SCIENTIFIC ARTICLE

Treatment of Proximal Interphalangeal Joint Flexion Contracture: Combined Static and Dynamic Orthotic Intervention Compared With Other Therapy Intervention: A Randomized Controlled Trial

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Purpose To test the effectiveness of static and dynamic orthoses using them as an exclusive treatment for proximal interphalangeal (PIP) joint flexion contracture compared with other hand therapy conservative treatments described in the literature.

Methods 60 patients who used orthoses were compared with a control group that received other hand therapy treatments. Clinical assessments were measured before the experiment and 3 months after and included active PIP joint extension and function.

Results A significant improvement in the extension active range of motion at the PIP joint in the second measurement was found in both groups, but it was significantly greater in the experimental group. Improvement in function (Disabilities of the Arm, Shoulder, and Hand score) between the first and second assessment was similar in the control and experimental groups.

Conclusions Using night progressive static and daily dynamic orthoses as an exclusive treatment during the proliferative phase led to significant improvements in the PIP joint active extension, but the improvement did not correlate with increased function as perceived by the patient. *(J Hand Surg Am. 2015;■(■):■−■. Copyright © 2015 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Therapeutic I.

Key words Proximal interphalangeal joint, orthoses, static orthotics, dynamic orthotics.

PROXIMAL INTERPHALANGEAL (PIP) joint flexion contractures are a common problem seen by surgeons and hand therapists after various types of injuries. Normal movement of the PIP joint requires bone support; intact articular surfaces; and integrity of the collateral ligaments, volar plate, and tendons. Deficiency in any of these structures can lead to a loss of finger motion and decreased function.[1] After injury, loss of joint mobility may either be due to the formation of adhesions or scar shortening of the periarticular structures, which limit the range of movement.[1−3] Different situations can lead to a loss of mobility at the PIP joint: fractures, joint dislocation, or subluxation, synovitis, edema, or soft-tissue injuries such as ligament damage or affectation of the volar plate.[2,4] Once the extension of the joint is lost, the treatment options are either conservative and/or surgical. Conservative treatment should be the first option before surgery is considered.[5] If conservative treatment fails, surgery is the option of choice.

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Received for publication May 7, 2014; accepted in revised form January 7, 2015.

No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

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0363-5023/15/■ ■-0001$36.00/0
http://dx.doi.org/10.1016/j.jhsa.2015.01.005

TABLE 1. Description of Control Group Treatment

Exercises Used in Control Group	Description
10 minutes of local thermotherapy	*Paraffin bath*
Active exercises, 3 sets of 15 repetitions of each exercise	*We started with opening and closing exercises overall fists*
MCP selective exercises	*Active flexion and extension in intrinsic plus*
PIP selective exercises	*With MCP in neutral position and then with MCP at 90°*
DIP selective exercises	*With MCP and PIP at 0°*
Involved stretching at PIP level	*5 sets of 3 repetitions, holding for 10 sec*
Therapeutic ultrasound	*0.8 w/cm^2 / 7 min*

MCP, metacarpophalangeal; DIP, distal interphalangeal.

A large number of nonsurgical interventions to restore the range of movement at the PIP joint have been described. There are previous studies on orthotic design and appropriate application. Orthosis fabrication techniques to remodel shortened soft tissue structures are well described by Fess.[5] The use of orthoses is described in most conservative treatment protocols in the literature and is usually combined with other hand therapy interventions, such as joint mobilization techniques, exercises, heat therapy, stretching, paraffin, ultrasound, or shockwaves. Moreover, nowadays there are barriers to care and limited resources for prolonged physiotherapy treatment, so that the use of orthoses alone could be attractive if its effectiveness is demonstrated.

The purpose of our study was to examine the effectiveness of the combined use of static-progressive and dynamic orthoses as the sole treatment for improved active PIP joint extension.

MATERIALS AND METHODS

Design

The study was a single-blind, randomized, controlled clinical trial. The ethics committee approved the experiment and all patients gave informed consent. This study was performed in accordance with the Declaration of Helsinki.

Inclusion criteria for this study were adult, hand trauma resulting in PIP joint flexion contracture, and time since injury between 4 weeks and 6 months. Exclusion criteria for this study were PIP joint bony derangement, associated nerve or tendon injury (including deficit extensor system) damage, Dupuytren disease, camptodactyly, fractures, inflammatory signs, joint instability, avascular necrosis, or infection of the affected finger.

Participants were recruited from a waiting list of a general hospital, and the experimental process was carried out at a hand rehabilitation center from June to September 2013.

