Role of Mechanical Strengthening Exercises on Hand Grip Following Dorsal Skin Graft

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ABSTRACT

The purpose of the study was to investigate the efficacy of mechanical strengthening exercises on hand grip strength following early excision and graft of dorsal hand burn. Forty male patients with age ranged from 20-40 had early excision and graft of dorsal hand burn due to thermal agent were included in the current study. They were recruited from burn unit of Kasr El-Aini Hospital, Cairo, Egypt. They were randomly divided into two equal groups: Group (A) (control group); who consisted of 20 patients received traditional physical therapy program (positioning, splinting, ultrasonic and exercises) and Group (B)(mechanical strengthening exercises MSE); who consisted of 20 patients received mechanical strengthening exercises in addition to the same traditional physical therapy program. All patients were underwent same medical, nursing and wound care management. Dynamometer was used to measure hand grip strength. Measurements were made after three and seven weeks of skin graft operation. The results of this study showed that, there were statistical significant difference in both groups but it was observed that all results concerning grip strength in group B had greater statistical significance improvement than the results concerning the same results of group A. It was concluded that mechanical strengthening exercises might be considered as a useful therapeutic tool in the management of post operative reconstruction of hand burn (skin graft) with the traditional physical therapy program than traditional physical therapy alone.

Key words: *Hand held dynamometer, Thermal burn, Skin graft, Grip strength, Mechanical strengthening exercises, Physical therapy.*

INTRODUCTION

Even though the hands constitute only 5% of the total body surface area (TBSA), thermal injury in the hands is not only one of the commonest burns but also one of the most difficult pathologies for burn surgeons to treat. Although rarely life-threatening, thermal trauma to the hands affects the extensor surface in the majority of cases and constitutes a major trauma that is disproportionate to the small body surface areas involved[1]. Recent analytical studies concerning injuries have established that the hand and wrist are affected in 35.8% of cases. Dorsum hand burns are usually in both hands. As the hand by reflex action clenches and covers the face. Dorsum skin is thin and has less subcutaneous tissue therefore it is liable to deeper burns which usually affects tendons, muscles, bones, and joints. Digital adhesion and joint stiffness are the consequence of burn depth, long-lasting edema, and local bacterial infection, causing connective tissue proliferation, stiffness, and contractures, with various hand deformations[2].

Restoration of normal hand function in these patients is a goal that is necessarily subordinate to sustaining life. Although it is generally agreed that the management of a critical burn patient should be primarily directed at the patient's survival, burned hands should never be neglected, since the majority of cases of post-burn morbidity, as well as the most devastating sequelae of thermal injuries, are related to hand burns[3]. The pathological changes produced by thermal injury to the hands are of multiple origins. Some are unavoidable, as a result of direct injury to various tissues and structures. In burned hand, the presence of edema, pain, inactivity and subsequent muscle wasting tend to greatly affect hand function and grip in acute phase of burn injury[4].

Motor control of grip is essential in daily life. As well as, grasping and transporting object is a frequently encountered task and its dysfunction can severely impact the patient's normal living[5].

Hand grip is one aspect of hand function which is highly objective and reliable measurement[6]. Assessment of grip strength

with dynamometry was the most common method of reporting motor outcome. Early post-operative power grip strength showed that values initially decreased and coincides with the assessment of pillar or scar pain or tenderness where higher pain scores were reported in the early post operative phase[7].

Mechanical strengthening exercise can improve the overall quality of life and reduce the symptoms of many clinical disorders. The effects of mechanical strengthening exercise on skeletal muscle are mediated by activation of muscle-specific signaling cascades that increase muscle mass, cytoskeletal protein levels and the force of contraction[8]. Repeated high-resistance exercise will result in a measurable increase of muscle size and strength. Delorme was the first to distinguish in a scientific paper between the adaptations to resistance and endurance exercise; he advocated the use of high-resistance exercise rather than endurance exercise for stimulating muscle hypertrophy. The American College of Sports Medicine (ACSM) currently recommends sets of resistance exercise with an 8–12 repetition maximum for promoting muscle growth and strength[9].

