

Research Paper: Proximal Interphalangeal Joint Flexion Contracture Treatment by Serial Casting Method and the Use of Thermoplastic Tape



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ABSTRACT

Objectives: Flexion contractures of the Proximal Interphalangeal joint are the most frequent complications resulting from surgical procedures and traumatic events. Orthotic interventions for the treatment of contractures may include serial splinting, serial casting, dynamic or static progressive orthoses, or a combination of these orthoses. This study aimed to determine the effects of serial casting methods using thermoplastic tape in the Proximal Interphalangeal (PIP) joint flexion contracture treatment.

Methods: Thirty-one patients with flexion contracture of the PIP joint (mean: 32.5°, range: 10-65°) were treated by serial casting method using thermoplastic tape. Flexion contracture, total active motion, extension lag and flexion gap were evaluated in the first session. The affected joint was casted after hand therapy interventions. Patients were requested to visit the clinic every other day for recasting and receiving exercises.

Results: After one month, the mean range of flexion contracture decreased from 32.5° to 10.7°. The mean range of flexion gap decreased from 3.2 cm to 1.8 cm. The mean range of extension lag decreased from 2.04 cm to 0.86 cm, and the mean range of total active motion increased from 81.67° to 128.81°. All of the aforementioned changes were statically significant ($P < 0.05$).

Discussion: The use of thermoplastic tape for serial casting is an effective and reliable method for the treatment of PIP joint flexion contracture.

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Highlights

- Flexion contracture of fingers is treated with a casting method.
- Casting with plaster of Paris is effective in reducing contracture but it may produce some complications.
- Thermoplastic materials are new casting materials that have benefits for serial casting.

Plain Language Summary

Flexion contracture of proximal interphalangeal joints of hand is a common condition resulting from injuries and trauma to hand. Sports injuries, finger and hand fractures, and tendon injuries might result in fixed flexion contracture. There are several ways to treat finger flexion contracture. One of the most effective treatments is serial casting. Serial casting with Plaster of Paris (PoP) material was used commonly in the past. Most recently with the improvement of available material for orthotic interventions, thermoplastic materials are more popular among therapists.

Using PoP causes a wide range of complications, such as skin lesions, limiting patient's performance in the activity of daily living, lack of patient's adherence to treatment, and so on. Thermoplastic material due to its antibacterial feature could resolve these problems. In this study, we decided to use thermoplastic tape instead of PoP to see if it is a good substitute for PoP. The results of this study revealed that using thermoplastic material is as effective as PoP in reducing flexion contractures of the finger. Furthermore, the patient's limitation reduces by the use of this type of material. The study patients were also satisfied using this kind of orthosis and report fewer skin complications. Therefore, thermoplastic material is a good choice for patients and therapists.

1. Introduction

The stiffness of finger joints is a prevalent complication following surgical procedures or traumatic events. The Proximal Interphalangeal (PIP) joints are particularly prone to stiffness and often develop flexion contractures [1]. This may be due to injuries to the joint surrounding tissues, the joint, edema, and poor positioning during immobilization after surgical procedures [2].

Significant improvements in regaining the range of motion in joints are often achievable through exercises and orthotic interventions [3]. Orthotic interventions vary from cylindrical serial casting method to dynamic orthotics. Modified Weeks Test (MWT) is a reliable method for therapists to decide which type of splint/orthotic is suitable for patients based on the joint responses to therapeutic interventions [4].

Dynamic orthoses with the use of traction devices, such as rubber bands or elastic threads, provide an extension in an affected joint and facilitate its flexion. Dynamic orthoses produce plastic deformation through creep. If the tissue is unloaded before failure occurs, it remains permanently lengthened as a result of its viscoelastic properties [5]. Serial static (serial casting) or static progres-

sive splints through the prolonged, constant load, can cause plastic tissues deformation via different processes [6] (stress relaxation).

The use of Plaster of Paris (POP) for serial casting method was first introduced by Paul Brand in India in the 1960s for treating stiff joints. As described by Brand, the technique is not a progressive stretching, but of growth. The cells of contracted tissue are stimulated to grow and become internally rearranged or modified by being held in maximum extension [7]. This process is time-consuming and the position of stiff joint must be held constant until remodeling occurs [8, 9].

The current research investigated the efficacy of serial casting method, using thermoplastic material instead of POP, in treating fixed PIP joint flexion contractures (regardless of the specific precipitating event). We also hypothesized that this intervention can increase the flexion range of motion and consequently decrease flexion contracture and flexion gap.