Intervention

A blinded hand therapist who did not participate in the experiment took baseline measurements (Spanish version of the Disabilities of the Arm, Shoulder, and Hand [DASH] questionnaire and active extension) prior to randomization.

All participants were instructed to complete the DASH questionnaire[6] before measurement of range of motion. Active extension range of motion of the PIP joint was measured using a standard baseline stainless 180° finger goniometer in a lateral position following the same protocol. All data were collected in the morning and after 10 minutes of active movement (opening and closing the hand in sets of 20 repetitions with 30 seconds of rest each minute to avoid muscle strain). Participants (N = 60) were entered in an Excel database in order of arrival and were randomized into 2 equal groups by an automatic program (30 patients in the control group and 30 in the experimental group).

Patients in the control group followed the hand-therapy treatment detailed in Table 1.

For the experimental group, static-progressive night and dynamic daily orthotic devices were constructed. For night static-progressive orthotics, an elastic material was used (Orficast; Orfit industries, Wijnegem, Belgium) at the maximum pain-free length allowed by the tissues (Fig. 1). For dynamic daily orthotics, non-perforated 2.0-mm thermoplastic material was used with Orfitube (Orfit Industries; Wijnegem, Belgium) as a dynamic component with a mobilizing force of 250−300 g/cm^2 (Fig. 2). Patients were instructed to wear it for at least 6 continuous hours per day and then remove it for activities of daily living.

We checked the static-progressive and dynamic orthoses once a week and adjusted them as necessary.

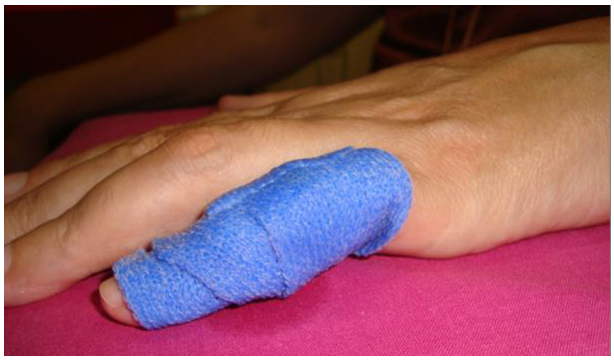

FIGURE 1: Night static orthotic.

Three months later, the first blinded hand therapist, who did not know which treatment the patients had received, re-evaluated function (DASH) and active extension under the same conditions and using the same instruments. Patients were instructed not to reveal the treatment they had received and were asked to remove the orthoses before visiting the evaluating therapist.

Outcome measures

The primary outcome was active extension measured using the lateral approach recommended by the American Society of Hand Therapists.

The Spanish version of the DASH instrument (www.dash.iwh.on.ca) for measuring upper extremity disability was the secondary outcome measure.

Data analysis

Means and standard deviations were calculated to describe the sample. Changes in active range of motion and DASH questionnaire were analyzed using analysis of variance with intervention (control, experimental) as the between-subjects variable, and time (pre−post) as the within-subjects variable. The main hypothesis of interest was intervention for time interaction. The level of significance was set at P less than .05. When an interaction was found, the inter-group effect size was calculated according to the Cohen d statistic.[6] An effect size of less than .2 reflects a negligible difference, between greater than .2 and .5 a small difference, between greater than .5 and .8 a moderate difference, and greater than 0.8 a large difference.

RESULTS

Sixty-three patients (20 women and 43 men) were included in the study. The index finger was the most affected in this study (38%) and most of the participants were employed (73%). Three patients were excluded from the study according to the DASH instructions because they did not complete 10% of the questionnaire. Sixty subjects (19 women and 41 men) completed the experiment. Demographic data of the participants is reported in Table 2. There were no significant differences between groups for continuous variables (age and degrees of extension loss), and the variable group was independent of categorical variables (sex, hand, occupation, or finger).

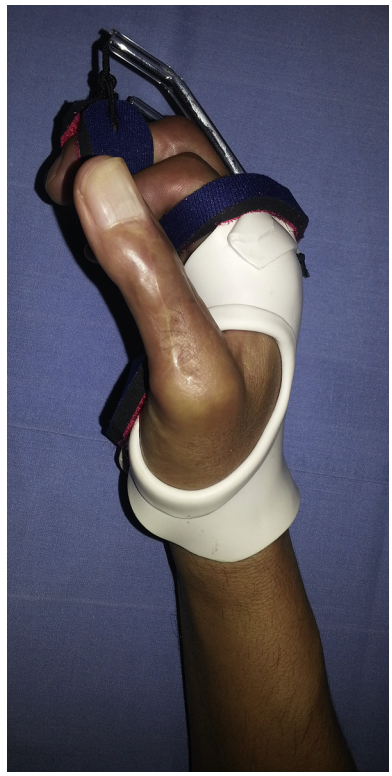

FIGURE 2: Daytime dynamic orthotic.