SUBJECTS, MATERIALS AND METHODS

Subjects

Forty male patients who had early excision and graft of dorsal hand burn due to thermal agent were included in the present study. They were selected from burn unit of Kasr El-Aini Hospital, Cairo, Egypt. Diagnosis and selection of the patients was made clinically by the plastic surgeons. The patients were randomly classified into two equal groups: group (A) (Control group); which was consisted of 20 patients who received a traditional physiotherapy program in forms of (positioning, splinting, ultrasonic and exercises) two sessions daily for four weeks period (one day rest every week) and group(B) (mechanical strengthening exercises) which was consisted of 20 patients who received a traditional physiotherapy program and mechanical strengthening exercises, two sessions daily for four weeks period (one day rest every week) after the complete healing of the skin graft which was detected by the plastic surgeons (usually being three weeks post- operative).

Inclusive criteria:

Patient's age was ranged from 20 to 40 years, the affected or treated site was dorsal hand, which had early excision and graft due to thermal burn injuries, the type of skin graft was auto graft, patient's sex was male and all patients had no associated injuries after burn.

Exclusive criteria:

Patients with neurological diseases, bone injuries, infections, vascular disease or rheumatoid arthritis would be excluded.

Equipment

(I) Therapeutic Equipment:

1-Hand held jamar dynamometer device:

It used for assessment. Sammons Preston Co. manufactures it, Chicago, USA. It provides simple adjustment for five size position and permits maximal isometric contraction. The readout of dynamometer dial is represented in pound and in kilograms. It is graded from zero till two hundred pounds and from zero to ninety kilograms[10,11].

2-Ultrasonic device:

Electronica Pagani Company, model T20, it's serial number is 719/1998, 230V, 50/60 Hz, maximum out put is 3W/Cm2 and made in Italy to enhance healing of skin graft.

(II) Measuring Equipment:

Hand held jamar dynamometer was used to asses the hand grip strength.

Procedures of the study:

(I) Assessment procedures:

*Steps for grip strength measurement:

Hand held dynamometer was used to measure the strength of hand muscles. The dynamometer was set on second handle position which is commonly used to measure strength of intrinsic and extrinsic hand muscles. The patients were instructed to assume the sitting position with back support while the affected limb was placed in shoulder adduction and internal rotation, elbow flexion, forearm in mid position and wrist in neutral position. The patients were instructed to squeeze the dynamometer as much as possible. Measurement of hand grip strength was

conducted before initial treatment (after three weeks post operative) and after the final session (after seven weeks post operative). Each measurement was repeated three times to establish intra-rater reliability. The mean strength value of the three trials was calculated and considered as the hand grip measure[11].

(II)Treatment procedures:

1-Positioning:

Positioning of the hand was closely integrated into a total program for function. Hand would properly positioned during acute period. It would be positioned in anti-deformity position and not in functional position[12].The correct hand positioning was maintained at all time except during exercises as well as debridement and activities of daily living, and it was initiated with elevation of the upper limb to reduce edema[13].

2-Splinting:

The splint was applied within the first 48 to 72 hours post burn, to avoid dramatic changes in edema and development of compartmental syndrome[13,14]. Splinting of burned hand was applied in anti-deformity (approximately 0 to 30 degrees wrist extension, 90 degrees metacarpophalangeal flexion, 0 degrees proximal interphangeal and distal interphalangeal flexion depending on depth of burn and thumb abduction with slight interphalangeal flexion)[12].

3-Therapeutic exercises:

Range of motion exercise was begun from the first day of admission of the burned patients[15]. Patients were exercised at least one time daily. Several short exercises session of 8 to 10 repetition of each exercises were often more effective than a single session. Slow and complete motions were encouraged rather than short jerky movement[16].

4- Ultrasonic treatment:

From 7to14 day post grafting ultrasonic was given in form of 0.5 W/cm^2 pulsating wave 20%at1MHz for five minutes around the edge of the skin graft and from 14 to 21 day it was given in the form of $0.1W/cm^2$ continuous wave at 3.0 MHz for five minutes around the edge of the skin graft[3].

