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Dynamic Splint versus Static Splint and Active Range of Motion in Treatment of Post Burn Hand Contracture

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Abstract : The Purpose: of this study was to investigate the therapeutic efficacy of the dynamic splint versus the static splint combined with active range of motion in treatment of post burn hand contractures. **Methods:** Forty patients with post burn hand contractures of both sexes ranged in age from 18 to 40 years participated in this study. Patients was selected within 6 months from the injury they were assigned randomly into two groups of equal numbers (20 for each group). **Group (A)**: modified dynamic splint group. **Group (B):** static splint with active range of motion group.
Evaluation for range of motion was done by the radiological measurement, hand grip strength was assessed by Hand held Dynamometer and Jebsen hand functional scale was used to evaluation of hand function. **Results:** ROM of MCP and hand functional scale had significant increase after treatment application (Post-treatment) for dynamic group when compared with the static splint and active range of motion group, while there were a non-significant difference in the hand grip strength (Post-treatment) between both groups of the study. **Conclusion:** modified dynamic metacarpophalangeal joint flexion orthoses provide continuous flexion to metacarpophalangeal joint that is needed for the restoration of range of motion in post-burn hand contractures. For the clinical application of hand orthoses.
Key words: Hand Contracture, Dynamic Splint, Static Splint, Range of Motion, Orthotic devices, Rehabilitation, Burns.

Introduction

Burn trauma is still a significant cause of morbidity and mortality in the world. It causes a spectrum of disability and deformity primarily by damaging the integumentary system of the patient. Hands are the most frequent sites of burn injury and ranked as one of the three most frequent sites of burn scar contracture[1]. Joint motion disorder is mostly found in the finger joints of burned patients. Among fingers, metacarpophalangeal joint (MCP) is most commonly found affected about 29.4% of burned hands[2].

The prevention of contractures after burn injury is difficult, especially when specialized burn care is not available. Hence, post-burn contractures are very common medical health problems after burn injury especially in the developing world. Contracture is a frequent and undesirable secondary complication after hand burn. The

rehabilitation treatment after the acute phase aims to minimize the deformity of joints, to preserve the functional state and to let the patient be able to return to work and home[3].

The longer it takes a burn injury to heal, the more likely it is a burn contracture will form. Contractures usually appear when the scar line is vertical to the skin tension line, as in scars across a joint [4]. Burns to the hand are common. Most are small and confined to the upper limb but some are part of a major burn. Although the hand comprises a small surface area 3%of TBSA It classified as severe injuries management of a hand burn assumes a high priority because of its functional importance. In more than 80% of severely burned patients, the hand is involved[5].

Even though hand burns do not often play a major role in mortality, they are important factors in successful re-integration into society and professional life Apart from functional rehabilitation, aesthetic outcome must be considered since hands cannot, similar to the face, be hidden by clothes so easily[6]. Joint motion disorder is mostly found in the finger joints of burned patients. Among fingers, metacarpophalangeal joint is most commonly found affected about 29.4%.of burned hands[2].

There are two key elements in burn contracture treatment, splinting of the burned area in its anatomic position and regular exercises through each joint's full range of motion. Splints are a highly effective method of helping prevent and manage burn contractures and are an integral part of comprehensive rehabilitation programmers [3].

Splinting is a common burn care intervention strategy based on logical anatomic and biomechanical principles. Regular exercises allow restoring some or all of the grip strength, mobility of the hand and returning to normal daily activities. Positioning and splinting are crucial components of a comprehensive burn rehabilitation program that emphasizes contracture prevention. The emphasis of these devices throughout the phases of rehabilitation fluctuates to meet the changing needs of patients with burn injury. Early, effective, and consistent use of positioning devices and splints is recommended for successful management of burn scar contracture[8].

So the main aim of this study is to investigate the therapeutic efficacy of the dynamic splint versus the static splint combined with active range of motion in treatment of post burn hand contractures by using various methods of evaluation (Radiographic measurement, Dynamometer and Hand function scale).

