

## The Effect of Russian Current Stimulation Versus Closed Kinetic Chain Exercise on the Range of Motion in Patients with Colles' Fracture

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### Abstract

**Background:** Hand stiffness is one of the major complications of post colles' fracture which associated with poor functional outcome, increase pain around wrist and impairment of Range of Motion (ROM) and grip strength.

**Objective:** This study compared the effects of Russian current stimulation and closed kinetic chain exercise on ROM of wrist joint in patients with 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 in the form of; wrist mobilization, stretching exercises, range of motion exercises (passive and active) and edema control of the wrist joint. Group II stimulated by electrical Russian current in addition to traditional exercise. Group III received closed kinetic chain exercise (wall press, plyometric wall push up, quadruped rhythmic stabilization, and push up exercises) plus traditional exercise. Outcome measures including ROM of flexion, extension, radial deviation and ulnar deviation were evaluated by baseline digital goniometer before and after 6 weeks of treatment program.

**Results:** Showed that Group II that received electrical Russian current stimulation 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 Russian current in addition to a traditional exercise program was more effective on wrist ROM than exercise alone after colles' fracture.

**Key Words:** Colles' fracture – Russian current – Closed kinetic chain exercise – Wrist ROM.

### Introduction

**COLLES'** fractures refer to extra-articular fractures of the distal radius that occur as the result of falling on the outstretched hand. These fractures occur in

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all adult age groups and demographics especially in osteoporotic women after menopause [1]. Several methods used in the treatment of colles' fracture which depend on fracture stability either stable or unstable. In stable fracture conservative treatment with closed reduction and casting is usually used for the treatment of this fracture [2]. Stiff hands reported being the troublesome problem for such patients, resulting in functional disturbances of hand performance after removal of cast causing a deficit in proprioception in wrist joint which produces neuromuscular incoordination [3]. Pain and weak hand grip another complications which interfere with functional outcomes after distal radius fracture, and these often result in patient dissatisfaction with either the physical appearance or functional performance of the hand involved, and may lead to difficulties with regard to carrying out daily tasks and thus a lower quality of life [4,5].

The purpose in the treatment of colles' fractures focus on obtaining a functional and painless wrist through decrease edema and pain in addition to increasing functional activities and wrist ROM [6]. Several methods of treatment, such as exercises (Stretching, Strengthening, Functional and proprioception exercises) or electrotherapy, as well as pain management and edema control have been used to improve wrist function and range of motion [2,7].

Closed Kinetic Chain (CKC) exercises stimulate the proprioceptive system by proprioceptive feedback to initiate and control muscle activation patterns. CKC exercises recruit more muscles in a shorter period of time, with less shearing force, increased compression and improved joint stability [8]. Neuromuscular Electrical Stimulation (NMES) is used in rehabilitation primarily to enhance muscle

strength (force production capacity) and to generate functional movements in individuals with upper motor neuron paresis [9].

The effect of NMES on muscle strength is dose related, with stronger electrically induced muscle forces during training resulting in greater strength gains [10]. This increase in strength may be due to changes oxidative enzyme activity, skeletal muscle fiber type and fiber size when using NMES on the correct settings to target the fiber types [11]. One type of Kilohertz-Frequency Alternating Current (KFAC) which is frequently used in the clinical context is the so-called Russian Current (RC). RC is typically applied in 50Hz sinusoidal bursts with a duty cycle of 50% (10ms on/10ms off). Russian Stimulation (at 2500Hz or 2.5kHz) has been shown to be effective in increasing muscle strength and torque generation through stimulation of type II muscle fiber [12].

It hypothesized that there was no difference between electrical Russian current and CKC exercise on wrist ROM on colles' fracture. Therefore, the purpose of this study was to compare the effect of Russian current stimulation and CKC exercise on wrist ROM in patients with colles' fracture.

### Material and Methods

Forty-five patients with stable colles' fractures collected from October 6 Hospital and Al-Sahel 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 <5mm) diagnosed by X-ray.
- 3- They participated in the study after 6 weeks of reduction.

#### *Exclusion criteria were:*

- 1- Patient less than 20 years old.
- 2- Intraarticular fracture of involved hand.
- 3- Any problem affects shoulder/elbow joints of the involved side.
- 4- Nerve lesions.
- 5- Fracture of the ulna.