5-Mechanical strengthening exercise procedures:

Using the hand held dynamometer by the Delorme technique:

(1) Determine the 10RM:

*Patient position:

The patients were instructed to assume the setting position with back support, 90 degree of elbow, the arm adducted and internal rotated, the forearm and wrist would be maintained in the neutral position resting on a table catching the dynamometer which was settled at the second handle position and measurement would be repeated ten times, then taking the mean value of the ten trials to be the (10 RM). This would be repeated pre the start of second, third and fourth week for a new (10RM) each week.

*Therapist position:

Standing beside patient holding around the readout prevents it from dropping.

(2) Strengthening procedures:

Patient and therapist position as pervious. Patient made 10 repetitions at 1/2 of the 10 RM, 10 repetitions at 3/4 of the 10 RM and 10 repetition at the full of the 10 RM as one bout. Patient carried out three bouts each session having a brief rest in between[17,18].

Data analysis

Paired t-test was conducted to compare before and after treatment in the same group in each group. Un paired t-test was conducted to test mean differences between two various groups. Data analysis and the level of significance were set at the level 0.05 level.

RESULTS

I- Results of Control Group (Group A)

Results of Grip Strength Measurement:

Regarding to table (1) and Fig. (1): the mean value of grip strength pretreatment was 2.5±0.604 Kg, While the mean value of grip strength after seven weeks of skin graft operation (post) was 5.18.±1.075 Kg, the table revealed that there were highly statistical significant ($P<0.01$) increased of grip strength (post) when compared with corresponding mean values (Pre) with a percentage of improvement of 107.5% after seven weeks of skin graft operation (post).

Table (1): The statistical analysis of mean differences of grip strength (Pre) and (post) for control group (Group A).

Statistics	Grip Strength (Kg)	
	Pre	Post
Mean	2.5	5.18
SD±	0.604	1.075
Max.	3.9	7.6
Min.	1.8	3
MD	-2.68	
t-value	10.526	
P-Value	0.01	
Significant	↑ Sig.	
% of Change	107.5%	

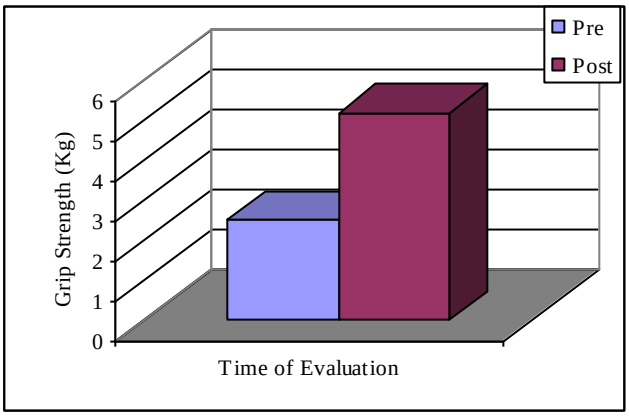

Fig. (1): Shows the mean values of grip strength Pre and post treatment for control group (Group A).

II- Results of MSE group (group B):

Results of Grip Strength Measurement:-

Regarding to table (2) and fig (2): the mean value of grip strength before initiation of MSE (Pre) was 2.79±0.73 Kg, while the mean value of grip strength after seven weeks of skin graft operation (post) was 6.56±1.04 Kg. The table also showed that, there were highly statistical significant (P<0.01) increased of grip strength after seven weeks of skin graft operation (post) when compared with corresponding mean value after three weeks of skin graft (Pre) with a percentage of improvement of 135.1%.

Table (2): The statistical analysis of mean differences of grip (Pre) and (post) treatment MSE group (Group B).

Statistics	Grip Strength (Kg)	
	Pre	Post
Mean	2.79	6.56
SD±	0.73	1.04
Max.	4.3	8.5
Min.	1.8	4.8
MD	-3.77	
T-value	14.25	
P-Value	0.01	
Significant	↑ Sig.	
% of Change	135.12%	

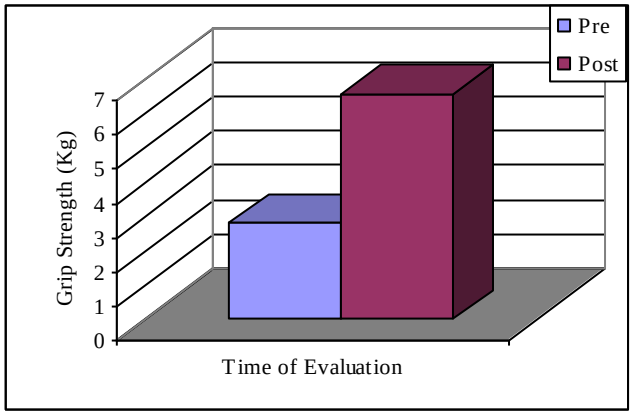

Fig. (2): Shows the mean values of grip strength Pre and post treatment for MSE group (Group B).

