The Effect of Burst Mode Alternating Current Versus Axial Load Exercises on Hand Improvement and Grip Strength Post Colles' Fracture

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Abstract

Background: Colles' fracture is one of the fractures that affect the lower third of the radius with complications after healing like; pain, and hand stiffness.

Objective: This study compared the effects of Burst Mode Alternating Current and closed kinetic chain exercise on pain, functional disability and grip strength post colles' fracture.

Methods: Forty-five patients with stable colles' fractures were randomly classified into three groups with fifteen patients in each group; Group I received traditional exercise as; wrist Mobilization, stretching exercises, range of motion exercises (passive and active) and edema control of the wrist joint. Group II stimulated by burst mode alternating current (Russian current) in addition to traditional exercise. Group III received axial load exercises (closed kinetic chain exercise) as; wall press, plyometric wall push up, Quadruped rhythmic stabilization, and Push up exercises) plus traditional exercise. All outcome measures including Pain, functional disability and grip strength were evaluated before and after the treatment program by Patient rated wrist evaluation (PRWE) questionnaire and hand dynamometer respectively.

Results: Showed that group II that received electrical burst mode alternating current had higher statistical significant than Group I and Group III ($p<0.05$).

Conclusion: The finding of the study revealed that stimulation of wrist flexors by burst mode alternating current (Russian current) in addition to a traditional exercise program was more effectivethan exercise alone after colles' fracture.

Key Words: Colles' Fracture – Burst mode alternating current – Axial load exercise.

Introduction

COLLES' fracture is a fracture of the distal radius approximately 2.5 cm proximal to the joint surface of the radius with dorsal (posterior) displacement of wrist and hand. It sometimes referred to as a 'dinner fork' or 'bayonet' deformity due to the shape of the resultant forearm [1]. Colles' fractures are seen in all adult age groups and demographics with a high majority in two distinct populations: younger patients who involved in high impact trauma and elderly patient with osteoporotic bone [2].

Patients with colles' fracture complained of pain, edema, decreased the range of motion, decreased strength, and decreased functional abilities. The pain becomes worse upon waking in the morning and was marginally relieved by medication [3].

Closed reduction with cast immobilization for about 6 weeks is one of the methods that used for the treatment of stable fracture to allow the fracture to heal without increase incidence of malunion. After removal of the cast and healing of the fracture, the swelling of the hand is present with pain and stiffness in the wrist joint. All these findings affect the physiological and biomechanical function of the hand [4]. Physical therapy plays a significant role in rehabilitation of patient with Colles' fracture which can be used several forms of rehabilitation during the treatment process, such as recommendations, patient education, and supervised exercise (hospital-based) or home-based active and passive mobilization exercises to facilitate patient functional recovery [5].

Axial load exercises refer to closed kinetic chain (CKC) exercises that stimulate joint receptors like Pacinian corpuscle and ruffini's ending receptors. The advantages attributed to CKC exercises result from the integration of sensorimotor feedback which reaches the central nervous system from
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receptors located in muscles and joints by increasing axial load on the articular surface through joint approximation [6].

Neuromuscular electrical stimulation (NMES) can be applied as a complement intervention to voluntary exercise training. NMES involves the application of an electric current through electrodes placed on the skin over the targeted muscles, thereby depolarizing motor endplates via the motor nerve and in turn, inducing skeletal muscle contractions [7]. NMES is composed of stimulation-rest cycles situated in regard to muscle motor points. In contrast to voluntary muscle actions, NMES activates the muscle to a greater extent under identical technical conditions. The muscle reaches higher values in blood flow and oxygen consumption during NMES compared with voluntary contractions [8].

Burst Mode Alternating Current (BMAC) is a form of neuromuscular electrical stimulation which described as a medium frequency alternating current (in the low kHz range-thousands of cycles a second), which is delivered in a pulsed (or burst or interrupted) output [9]. Various forms of (kHz range) electrical stimulation ‘medium frequency’ have been advocated for motor stimulation effects, and more recently, for hypoalgesia. Russian Stimulation (at 2500Hz or 2.5 kHz) has been shown to be effective in increasing muscle strength and torque generation. It differs than other forms of neuromuscular electrical stimulation as it produces low skin resistance resulting in maximum muscle contraction and recruitment of most motor units [10].

