month periods when compared to the control hand. The splinted hands revealed a mean improvement of 9° at 1 month and a mean improvement of 15° at 2 months. This difference, however, was not statistically significant (see Table 3).

Table 4 shows that an individual's PIP extension measurements varied widely. Two subjects’ measurements improved at 2 months. Patient #4 exhibited +43° improvement of active PIP extension on the splinted hand, whereas the control hand was -21°. Similar differences were seen on passive PIP extension with a +60° change on the splinted hand, compared to a control measurement of +3°. Since measurement error was 10 ± 7° (active extension) and 11 ± 7° (passive extension), we concluded that this subject’s passive and active extension was significantly improved by splinting. Review of this person’s clinical characteristics at entry and during this study revealed nothing to distinguish her from the nonresponders. She was 31 years of age, had had mild PSS for 1½ years since her diagnosis, and her disease was stable (no exacerbations) during the study.

Patient #8 also improved in active and passive extension at 2 months' evaluation (+28° and +43°, respectively). However, in the control hand there was borderline improvement in passive extension (+15°) and an equal improvement in active extension (+28°). This suggests that the improvement in the splinted hand could be related to remission in the disease just as easily as to the splinting. The other 6 subjects showed no improvement in the splinted hand.

In evaluating whether the use of the splints served to maintain the PIP range of motion, we found no significant difference between splinted and unsplinted hands.

Discussion

This study documents several facets of the treatment of PSS contractures. First, splinting in PSS is associated with major difficulties. Of the 19 subjects, 21% had toxicity (splint-exacerbated Raynaud's phenomenon) secondary to the splinting per se despite frequent and careful attempts to alleviate problems. However, it is important to note that the splinting did not induce...
Table 4
Proximal Interphalangeal (PIP) Extension at 2 Months for Individual Patients

<table>
<thead>
<tr>
<th>Improvement*</th>
<th>Patient</th>
<th>Active</th>
<th>Control</th>
<th>Active</th>
<th>Control</th>
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<tbody>
<tr>
<td>Yes</td>
<td>4</td>
<td>+43</td>
<td>-21</td>
<td>+60</td>
<td>+3</td>
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<td>8</td>
<td>+28</td>
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<td>+43</td>
<td>+15</td>
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<tr>
<td></td>
<td>1</td>
<td>-34</td>
<td>-4</td>
<td>ND</td>
<td>ND</td>
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<td>2</td>
<td>+6</td>
<td>-24</td>
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<td>7</td>
<td>+18</td>
<td>-6</td>
<td>+14</td>
<td>+6</td>
</tr>
</tbody>
</table>

*A change >18º is considered significant because the difference (mean ± SD) between two baseline measurements was 11 ±7º (n = 7) for passive range; and 16 ±7º (n = 8) for active range. *ND = not done.

ulceration, nor did it cause any additional sensory or skin problems. Sixteen percent did not complete the trial because their underlying disease worsened. Overall, 58% of the 19 subjects could not complete the study, emphasizing the difficulty in carrying out splinting studies with this disease.

Second, even prolonged splinting, averaging 8 hours per day, did not result in a significant reduction in the finger flexion contractures over a 2-month period. Nor was the baseline PIP extension maintained by wearing the splint, as neither splinted nor unsplinted hand worsened significantly. The finding that no statistically significant differences occurred between the PIP extension of the splinted and control hands indicates that the splinting served neither to maintain nor to improve PIP extension of motion.

Third, only 1 subject responded to splinting. The lack of statistically significant differences between splinted and unsplinted hands of the subjects as a group could be a function of the small study sample. Possibly a study using a larger sample would demonstrate differences. Unfortunately, despite a large clinic population and 2 years of effort we could not recruit more than 19 suitable PSS patients into the study.

Conclusions

Of 19 subjects entered into the study, 8 completed the 2-month splinting protocol. The PIP extension of only 1 of these subjects improved significantly as a consequence of the splinting program. Analysis of the 8 subjects as a group indicated no significant change as a consequence of the splinting. Additionally, we found no statistically significant evidence to indicate that the splint had served to maintain the PIP extension when compared to the unsplinted hand as neither group worsened significantly.

Thus, we conclude that the splint and the proto-
col employed did not improve nor maintain PIP extension for this group of scleroderma subjects. Indeed, a response rate of only 1 of the 19 subjects entered into the study does not warrant use of this protocol of dynamic splinting to correct the PIP contractures or maintain PIP extension in the hands of scleroderma patients.

Acknowledgments

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References