Subjects and Method

Subjects

Forty hand burn patients with limited range of motion at the metacarpophalangeal joints were recruited from outpatient clinic of Plastic Surgery department in Assuit University Hospital. Their ages were range from 18 to 40 years from both sexes. Patients who had forth degree burn, amputation, fracture in the hand, degenerative joint diseases in the hand, open wounds, peripheral nerve disorders or cervical radioculopathy were excluded from the study All patients were given a full explanation of the treatment protocol and a written informed consent form giving agreement to participation and publication of results was signed by the patients. The patients were randomly assigned into two groups of equal numbers (20 for each group) **Group (A)**: modified dynamic splint group. **Group (B):** static splint with active range of motion group.

Instrumentation

Measurement and tools

Radiographic measurment:

Philips Omni x-ray machine was used for radiographic measurement for ROM assessment of MCP joint[9].

Dynamometer:

Hand held dynamometer (HHD) was used to measure hand grip strength. A hand-held dynamometer with a high upper limit of force (exceeds 650N) to obtain reference values for hand grip strength.

Hand functional scale;

Jebsen hand functional test stated to assess disability and the effectiveness of treatment it's important to be able to evaluate the functional capabilities of a patient, one of the most important of which is hand function [10].

Treatment tools

Dynamic splint:

Fabricated dynamic splint fitted to the back of the hand made from Koreans the material which suitable for patient state. The splint applied continuous flexion of the second through fifth metacarpophalageal joints for treatment of dynamic group patients.

Static splint

Fabricated static splint fitted to the back of the hand made from thermoplastic the material which suitable for patient state. It was used in the treatment of static group patients.

Assessment procedures

Active range of motion was measured by radiographic assessment for ROM the vertical midline of the distal phalanges and The metacarpal bones in the palm of the hand were used as lines of reference for measurement. These lines correspond to the anatomical axes of movement at the metacarpophalageal (Figure 1) [9], grip strength was measured by hand held dynamometer (Figure 2) and hand function assessed by Jebsen hand function scale. All parameters were estimated at the beginning and the end of the treatment after 8 weeks.

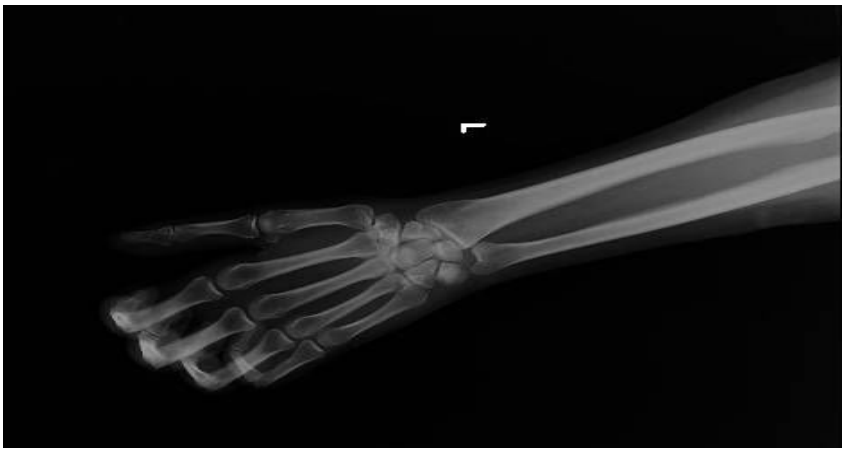

Figure (1): Radiographic measurement of ROM.

Figure (2): Hand held dynamometer.

Treatment procedures

Both groups received the standard rehabilitation therapy focused on hand therapy as following:.