#### *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- 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- Range of motion exercises:* Passive ROM for fingers (flexion, extension, abduction and adduction), thumb (flexion, extension, abduction, adduction and opposition) and wrist joints (flexion, extension, radial and ulnar deviations).

- 1- Active assisted ROM for all motions of fingers, thumb and wrist joints.
- 2- Active free ROM (without any assistance) through the available ROM.

*C- Edema management:* With the patient sitting on a chair, the examiner performed passive range of motion for fingers and wrist joint firstly then the patient was asked to apply active finger and wrist motion through the available range for three sets, ten repetitions in each set with the hand elevated on a towel.

*D- 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 2.5kHz, with a burst duty cycle of 50% and intensity adjusted according to patient tolerant. The burst duration is 10 milliseconds at 50Hz.

*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 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 instruct 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 3 times a week.

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

*Outcome measures:*

ROM measurements (wrist flexion-extension, radial-ular deviation) of injured hand were used as outcome measures. Pre-treatment (baseline) and post-treatment (after six weeks) measurements were recorded.

*Range of motion:*

Baseline digital goniometer (Baseline®, Aurora, IL, USA) for assessment of wrist ROM; flexion, extension, radial and ulnar deviation [13]. The patient was seated on high back support chair with elbow flexed about 90 degree and forearm rested on the handle of the chair. The fulcrum fixed on the middle of the dorsal surface of the wrist joint for measuring deviations and on ulnar styloid process for measuring flexion and extension [14]. The device displays 0 to 180 degrees on an LCD screen for viewing readings and has the ability to freeze angle measurements for reference.

The range of motion performed for three 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  $p < 0.05$ .

## Results

In this study 45 patients (30 male and 15 female) were assigned randomly into 3 groups; Group I (n=15) their mean age was  $36.13 \pm 8.5$  years old, mean weight was  $79.06 \pm 5.92$  and mean height was  $169.4 \pm 7.14$ . Group II (n=15) their mean age was  $36.53 \pm 5.75$  years old, mean weight was  $83.2 \pm 6.48$  and mean height was  $169.86 \pm 3.56$ . Group III (n=15) their mean age was  $33.06 \pm 8.41$  years old, mean weight was  $81.93 \pm 7.38$  and mean height was  $169.13 \pm 7.43$ . 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 (0.415, 0.791, 0.709 and 0.549) for wrist flexion, extension, radial deviation and ulnar deviation 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)].

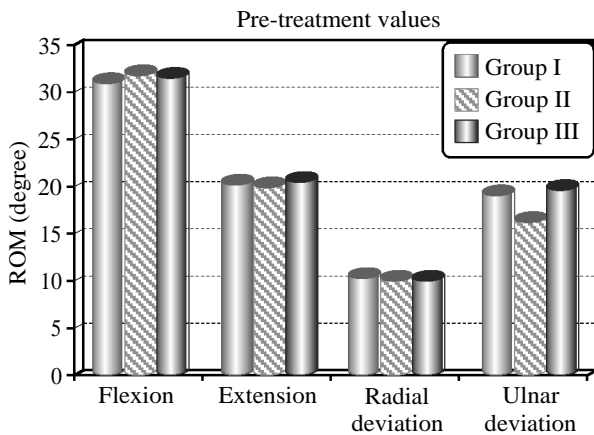


Fig. (1): Pre-treatment values of all variables in three groups.

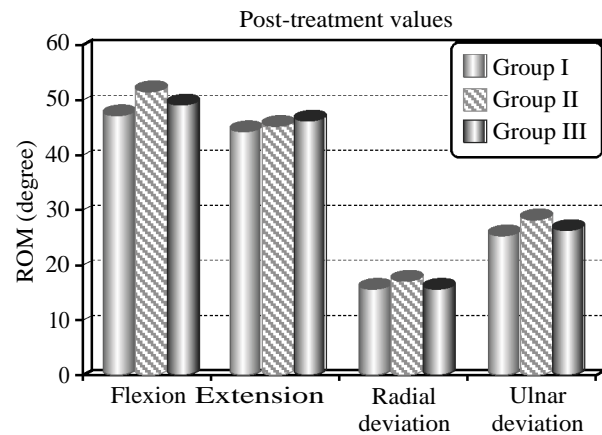


Fig. (2): Post-treatment values of all variables in three groups.