2. Methods

A power analysis indicated that a total sample size of 27 participants would provide 80% power with the alpha level of 0.05 to detect a medium effect size. To account

for an expected loss of 20% to 25% of patients, we enrolled 35 patients into this intervention.

The patients who gained 5-10° increase in passive ROM after therapeutic interventions in one session (heat, stretching and exercises) were included to be treated by serial casting method based on MWT [10]. The patients whose range of motion in the PIP joint increased more than 10° after the intervention or were unable to complete the therapeutic sessions or refused to participate in the study were excluded.

Finally, 31 adult patients with a flexion contracture of the PIP joint completed the study between May 2015 and February 2016. All individuals provided a written informed consent form prior to conducting the study. The Medical Ethics Committee of the University of Social Welfare and Rehabilitation Sciences approved the study protocol. Thirty-one patient with the Mean±SD age of 33.94±15.20 years participated in the study. Eleven (35.5%) patients were women and 20 (64.5%) were men (Table 1).

The mean measure of active PIP motion was 81.6°; (ranging from 10-179°). The average level of flexion contracture was 32.5° (ranging from 10-65°), and the average flexion gap was measured as 3.2 cm (ranging from 0.5 cm to 8.0 cm).

All patients with flexion contracture in their fingers were evaluated for an active and passive range of motion, as well as the degree of flexion contracture and flexion gap in the first session. After conducting a 45-minute therapeutic intervention, the patients were reevaluated, and those who gained ≤10° in the extension of PIP were enrolled into the study. Patients were visited every other day. After conducting the therapeutic interventions (paraffin wax, oil massage and passive and active joint exercises), PIP joint was casted in the newly gained range of motion.

Orficast thermoplastic tape was used instead of POP. The material was activated in hot water (68°C) for about one minute. During molding the material for casting the PIP joint, patients were requested to keep their hands in plus position to facilitate intrinsic muscles activities, to gain the most extension range of motion. After removing the Orficast from the hot water, it was gently dried with a towel and, molded on the patient's finger by wrapping and overlapping each layer to cover 50% of the previous layer (Figure 1).

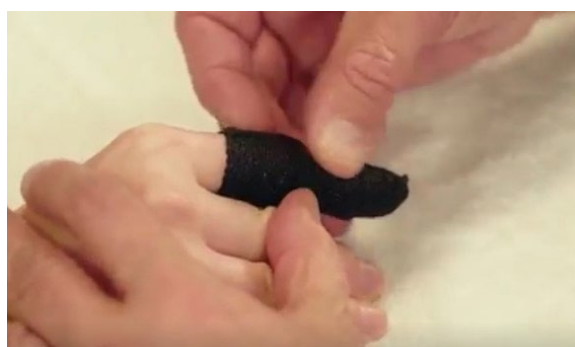
The affected finger was positioned in maximum possible extension with the MCP joint held in flexion. After 1 minute, the material was sufficiently hardened and could be removed for trimming as needed. The finger's skin color and circulation were evaluated at this time. If the splint was too tight, a new one was fabricated. All orthotic interventions were performed by an experienced occupational therapist.

After one month, the patients were reevaluated in terms of the range of total active motion, the contracture degree, extension lag and flexion gap. The range of motion was measured by a handheld Jamar goniometer placed on the dorsum of the finger. Flexion gap was measured using a ruler as the vertical distance from the tip of the finger to the distal palmar crease while the patients tried to make a fist.

Continuous variables (the active PIP range of motion, the degrees of contracture, flexion gap and extension lag) were compared before and after conducting the intervention by Paired Samples t-test. Spearman's correlation coefficient was used to detect the relation between dependent variables and independent categorical variables. Pearson's correlation coefficient was also used to detect the relation between continuous variables. Analysis of Variance (ANOVA) was applied to detect the differences between outcome measurements in the three groups of patients based on their referral time. SPSS was used for data analysis.

3. Results

The pre-test Mean±SD score of flexion contracture was 32.5±14.3. After conducting the intervention, it decreased to 11.6(=8.2). The mean range of flexion gap decreased to 1.43° (from 3.29±1.71 to 1.86±1.07). The difference in the active range of motion was statistically significant before and after the treatment (P=0:001, effect size: d=1.09) (Table 2). The difference in TAM (P=0.001),



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Figure 1. Wrapping Orficast over the patient's finger

Table 1. Demographic characteristics of the patients

Variables		N (%)
Gender	Men	20(64.5)
	Women	11(35.5)
Injured hand	Right	14(45.2)
	Left	17(54.8)
Time passed from injury (months)	0-6	2(6.5)
	6-12	7(22.6)
	≥12	22(71)
Total active motion at the baseline	Excellent	2(6.5)
	Good	3(9.7)
	Fair	6(19.4)
	Poor	20(64.5)

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flexion contracture ($P=0.001$, effect size: $d=2.23$), extension lag ($P=0.000$) and flexion gap ($P=0.000$) were statistically different before and after casting (Table 3).