- Move each joint of the patient's hand individually by stabilizing the proximal bone with the index finger and thumb of one hand and moving the distal bone with the index finger and thumb of the other hand.
- Exercise, performed multiple times throughout the day**.** MCP Joints of the Fingers: Flexion and Extension and Abduction and Adduction.
- Active ROM performed isolated joints before composite ROM. Composite ROM is required to provide maximal tissue elongation and treat scar contracture of the hand [11].

Dynamic group received the modified dynamic (Figure 3) metacarpophalangeal joint flexion orthoses to control contracture of the metacarpophalangeal joint for 3 hours per day for 8 weeks. Static group received static splint (Figure 4) worn as a night splint each day for a time periods of 8 weeks. Exercise, performed multiple times throughout the day.

Figure (3) Applied dynamic splint of the second through fifth metacarpophalageal joint.

Figure (4) Application of static splint .

Statistical Analysis

Statistical analysis was conducted using SPSS for windows, version 18 (SPSS, Inc., Chicago, IL). The data regarding to the patients age, sex, weight, height, and BMI were collected before entry of the study. The data regarding to ROM of 2nd, 3rd, 4th, and 5th MCP joints, to hand grip strength and to hand function were collected before and after 8 weeks of treatment. Descriptive statistics in form of mean and stander deviation were calculated for all patients in both groups. Paired test was used to compare the dependent variable, within each group. Unpaired t test was conducted to compare hand grip strength, ROM of 2nd, 3rd, 4th, and 5th MCP joints between both groups in the "before" and "after" treatment with the alpha level 0.05.

Results

Baseline and demographic data

There were no statistically significant differences (P>0.05) between subjects in both groups concerning age, weight, height, and BMI (Table 1).

Table (1):General characteristics of all patients

	Age (years)		**Height (c.m)**		**Weight (k.g)**		**BMI**	
Group	**Group (A)**	**Group (B)**	**Group (A)**	**Group (B)**	**Group (A)**	**Group (B)**	**Group (A)**	**Group (B)**
Mean±SD	39.98 ±2.656	39.19 ±2.721	169.50 ±9.77	166.10 ±9.19	72.65 ±11.22	71.45 ±11.13	25.15 ±2.00	25.89 ±3.44
t-value	0.801		1.13		0.34		-0.84	
p-value	0.430		0.264		0.736		0.408	
Level of sign.	N.S.		N.S.		N.S.		N.S.	
N.S. : no significant difference								

Metacarpophalangeal joint (MCP) ROM:

As indicated at table (4) and illustrated at figure (3) the mean ± SD values of the 2^{nd} , 3^{rd} , 4^{th} and 5th MCP joints ROM in dynamic group before treatment was 55.72±5.36, 54.83±4.6, 56.08±5.03and 48.66±5.26 respectively and after treatment was 74.5±5.43, 74.58±4.54, 77.33±6.42and 73.25±6.42 respectively. the mean ± SD values of the 2^{nd} , 3^{rd} , 4^{th} and 5th MCP joints ROM in static group before treatment was 51.41±5.31, 54.66±4.83, 55.08±5.23 and 53.18±6.36 respectively and after treatment was 54.5±4.21, 61.25±4.33,

62.08±5.23 and 63.08±7.39 respectively. Paired t-test revealed that there was a significant increase of the 2nd , 3rd , 4th and 5th MCP joints ROM after treatment application for Dynamic Group with P-value ≤ 0.05. Also there was a significant increase of the 2nd, 3rd, 4th and 5th MC ROM after treatment application for Static Group with P-value ≤ 0.05.

As shown at table (5) Unpaired t-test showed that there was no significant difference in the before treatment mean values of 2nd, 3rd, 4th and 5th MCP ROM between both groups (dynamic group and static group) with p-value= 0.067, 0.932, 0.638 and 0.077).