III-***Comparative Analysis between Groups of the Study:***

Comparative Analysis of Patients Demographic data:-

As observed in table (3); the comparative analysis of mean difference of age, revealed that there were no statistical significance differences (P>0.05).

Table (3): Comparative analysis of mean differences of patients age between group A and group B.

Statistics	AGE (Years)	
	Group A	Group B
Mean	24.95	23.45
SD±	4.21	5.7
MD	1.5	
t-Value	0.94	
P-Value	0.35	
Significance	NS	

(b) Comparative analysis of results of grip strength between groups of the study:-

As shown in table (4), and fig. (3), the statistical analysis of mean differences of grip strength between the two groups of the study (Pre) and (post) treatment, revealed that there were no statistical significant (P>0.05) difference of the mean values of grip strength after three weeks of skin graft operation (Pre) between both groups of the study while there were highly statistical significant (P<0.01) increased of the mean values of grip strength after seven weeks of skin graft operation (Post).

Table (4): Comparative analysis of the mean value of grip strength (Pre) and (post) treatment for both groups of the study.

Statistics	Grip Strength (Kg)			
	Pre		Post	
	Group A	Group B	Group A	Group B
Mean	2.5	2.79	5.18	6.56
SD±	0.604	0.73	1.075	1.04
MD	-0.29		-1.38	
t-value	1.36		4.108	
P-value	0.18		0.01	
Significant	NS		Sig.	

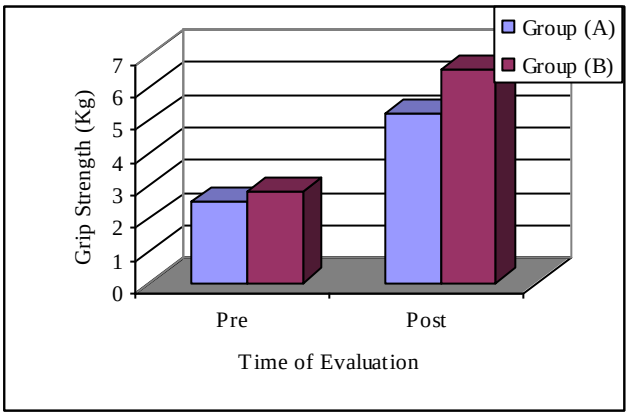

Fig. (3): Shows the mean values of grip strength (Pre) and (post) treatment for both groups of the study.

DISCUSSION

This study was designed to investigate the efficacy of mechanical strengthening exercises on hand grip strength following early excision and graft of dorsal hand burn. As the hand is the useful human tool with a remarkable capacity to perform precise movements needed in daily living activities as grasping, touching and manipulating objects[19]. Burn to hand, although usually not life threatening, but can cause both physical and functional disability as well as cosmetic problems. These problems result from the direct effect of heat, or from secondary effect of edema, pain, immobilization, disuse atrophy, soft tissue loss, contractures formation and inadequate or inappropriate splinting. Therefore, early management of these changes helps to decrease edema, restoration of hand functions and decrease period of hospitalization[20].

In this study; forty male patients with age 20-40 had early excision and graft of dorsal hand burn due to thermal agent were randomly divided into two equal groups. Group (A);which received a traditional physiotherapy program (which consisted of: positioning, splinting, ultrasonic and exercises), two sessions daily for four weeks period (one day rest every week) and group (B); which received mechanical strengthening exercises (using hand held dynamometer by delorme technique), two sessions daily for four weeks period (one day rest every week) after complete healing of the skin graft which was detected by the plastic surgeons in addition to traditional physical therapy program.