There were no difference in TAM before and after interventions with regards to gender ($P=0.5$, Spearman's

$\rho=-0.12$), age ($P=0.7$, Pearson's $Rho=-0.15$), and time past from injury ($P=0.7$, Spearman's $Rho=-0.5$) in all patients. The difference in flexion contracture was statistically significant ($P=0.001$, effect size, $d=2.23$). Outcome measurements were independent from time passed from injury based on ANOVA results ($P>0.05$).

Table 2. Frequency of TAM after the treatment based on strickland criteria

Variables	%	
	Before	After
Total active motion	Excellent	45.5
	Good	9.7
	Fair	32.3
	Poor	12.9

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Table 3. Differences between variables at pre-test and post-test

Variables	Mean±SD		P
	Before	After	
TAM	81.67±39.85	128.81±38.35	0.001
Flexion gap	3.29±1.71	1.86±1.07	0.000
Extension lag	2.04±1.22	0.86±0.71	0.000
Flexion contracture	32.52±14.36	11.61±8.20	0.001

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4. Discussion

Flexion contractures can be treated by various kinds of orthotic or exercises, regardless of their causes. When the soft tissue is responsible for the contracture, it can be treated with orthotics. When the major problem is in the joints, it is suggested to use total end range time to keep the joint in its maximal tolerable range with continuous stress in the long term [11]. Cylindrical serial static method is among the treatment choices of this condition. The issue is always irritation of skin by POP during the long-time immobilization needed for treatment [12] (one month). Finding a substitution method to overcome this problem can help the patients and clinicians.

Our findings suggest that holding the contracted tissue over time can reduce contracture [13], which is consistent with previous studies [14, 15]. Many authors believe that long-term immobilization should be avoided due to the risk of losing motion. This idea does not hold merit with regards to the stiff joints and adherent tissues of hand and fingers. When live tissue is held under constant stress, more collagen will be produced; the tissue will overcome the adherence, and improvements in the range of motion will be noticeable [8].

A study on using plaster casts for the elbow, wrist, and finger flexion contractures, reported significant improvements in the range of motion [15]. Serial casting in the PIP joint was also reported to be beneficial in patients with rheumatoid arthritis, leading to improvements in their range of motion and decrease in their contractures [16]. Use of casting for 8 weeks, to manage crush injuries significantly improved the range of motion and decreased flexion contracture [17]. The benefit of using casting instead of dynamic orthosis was also reported [18]. This theory claims that the increased range of passive motion in a stiff joint is proportional to the amount of time the joint is held at its end range position, or total end range time.

Increasing joint flexion range of motion and decreasing contracture suggested the effectiveness of using this method for treating fixed contractures. Our results supported that this method can be used for the patients regardless of the time passed from their injury. Findings of this study confirmed that this method can be used on all genders and age categories. Besides the measured variables, we received no report of skin irritation. Moreover, patients were able to perform their Activities of Daily Living (ADL) with minimal limitations and precautions. The patients were also able to wash their hands during the day. There are some reports on the limitations and

problems with using POP [19], which can be eliminated with the use of Orficast.

The obtained results declared that cylindrical serial casting method with the use of thermoplastic tape is effective in the treatment of PIP joint flexion contractures, as well as using POP with fewer limitations.

We disregarded any criteria to evaluate satisfaction and skin irritation in the patients. The lack of a functional evaluation fails to provide important patient information on how the contracture interferes with ADL and how the use of an orthosis contributes to improvements. The lack of a control group or a parallel treatment group using POP was another limitation to this study.

5. Conclusion

Cylindrical serial casting can be considered in treating flexion contractures. Thermoplastic materials are appropriate substitutions for POP, without causing any long-term skin irritations.

Ethical Considerations

Compliance with ethical guidelines

The Medical Ethics Committee of the University of Social Welfare and Rehabilitation Sciences approved the study protocol.

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Authors contributions

All authors contributed in preparing this article.

Conflict of interest

The authors declare no conflict of interest.

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