The analysis of variance showed the existence of a main effect on time ($F(1, 58) = 264$, $P < .001$), indicating a significant improvement in the active range of motion at the PIP joint in the second measurement. Analysis also showed a main effect of intervention ($F(1, 58) = 8$, $P < .01$). The interaction between the 2 variables was significant ($F(1, 58) = 44$, $P < .001$). Paired test comparisons showed that there was an improvement in both groups, but it was significantly greater in the experimental group ($M = -20$, $t(29) = 13$, $P < .001$, Cohen $d = 1.9$) than in the control group ($M = -9$, $t(29) = 9$, $P < .001$, Cohen $d = 0.60$).

Regarding the DASH questionnaire, analysis of variance showed a main effect of time ($F(1, 58) = 71$, $P < .001$) indicating a significant improvement in function in the second measurement in both groups (Table 3). The analysis showed no effect of

TABLE 2. Demographic Data

	Control Group		Experimental Group		
	Mean	95% CI	Mean	95% CI	*P* Value
Age (y)	36	31–41	36	32–42	$t = -.07$ $P = .94$
AROM (deg) (pretreatment)	36	32–42	34	29–39	$t = .09$ $P = .39$
Sex	18 men / 12 women		23 men / 7 women		$P = .16$
Affected finger	12 (I), 5 (R), 10 (M), 3 (S)		11 (I), 10 (M), 6 (R), 10 (M), 3 (S)		$\chi^2 = .13$ $P = .99$

AROM, active range of motion; I, index finger; R, ring finger; M, middle finger; S, little finger; CI, confidence interval.

intervention ($F(1, 58) = 1.1$, $P > .05$) and no effects of the interaction between group and time ($F(1, 58) = 0.92$, $P > .05$). Improvement in function (DASH) between the first and second assessment was similar in the experimental and the control groups (respectively, M = −4, $t(29) = 5$, $P < .001$, Cohen $d = 0.45$; M = −5, $t(29) = 8$, $P < .001$, Cohen $d = 0.69$). Treatment of the experimental group did not produce any further improvement in function compared to the treatment of the control group.

TABLE 3. Pre- and Posttreatment Analyses (ANOVA) for AROM and DASH Outcomes

	Control Group Mean (95% CI)	Experiemental Group Mean (95% CI)
AROM (pre)	−37 (−42 to −32)	−34 (−39 to −29)
DASH (pre)	37 (27–52)	35 (23–61)
AROM (post)	−28 (−34 to −23)	−13 (−17 to −11)
DASH (post)	32 (21–47)	31 (20–57)

AROM, active range of motion; DASH, Disabilities of the Arm, Shoulder, and Hand questionnaire; CI, confidence interval; pre, pretreatment; post, posttreatment.

DISCUSSION

Although it is necessary to continue with research about the effectiveness of static and dynamic orthoses, these preliminary findings suggest that using them as a single treatment may be a viable alternative for improved active extension in the PIP joint.

Previous studies have suggested that for optimal results, the best period of intervention was between 3 weeks, when the collagen regeneration process starts, and up to 6 months (modulation phase).[7] Patients included in our study had sustained finger damage between 4 weeks and 6 months previously, which could be the reason that we found improvements in both groups.

The effectiveness of the use of orthoses in loss of movement of the PIP joint is the main objective in a great number of studies. Prospective studies such as those of Flowers and Lastayo, where serial orthoses were applied with application of local heat and exercises, demonstrated a greater improvement in the range of motion in the group where the orthotic was applied for longer.[7] In the Flowers and Lastayo study, however, there was not a control group with only orthotic treatment in order to determine the effectiveness of the orthotic intervention. In other experiments, dynamic orthotics were applied. Prosser suggested that changes in range occur in cases where the application of the orthosis was maintained for a longer period.[8] Bonutti validated this concept of best results with increased application time in a series of cases treated with static-progressive orthoses.[9] In that study, use of the orthotic for 30 minutes 3 times a day was proposed. During treatment, patients increased tightness every 5 minutes as tolerance permitted. Results showed a better cost–benefit analysis with this type of protocol than in protocols where the orthotic was maintained for a period. Nevertheless, similar to other studies, a control group was lacking, so we cannot confirm that the result was due to the application of the orthotics. Several studies have concluded that better results in both static and dynamic orthoses are obtained using long application times.[7–11]

We therefore cannot establish whether the treatment effect is due to the application of the orthotic device, because of other therapy interventions used in the studies, or even because of the natural evolution of the damage. This is perhaps one of the strengths of the present study, in which 2 different types of

orthotic device described previously in the literature were applied with long application times (6–8 hours) without any additional treatment.