There was significant difference (p-value< 0.05) in the after treatment mean values of 2nd, 3rd, 4th and 5th MC ROM between both groups (dynamic group and static group) with favor to the dynamic group

Table (3): Comparison between Mean ±SD of the 2nd , 3rd , 4th and 5th MCP joints ROM before and after treatment in each group (dynamic and static):

MCP ROM	Dynamic Group			Static Group		
	Before	After	P-value	Before	After	P-value
2nd MCP	55.72±5.36	74.5±5.43	0.000*	51.41±5.31	54.5±4.21	0.003*
3rd MCP	54.83±4.6	74.58±4.54	0.000*	54.66±4.83	61.25±4.33	0.000*
4th MCP	56.08±5.03	77.33±6.42	0.000*	55.08±5.23	62.08±5.23	0.000*
5th MCP	48.66±5.26	73.25±6.42	0.000*	53.18±6.36	63.08±7.39	0.000*

Table (4): Comparison between Mean ±SD of the 2nd, 3rd, 4th and 5th MCP joints ROM between groups (dynamic and static) before and after treatment:

MCP ROM	Before treatment			After treatment		
	Dynamic Group	Static Group	P-value	Dynamic Group	Static Group	P-value
2nd MCP	55.72±5.36	51.41±5.31	0.067	74.5±5.43	54.5±4.21	0.000*
3rd MCP	54.83±4.6	54.66±4.83	0.932	74.58±4.54	61.25±4.33	0.000*
4th MCP	56.08±5.03	55.08±5.23	0.638	77.33±6.42	62.08±5.23	0.000*
5th MCP	48.66±5.26	53.18±6.36	0.077	73.25±6.42	63.08±7.39	0.002*

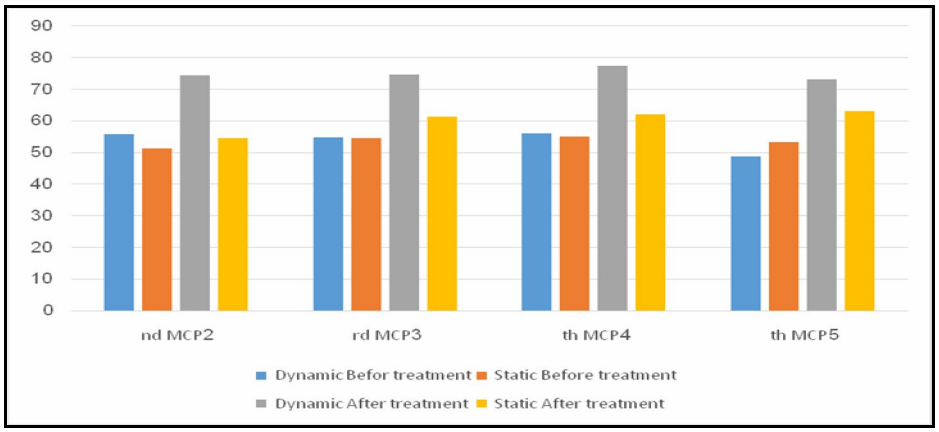

Figure (1): Mean values of the MCP joint ROM in both groups before and after treatment.

Hand grip strength:

As presented in table (3) and illustrated in figure (2) the mean ± SD values of Hand grip strength before treatment and after treatment was **10.5±3.6** and **20.08±4.48** respectively in dynamic group and **9.5±3.6** and

17.25±4.09 respectively in static group. Paired t-test revealed that there was significant improvement of hand grip strength in dynamic group and static group with p-value <0.001 with percentage of improvement 91.23 % and 81.57% respectively. Unpaired t-test showed that there was non-significant difference in the hand grip strength before treatment and after treatment between both groups of the study p-value= **0.504 and 0.12** respectively.