It hypothesized that there was no difference between burst mode alternating current and axial load exercise on pain, function and grip strength post colles’ fracture. So, the aim of this study was to compare the effect of burst mode alternating current and axial load exercise on pain severity, functional disability and grip strength post colles’ fracture.

Material and Methods

Forty-five patients with stable colles’ fractures collected from October 6 hospital and Alsahel hospital treated conservatively with closed reduction and casting and after removal of plaster cast they involved in the study from January 2013 to May 2013. All patients were assigned randomly into three groups by drawing of lots; group I (traditional exercise), group II (Russian stimulation) and group III (CKC).

Inclusive criteria:
1- Age range from 20 to 50 years.
2- Unilateral fracture of the distal radius without misalignment (dorsal angulation <15°, Axial radial shortening <5 mm) diagnosed by X-rays.
3- They participated in the study after 6 weeks of reduction.

Exclusion criteria were:
1- Patient less than 20 years old.
2- Intra-articular fracture of involved hand.
3- Lesion of median, ulnar or radial nerves.
4- Involved of ulnar fracture.

Randomization method:
Each participant assigned a unique number. These numbers were written on a piece of paper. The paper has the same size otherwise the selected sample will not be truly random. The pieces of paper were placed in a container and thoroughly mixed with strongly shaking the container. The numbers selected by trusted physical therapist in the same hospital without looking and after selection of the desired numbers for each group, the assigned number put in closed envelope and delivered to the researcher at beginning of treatment.

This study approved by the ethical committee of faculty of physical therapy, Cairo University. All patients completed an informed consent form and informed about the aim of the study without any explanation to treatment.

Intervention:

Group (I): Received traditional exercise program in the form of:

a- Wrist Mobilization: With patient sitting on high back support chair, gentle traction with oscillatory technique (gliding) for thirty seconds were used to increase wrist range of motion in all directions with the frequency of two strokes per one second and repeated six times during session. For progression, ten seconds was added to the frequency of mobilization technique each session.

b- Passive range of motion: The wrist and fingers were moved slowly, gently and smoothly in all directions passively through the available range of motion. Passive range of motion was applied for five minutes at beginning and for five minutes at the end of the session.

c- Active range of motion: Patient was asked to perform wrist flexion, extension, radial and ulnar deviation as well as fingers flexion, extension
and abduction actively as much as possible for two sets each set ten repetitions (i.e. twenty repetitions at beginning of session and twenty repetitions at end of session).

**d- Edema control:** Hand was elevated on towel with pressure applied to the volar and dorsum of the hand with passive ROM applied by the examiner firstly then patients was asked to perform flexion and extension of fingers for fifteen repetitions of fifteen second relax for three times.

**e- Strengthening exercises:** The examiner resisted the patient range of motion in the following progressive manner; gently isometric resistive exercise to wrist flexors, extensors, radial and ulnar deviator. The second progression was gentle resistive exercises to digits and wrist and improves the power grip through the use of hand dynamometer

**Group (II): Received Russian current stimulation in addition to traditional exercise:**

Electrical stimulation was carried out using phyaction 787 device (Manufactured by Uniphy, serial number 24823, Netherlands). Two equal sized carbon rubber electrodes were placed on common flexor origin (below medial epicondyle of humerus) and the other on distal part of flexor carpi radialis and flexor carpi ulnaris, perpendicular to the longitudinal axis of the forearm for fifteen minutes time of stimulation. The frequency was 2.5 kHz, with a burst duty cycle of 50% and intensity adjusted according to patient tolerant. The burst duration is 10 milliseconds at 50 Hz.

**Group (III): Received closed kinetic chain exercise plus traditional exercise:**

**a- Wall press exercise:** The patient stood with feet shoulder-width apart, arms held directly out in front of the body at about 140° of elevation against the wall. Feet are approximately two to three feet (0.6-0.9 meter) away from the wall. The patient pressed on the wall with the distal extremity fixed on a stable surface and asked to keep pressing for thirty seconds.

**b- Plyometric wall push-up exercise:** The patient stood away from the wall by about two feet with both arms in front of body at approximately 120°. The chest was lowered toward the wall until the elbows were bent approximately 45° to 60°. The patient then forcefully pushed the wall to return to the starting position.