In the current study; hand grip strength was used as a measurement of mechanical strengthening exercises effect on hand grip (using hand held dynamometer). The measurement procedures were conducted after three weeks of skin graft operation (pre) and after seven weeks of skin graft operation (post).

In this study, all factors that might affect the parameters of the study had been controlled including age, duration from burn injury, type of skin graft, times of evaluation. Pre-applications data obtained were evaluated and compared with no significant differences between the two groups.

The results of this study revealed that mechanical strengthening exercises was an effective therapeutic modality in improving grip strength in mechanical strength exercise group(MSE) as compared to control group receiving traditional physical therapy only.

By comparing the results of both groups, it revealed that, there were no statistical

significant (P>0.05) difference of the mean value of grip strength after three weeks of skin graft operation (Pre) between both groups of the study, while there were highly statistical significant (P<0.01) increased of the mean value of grip strength after seven weeks of skin graft operation (Post) between both groups of the study.

The results of the current study come in agreement with the results of study done by Brighton et al.,[21] who studied the effect of a long term exercise on rheumatoid hand function "grip and pincer grip strength" and they concluded that it would appear that regular home strength exercise program for hand was effective in improving hand function. Barillo et al.,[22] designed a study to evaluate the utility of a standardized system for the acute management of burns to the hands and upper extremities; in this study they used splinting, CPM and active resisted exercises provided by work simulator and they concluded that the use of this protocols allowed timely completion of soft tissues closure, rapid return of grip strength and total active motion indices to functional levels by the time of burn center discharge. As well as O'Brien et al.,[23] decided that a program of strengthening exercise for hand in rheumatoid arthritic patient was more beneficial compared with simple stretching or advices alone in improving hand functions including grip strength. Nossier and Abo Elnaga[24], applied a study to evaluate the effect of continuous passive motion device (CPM) on hand function in patient with hand burns injury (second degree burn). In this study they used positioning, active ROM exercises, splinting and CPM and they concluded that the use of this protocols increase hand grip strength by 111.56 %. Our results also confirmed by Guzelkucuk et al.,[25] who concluded that therapeutic exercise in form of passive, active assisted and strengthening exercise was successful in improving hand function in patient with hand injuries. In addition Harth et al.,[26] evaluate the effectiveness of patient hand rehabilitation program on hand ROM, grip and pinch strength and they decided that this program was more effective and cost saving as well as it improved hand function.

It was concluded that mechanical strengthening exercises using hand held dynamometer is an effective modality in improving hand grip strength following early excision and graft of dorsal hand burn.

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الملخص العربي

دور تمرينات التقوية الميكانيكية علي قبضة اليد تبعا لترقيع جلد ظاهر اليد

الهدف من البحث الحالي هو معرفة دور تمرينات التقوية الميكانيكية علي قبضة اليد تبعا لترقيع جلد ظاهر اليد وذلك من خلال معرفه مدي زيادة قوة قبضة اليد. اشترك في البحث أربعون مريضا من الرجال تم تقسيمهم إلي مجموعتين: المجموعة الأولي وتم علاجها ببرنامج العلاج الطبيعي التقليدي و المجموعة الثانية وتم علاجها بتمرينات التقوية الميكانيكية بالاضافه إلي برنامج العلاج الطبيعي التقليدي وتم علاج المرضي بواقع جلستين يوميا لمدة أربعه أسابيع يتخللها يوم راحة كل أسبوع. تم قياس قوة قبضة اليد بواسطة جهاز قياس القوة الميكانيكية . و قد سجلت المجموعة الثانية التي عولجت بتمرينات التقوية الميكانيكية بالاضافه إلي العلاج الطبيعي التقليدي نتائج ذات دلاله احصائيه عن المجموعة الأولي الضابطة. ونستخلص من هذا البحث إلي إن تمرينات التقوية الميكانيكية من الوسائل العلاجية المفيدة في علاج مرضى ترقيع جلد ظاهر اليد نتيجة لحدوث حرق حراري حيث أنه يساعد في تحسين قوة قبضة اليد و تقليل نسبة حدوث التشوهات.

الكلمات الدالة : حرق حراري ، تمرينات التقوية الميكانيكية ، جهاز قياس القوة الميكانيكية لقياس قوة القبضة ، ترقيع الجلد ، قوة قبضة اليد .