Table (2):Comparison between Mean ±SD of Hand grip strength before and after treatment in each group, and between groups (dynamic and static):

Hand Grip Strength	Means ± SD Pre test	Means ± SD Post test	% of improvement	t-value	P- value
Dynamic group	**10.5±3.6**	**20.08±4.48**	91.23%	-23	0.000*
Static group	**9.5±3.6**	**17.25±4.09**	81.57%	-31	0.000*
t-value	**-0.679**	**-1.617**			
P- value	**0.504**	**0.12**			

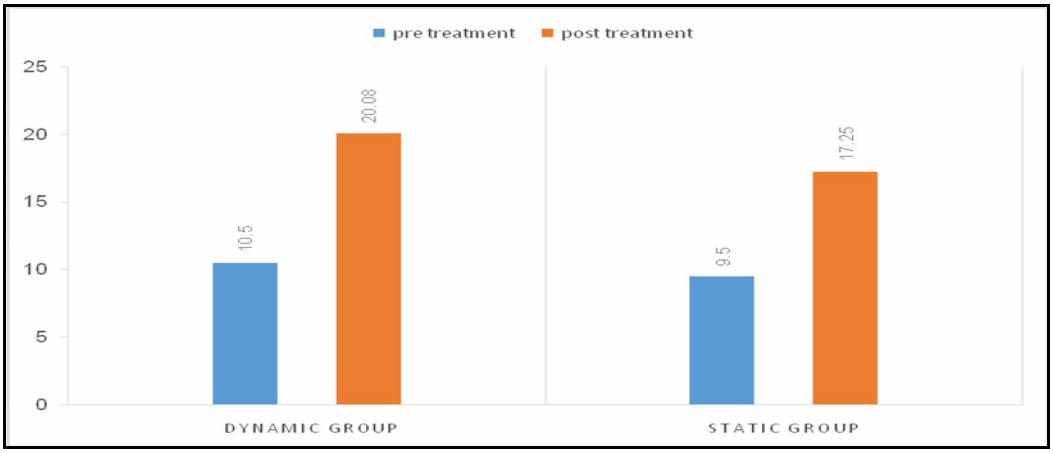

Figure (2):Mean ±SD of Hand grip strength before and after treatment in both groups (dynamic and static).

Function hand scale :

As presented in table (2) and illustrated in figure (1) the mean ± SD values of Function hand scale before treatment and after treatment was **17.05±1.07**and **16.55±2.28** respectively in dynamic group and **8.99±1.42** and **13.3±1.74** respectively in static group. Paired t-test revealed that there was significant improvement of function hand scale in dynamic group and static group with p-value <0.001 with percentage of improvement 47.27 % and 19.63% respectively. Unpaired t-test showed that there was non-significant difference in the function hand scale before treatment between both groups of the study p-value= **0.507**. After treatment there was non-significant difference in the function hand scale between both groups of the study p-value <**0.0001** with better results in dynamic group.

Table (3):Comparison between Mean ±SD of Function hand scale before and after treatment in each group, and between groups (dynamic and static):

FUNCTION HAND SCALE	Means ± SD Pre test	Means ± SD Post test	% of improvement	t-value	P- value
Dynamic group	**17.05±1.07**	**8.99±1.42**	47.27%	56.042	0.000*
Static group	**16.55±2.28**	**13.3±1.74**	19.63%	18.839	0.000*
t-value	**0.674**	-6.648			
P- value	**0.507**	0.000			