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

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

Kg : Kilogram.  
Cm : Centimetre.

p : Probability.  
NS : Non-significant.

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

Items	Pre-treatment			F-value	p-value	Significant
	Group I (n=15)	Group II (n=15)	Group III (n=15)			
Wrist flexion (°)	31.46±1.54	32.15±1.48	31.97±1.37	0.898	0.415	NS
Wrist extension (°)	20.64±1.24	20.44±1.46	20.80±1.59	0.236	0.791	NS
Radial deviation (°)	10.53±0.98	10.52±0.87	10.29±0.78	0.347	0.709	NS
Ulnar deviation (°)	19.39±1.11	16.58±0.99	19.83±1.17	0.608	0.549	NS

p : Probability.

NS : Non-significant.

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

Items	Post-treatment			F-value	p-value	Significant
	Group I (n=15)	Group II (n=15)	Group III (n=15)			
Wrist flexion (°)	47.91±1.74	52.18±1.39	49.82±1.03	33.928	0.0001	*S
Wrist extension (°)	45.23±0.92	45.60±1.33	46.81±0.66	9.987	0.0001	*S
Radial deviation (°)	16.53±0.96	18.20±1.28	16.44±0.69	14.534	0.0001	*S
Ulnar deviation (°)	26.22±1.02	28.98±0.63	26.92±1.49	25.379	0.0001	*S

(°) : Degree for range of motion.

p : Probability.

\*S: Significant.

### Discussion

Several studies compare between physiotherapy programs supervised by a physiotherapist and instructed home program in decreasing pain functional disability and edema as well as increase range of motion in patients with colles' fracture

[15,16]. Oskarsson et al., [16] compared a program of exercise supervised by physiotherapist for six weeks after cast removal with self-training exercises; the finding revealed that both exercises had the same results with greater increase in wrist movement in group of supervised exercise program than the other group.

The results of traditional exercise group are inconsistent with the results of Kuo et al., [17] study who statement that early mobilization of the wrist joint lead to increase in both strength and movement without any observational progression of residual deformity. Burke et al., [18] report that applying mobilization early confirmed the improvement in strength and pain; however there was no significant improvement in the range of movement of the healed wrist.

In contrast, Rupali and Jeetendra [19] found that there is no difference between home bases exercise and Institution-bases Occupational Therapy (IOT) as they were equal in decreasing pain and improve hand function also Kristin et al., [20] found that there was no difference between clinic-based therapy group (who received traction, tendon gliding, edema treatment) and a home program exercise group (who advised to wrist flexion/extension) in all outcomes used in his study (pain, hand strength and range of motion).

Ubinger et al., [21] conducted a study on the proprioception of the upper extremity on a fastex (computer input mat which looks similar to a Twister mat). Three CKC activities are applied for four weeks in their study and the result was minimizing instability index scores. The minimizing in scores was relegated to sensitization of heightened awareness due to repeated exposure to the closed chain activities.

In a study of Stephen and Richard [22] 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 the range of motion that was assessed using a goniometer and 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.

The finding of Group III (CKC) exercise did not agree with the finding of Maciel et al., [23] study who reported that home-based exercise has no difference than activity-focused physiotherapy after 24 weeks of rehabilitation. There are a couple of possible explanations for these differences. First, in the study of Maciel et al., a physiotherapist was the provider of treatment in both treatment groups (Group A and Group C). Second, the treatment administrated by the physiotherapists in Maciel et al., concentrated on techniques to restore activity. This appears to be in contrast with much of the musculoskeletal physiotherapy practice where there

has traditionally been a focus on treating impairments [24].

Electrical stimulation is used extensively in physical therapy, and "Russian currents" have been advocated for use in increasing muscle force [25]. The rationale for using Russian current is that the skin acts as a capacitive barrier to the flow of the current. As the frequency of the applied current increases, the skin offers progressively lower impedance [26].

Ward et al., [27] found that greater muscle torque in wrist extensors produced by applying Russian current for about 10 minutes with more comfortable sensation than low-frequency and short-duration currents. Clarification of the results of ward et al., study is that when bursts of kilohertz-frequency AC are used, successive pulses within a burst can summate causing action potential due to pushing the nerve fiber membrane closer to threshold [28].