We found an improvement in active extension in all participants regardless of the group that they were assigned to, with even better results in the range of the PIP joint in the experimental group. But function measurement with the DASH questionnaire, although reflecting a clear improvement, showed no differences between groups. This could be because patients did not perceive loss of movement at the PIP joint as a loss of function or because they may have already learned to compensate functionally for the loss of motion. Our main hypothesis regarding the DASH questionnaire was that it was not sensitive enough to detect changes in the active range of motion of the PIP joint.

Previous investigators have also concluded that there is no relationship between the level of dysfunction (DASH) perceived by the patient and the loss of mobility at the PIP joint level.[10–12] Others variables such as pain intensity should be included in future studies to determine the relationship between function and pain in deficits in the PIP joint range of motion due to the positive relationship between pain and function.

Further studies are necessary to determine how much each orthotic device contributes to the result and to propose future conservative treatments based on their application for a specified time before surgery. A cost–benefit analysis will also need to be carried out.

Our research data indicate a significant improvement in the range of motion in both groups, but especially in the treatment group. Future research could be focused on determining the impact that this improvement preoperatively may have on postoperative recovery. The improvement of active extension was significantly greater in the experimental group, and so the combined use of night static-progressive and daily dynamic orthoses as a single treatment during the proliferative phase may lead to significant improvements in PIP joint active extension. The effectiveness of different orthoses as a single treatment should also be determined. We must also considere future studies comparing one orthosis to another in order to determine the best device not only for flexion contracture resolution but also for patient satisfaction.

ACKNOWLEDGMENT

This trial is registered at clinicaltrial.gov with identifying number NCT 01914991.

REFERENCES

1. Lorea P, Medina Henriquez J, Navarro R, Legaillard P, Foucher G. Anterior tenoarthrolysis for severe flexion contracture of the fingers (the "TATA" operation): A review of 50 cases. *J Hand Surg Eur*. 2007;32(2):224–229.
2. Colditz JC, Schneider AM. Modification of the digital serial plaster casting technique. *J Hand Ther*. 1995;8(3):215–216.
3. Colditz JC. Therapist's management of the stiff hand. In: Hunter JM, Mackin EJ, Callahan AD, eds. *Rehabilitation of the Hand and Upper Extremity*. St. Louis, MO: Mosby Inc., 2002:1021–1049.
4. Akeson W, Arniet D, Abel M, Garfin S, Woo L-Y. Effects of immobilization on joints. *Clin Orthop*. 1987;(219):28–37.
5. Fess EE. A history of splinting: to understand the present, view the past. *J Hand Ther*. 2002;15(2):97–132.
6. Rosales RS, Delgado EB, Díez de la Lastra-Bosch I. Evaluation of the Spanish version of the DASH and carpal tunnel syndrome health-related quality-of-life instruments: Cross-cultural adaptation process and reliability. *J Hand Surg Am*. 2002;27(2):334–343.
7. Flowers K, LaStayo P. Effect of total end range time on improving passive range of motion. *J Hand Ther*. 1994;7(3):150–157.
8. Prosser R. Splinting in the management of proximal interphalangeal joint flexion contracture. *J Hand Ther*. 1996;9(4):378–386.
9. Bonutti P, Lee F, Hotz MW. Restoring wrist flexion/extension using principles of stress relaxation/static progressive stretch. Paper presented at: AAOS Scientific Presentation; February 6–7, 2003; New Orleans, LA.
10. Van Oosterom FJ, Ettema M, Mulder PG, Hovius SE. Impairment and disability after severe hand injuries with multiple phalangeal fractures. *J Hand Surg Am*. 2007;32(1):91–95.
11. Boccolari P, Tocco S. Alternative splinting approach for proximal interphalangeal joint flexion contractures: no-profile static-progressive splinting and cylinder splint combo. *J Hand Ther*. 2009;22(3):288–293.
12. Bracks C. Low profile extension splint for active extensor lag of the proximal interphalangeal joint. *J Hand Ther*. 2007;20(3):274–276.