**c- Quadruped rhythmic stabilization exercise:** Patient on hands and knees on a table or floor with the head and spine kept in neutral position. The examiner instructs the patient to hold the body without any movement against short, rapid pushing motions from side to side, front to back, and along diagonals. The pushing motions progressed from submaximal to maximal intensities and from slow to fast. The patient was asked to preserve the balance while the exercise maintained for thirty seconds, and each week the time increased by five seconds for progression.

**d- Push up exercise:** Quadruped on a plinth or on the floor. The patient lowered the body into arms until the elbows bent approximately 45° to 60°. The patient then pushed the floor to return to the starting position.

All patients in the three groups were applied the program three timed a weak for one hour in the session.

CKC exercises performed ten times and each week two more repetitions added as a progression.

**Outcome measures:**

- Pain, functional disability, and grip strength of injured hand were used as outcome measures. Pre-treatment (baseline) and post-treatment (after six weeks) measurements were recorded.

- Pain and functional disability:
  - Patient rated wrist evaluation (PRWE) questionnaire: The PRWE questionnaire considered a subjective outcome measure consisting of fifteen questions answered on a scale of one to ten. Five questions focus on wrist pain, and ten questions focus on function. The patient was asked to describe the pain, as well as the function of the involved hand on the scale and the answered numbers for pain and function were calculated for each one separately for analysis [11].

- Grip strength:
  - A Jamar dynamometer for measurement of grip strength in kilograms (Jamar, J.A. Preston Co., Michigan, USA) [12,13]. The maximal muscle strength was measured with the patient were seated on high back support chair with elbow flexion 90°, and wrist placed in neutral position [14]. Grip strength performed for 3 repetitions and the mean of the three trials was record.

**Statistical analysis:**

Analysis of variance (ANOVA-test) was used to compare values of the three groups pre-treatment and post-treatment. Significance was set at \( p < 0.05 \). Data were represented as mean ±SD.
Results

In this study 45 patients (30 male and 15 female) were assigned randomly into three groups: group I (n=15) their mean age was 36.13±8.5 years old, mean weight was 79.06±5.92 and mean height was 169.4±7.14. Group II (n=15).

Mean age was 36.53±5.75 years old, mean weight was 83.2±6.48 and mean height was 169.86±3.56. Group III (n=15) their mean age was 33.06±8.41 years old, mean weight was 81.93±7.38 and mean height was 169.13±7.43. All Demographic data were stated in Table (1).

There was no significant difference in physical characteristics between three groups. Before applying treatment program p-value was (0.869, 0.508 and 0.767) for pain, functional disability and grip strength respectively as shown in Table (2) and Fig. (1).

The results at the end of the treatment program revealed that group II that received electrical Russian current stimulation in addition to traditional exercise program showed a greater statistical significant than group I and group III where p-value was (0.0001) for pain, functional disability and grip strength as shown in Table (3) and Fig. (2).

Table (1): Physical characteristics of the patients in the groups.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Group I (n=15)</th>
<th>Group II (n=15)</th>
<th>Group III (n=15)</th>
<th>F-value</th>
<th>p-value</th>
<th>p-value</th>
<th>Significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>36.13±8.5</td>
<td>36.53±5.75</td>
<td>33.06±8.41</td>
<td>0.919</td>
<td>0.407</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>weight (kg)</td>
<td>79.06±5.92</td>
<td>83.2±6.48</td>
<td>81.93±7.38</td>
<td>1.534</td>
<td>0.228</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Height (cm)</td>
<td>169.4±7.14</td>
<td>169.86±3.56</td>
<td>169.13±7.43</td>
<td>0.052</td>
<td>0.949</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>

P: Probability, NS: Non-significant.

Table (2): Comparison of pre-treatment values between the three groups.

<table>
<thead>
<tr>
<th>Items</th>
<th>Pre-treatment</th>
<th></th>
<th></th>
<th>F-value</th>
<th>p-value</th>
<th>p-value</th>
<th>Significant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group I (n=15)</td>
<td>Group II (n=15)</td>
<td>Group III (n=15)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain</td>
<td>29.26±3.99</td>
<td>30.06±4.39</td>
<td>29.6±4.03</td>
<td>0.141</td>
<td>0.869</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Functional disability</td>
<td>70.4±3.41</td>
<td>71.13±4.1</td>
<td>72.06±4.13</td>
<td>0.689</td>
<td>0.508</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Gripstrength (kg)</td>
<td>9.8±2.07</td>
<td>10.2±2.48</td>
<td>10.4±2.29</td>
<td>0.267</td>
<td>0.767</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>

P: Probability, NS: Non-significant.