Combination between NMES and voluntary exercises is controversy [29]. However, some researchers have found NMES increased strength in healthy muscles combined with exercise [30] and others found no change in muscle strength [31].

Russian current stimulation result in an increase in muscle force (torque, strength) especially when combined with voluntary exercise. It is suggested that the combination between the stimulation and a voluntary exercise program will help the participating individual to produce the greater amount of work, thus the results might reasonably be expected to be better [32].

Delitto et al., [33] found that treating an elite weightlifter with Russian stimulation produce significant improvement in strength than those who treated by training alone. Snyder-Mackler et al., [34] compared three forms of electrical stimulation; Russian stimulation, Interferential Therapy (IFT) and NMES (muscle stimulation). They found that the highest average force result from the application of Russian stimulation than IFT and NMES stimulation. Snyder-Mackler et al., [35] Compared electrical Russian stimulation group with a voluntary exercise group after ACL reconstruction. Increasing in strength outcome obtained with the Russian Stimulation group was significantly better than those undertaking exercises.

Selkowitz [36] comparing a Russian Stimulation (only) with voluntary exercise (only) for 4 weeks (3 times weekly) on quadriceps muscle and the result was significant increases in isometric strength compared with the exercise-only group.

Closed kinetic chain exercise need more time and greater range of motion in upper limb joints especially wrist joint during quadruped and push up activities and active range of motion has a little effect on recruitment of all muscle fibers. This may explain the difference between the three groups.

Limitations of this study are small sample size for each group in addition to subjective measurement of pain and function.

#### *Conclusions:*

Rehabilitation of colles' fracture with Russian current stimulation in addition to traditional exercise program appeared to improve wrist ROM. Long-term effects of physiotherapy and electrical stimulation following distal radius fracture must be investigated in the future studies.

#### *Recommendations:*

Future studies are needed to investigate:

- The effect of closed kinetic chain exercises Versus Home-Based Program in Rehabilitation of Distal Radius Fractures.
- The Effects of Closed Kinetic Chain Exercise Using EMG Biofeedback on Patellofemoral Pain Syndrome (PFPS) Patient's Pain, Muscle Functions and range of motion.
- The effect of electrical Russian current stimulation in compared to another type of electrical current (e.g. faradic current stimulation) on hand function.
- The effect electrical Russian stimulation on enhancing the healing of the comminuted intra-articular fracture of distal radius.

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## الملخص العربي

هدف الدراسة: أجريت هذه الدراسة للمقارنة بين تأثير التيار الكهربائي الروسي وتمارين السلسلة المغلقة على حركة مفصل الرسغ في المصابين بكسر النهاية السفلى لعظمة الكعبرة.

خطوات الدراسة: وقد أجريت هذه الدراسة على خمسة وأربعين رجلاً وامرأة ممن يعانون تيبس باليد بعد كسر كولس؛ تم اختيارهم من العيادة الخارجية بمستشفى جامعة ٦ أكتوبر ومستشفى الساحل، تم تقسيم جميع المشاركين عشوائياً إلى ثلاث مجموعات متساوية في العدد، كل مجموعة تكونت من خمسة عشر فرداً، المجموعة الأولى (مجموعة التمرينات التقليدية)، المجموعة الثانية (مجموعة التيار الكهربائي الروسي) بالإضافة إلى التمرينات التقليدية والمجموعة الثالثة (مجموعة تمرينات السلسلة المغلقة) مع التمرينات التقليدية وقد تم تقييم جميع المرضى باستخدام قياس مدى الحركة لمفصل الرسغ باستخدام جهاز منقل مقياس الزوايا الرقمي وذلك قبل بداية البرنامج العلاجي وفي نهاية البرنامج العلاجي بعد ستة أسابيع.

النتائج: أظهرت النتائج تحسن ذو دلالة إحصائية في المجموعة الثانية الذين تلقوا التيار الكهربائي الروسي عن المجموعة الأولى والمجموعة الثالثة.

الخلاصة: وهكذا يمكن أن نستخلص أن تحفيز العضلات القابضة في المعصم من قبل التيار الروسي بالإضافة إلى ممارسة البرنامج التقليدي كان أكثر فعالية من ممارسة الرياضة وحدها بعد كسر النهاية السفلى لعظمة الكعبرة.