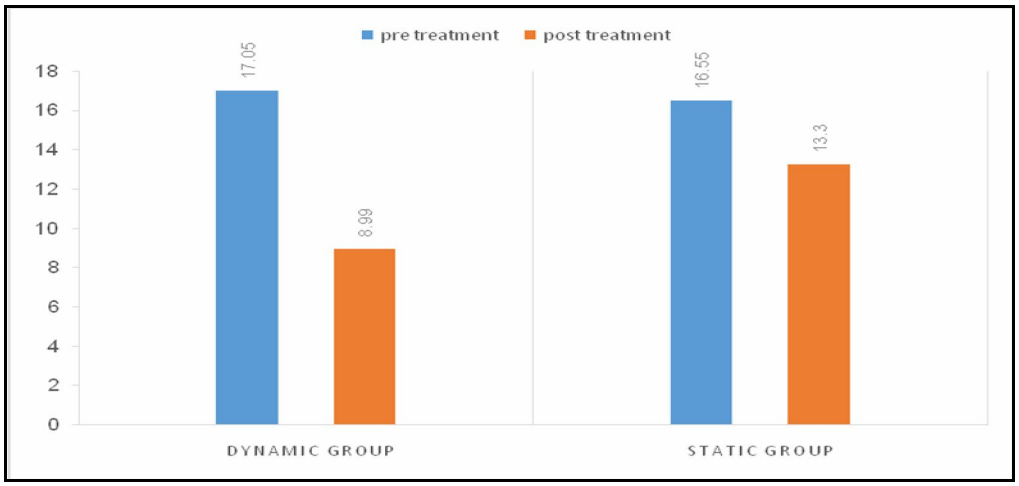

Figure (3):Mean ±SD of Function hand scale before and after treatment in both groups (dynamic and static)

Discussion

This study investigated the therapeutic efficacy of the dynamic splint versus the static splint combined with active range of motion in treatment of post burn hand contractures by using various methods of evaluation (Radiographic measurement, Dynamometer and Hand function scale). The results of current study revealed that there was significant improvement of Function hand scale in favor of dynamic group. Also there was significant improvement of 2nd, 3rd, 4th and 5th metacarpophalangeal joint ROM and hand function in favor of dynamic group. While, there was no significant difference in hand grip strength between dynamic group and static group.

The result of the current study supported by Lindenhovius, Doornberg [12] who tested the null hypothesis that there is no difference in improvement of motion and Disabilities of the Arm, Shoulder and Hand (DASH) scores between static progressive and dynamic splinting on sixty-six patients with post-traumatic elbow stiffness Elbow function was measured at enrollment and at three, six, and twelve months later. Patients completed the DASH questionnaire at enrollment and at the six and twelve-month evaluation. Post-traumatic elbow stiffness can improve with exercises and dynamic or static splinting over a period of six to twelve months, and patience is warranted. There were no significant differences in improvement in motion between static progressive and dynamic splinting protocols, and the choice of splinting method can be determined by the patients and their physicians.

The result of this study came in accordance with [13] who compared the outcomes of dynamic and static splinting postoperatively. Of the 57 patients managed by split grafts, 36 (44 hands) had Kirschner (K) wires applied with static splints, whereas 21 (26 hands) had dynamic splinting. The mean age was 11 (range 2–37) and 15 (range 2–50) years in the two groups. Before and after the operation, basic hand functions were evaluated clinically, and the results analyzed statistically. The mean follow-up times were 18 and 14 months respectively, and recurrence rates were 22% and 14%. The results showed that the postoperative dynamic splinting is superior to fixation with K-wires with or without static splints.

The result of this study came in consistent with _ENREF_8[14] compared the application of constant tension to elongate tissue using a static splint versus the use of dynamic splint to achieve tissue creep and full elbow extension. This case report demonstrates for this patient the superiority of a dynamic elbow extension splint over a static splint when used to correct progressive loss of elbow range of motion.

It can explained that Dynamic splint is an effective method for increase the hand joints (2nd, 3rd, 4th, 5th Me put joints) ROM and enhancing the hand function in the post burn patient with hand contractures as the dynamic splint use tow mechanical properties creeping and stress relaxation. Creeping is using constant force applied by the dynamic split lead to continuous deformation of the tissues under constant. Stress relaxation viscoelastic property of materials in which the displacement is constant and the force varied over time. Stress

relaxation viscoelastic properties causing the material to reach plastic deformation state more quickly than applying creeping based loading

Conclusion

The modified dynamic metacarpophalangeal joint flexion orthoses provide continuous flexion to metacarpophalangeal joint that is needed for the restoration of range of motion in post-burn hand contractures with superior results than the static hand splint. For the clinical application of hand orthoses in patients with hand disorders, additional research into its affects are required.

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