Table (3): Comparison of post-treatment values among three groups.

<table>
<thead>
<tr>
<th>Items</th>
<th>Post-treatment</th>
<th></th>
<th></th>
<th>F-value</th>
<th>p-value</th>
<th>p-value</th>
<th>Significant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group I (n=15)</td>
<td>Group II (n=15)</td>
<td>Group III (n=15)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain</td>
<td>26.13±3.97</td>
<td>19.06±2.96</td>
<td>23.06±4.30</td>
<td>13.106</td>
<td>0.0001</td>
<td>*S</td>
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<tr>
<td>Functional disability</td>
<td>59.8±3.27</td>
<td>49.13±4.13</td>
<td>54.53±3.81</td>
<td>30.177</td>
<td>0.0001</td>
<td>*S</td>
<td></td>
</tr>
<tr>
<td>Gripstrength (kg)</td>
<td>17.26±1.94</td>
<td>24.13±2.44</td>
<td>20.26±2.31</td>
<td>35.282</td>
<td>0.0001</td>
<td>*S</td>
<td></td>
</tr>
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</table>

Discussion

The findings of the present study are in agreement with a study by Watt et al. [15] who reported that patients who attended physiotherapy achieved greater increases in wrist extension and grip strength compared to the non-physiotherapy group. Another study suggested that patients supervised by a physiotherapist were more satisfied with their treatment results but did not achieve any functional advantage over those who performed unsupervised therapeutic exercise [16].

The results of traditional exercise group are inconsistent with the results of Li-Chieh et al. [4] study who reported that early wrist mobilization resulted in rapid recovery of both strength and movement without adversely influencing the progression of residual deformity. Burke et al. [17] reported that early mobilization demonstrated distinct improvement in strength and pain; however there was no significant improvement in the final range of movement of the healed wrist.

NMES performed three times a week lead to the greater increase in muscle strength and function as compared to two sessions per week [18]. Petrofsky et al. [19] have indicated that both the electrode size and positioning are critical for NMES effectiveness. In that respect, electrode size must be optimally matched to the stimulated muscle because too small electrodes would increase the current density and lead to more painful sensation [20].

Laufer et al. [21] compared three stimulation modes: 50Hz, modulated from 2.5kHz: 50Hz monophasic NMES: 50Hz biphasic NMES. All subjects (healthy volunteers, not patients) were randomly treated with all stimulation modes. Both the NMES type stimulations generated an advantage over the 2.5kHz stimulation interestingly, the biphasic NMES gave the strongest result in this instance. The 2.5kHz AC (effectively Russian stimulation) not only generated the weakest muscle force output but also gave rise to a more rapid fatigue response. This was a carefully controlled experiment giving rise to challenging results.

The significant improvement of wrist pain and function in patients with group C Who received closed kinetic chain exercise program, had confirmed previous researches like those of Wakefield and McQueen and Watt et al. [22,15]. In a study of Stephen and Richard [23] a program of an isometric exercise were applied to wrist flexors and extensors with active range of motion to all wrist movement and the result was increase in grip strength that was measured using a grip dynamometer. Also, the result was decreased in the pain level that is encouraging the patients to do their functional activities. This is inconsistent with the findings of the closed kinetic chain exercise group.

A study by Mattacola and Lloyd [24] on the effectiveness of a 6 week strength and proprioception training program on improving dynamic balance found that strength and proprioceptive training improve the ability to balance for dynamic testing conditions (means and standard deviations differed significantly between baseline and intervention measures).

Conclusions:

The combination between burst mode alternating current and traditional exercise program may be one of the effective methods in decreasing pain, function and enhancing hand grip strength.

Recommendations:

Future studies should be conducted to explore the long term effect of Russian current and closed kinetic chain exercises post colles fracture and compare with other approaches as open kinetic chain exercises and instructed home program.

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