Efficacy of Electromagnetic Therapy on Facial Asymmetry in Patients with Chronic Bell's Palsy

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Abstract

Background: Bell's palsy is characterized by partial or complete paralysis of facial muscles. Electromagnetic therapy enhances nerve regeneration and neural growth by inducing modification in the micro-environment around and within the cell, as well as in the cell membrane. **Aim:** To evaluate the effect of electromagnetic therapy on facial asymmetry in patients with chronic bell's palsy. **Materials and Methods:** Thirty patients (male and female), with chronic bell's palsy, aged 25 to 45 years participated in the study. They were randomly assigned to two equal groups. Group A (experimental group) received Pulsed Electromagnetic Field Therapy (PEMFT) in addition to standard physical therapy program while group B (control group) received standard physical therapy program. Patients in both groups were evaluated pre- and post-treatment for facial asymmetry using the House-Brackmann (HB) facial nerve grading system and for facial nerve degeneration using electro-neurography (ENog). **Results**: Both groups (group A and group B) showed significant increase on the HB facial nerve grading system and significant decrease in the percentage of facial nerve degeneration. Additionally, there was significant difference in HB facial nerve grading system and percentage of facial nerve degeneration between both groups, post treatment (p=0.001 and p=0.005) respectively. **Conclusion:** Pulsed Electromagnetic Field Therapy added to standard physical therapy program results in better improvement of facial asymmetry and decreases facial nerve degeneration in in patients with chronic bell's palsy.

Key Words: Bell's palsy, Electro-neurography, House-Brackmann facial nerve grading system, Physical therapy, Electromagnetic therapy, Pulsed Electromagnetic Field Therapy

Introduction:

Bell's palsy is an acute-onset peripheral neuropathy of the facial nerve causing ipsilateral paralysis of half side of the face. It is the most common cause of lower motor neuron lesion facial palsy **(Evistonet al., 2015)**. Bell's palsy affects 20 – 25 people per 100,000, per year **(Karaganova and Mindova, 2016).**

Bell's palsy affects men, women, and children and can occur at any age, but is more common in age range 15 to 45 **(Song, et al., 2008)**. The incidence is slightly increased in pregnancy (45 per 100,000) **(Holland and Weiner, 2004)**

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and the recurrence rate on the same side is 12%, with a 36% on the same side **(Zandian, 2014)**. Generally, bell's palsy affects only one of the paired facial nerves and one side of the face, however, in rare cases, it can affect both sides **(Prabasheela et al., 2017)**.

There is evidence that causes of bell's palsy include immune, infective, and ischemic mechanisms, but the actual cause, still, remains unclear **(Evistonet al., 2015).** Risk factors include diabetes, hypertension, hypothyroidism, obesity, and weak immune system. A family history is present in 4-8% of cases of bell's palsy **(Potterton, 2015)**.

The diagnosis of bell's palsy is based on clinical presentation in the form of weakness of muscles supplied by all branches of the facial nerve resulting in dropping of the eye brow, incomplete eyelid closure, impaired closure of the mouth, dropping of the corner of the mouth, dry eye, hyperacusis of sound, impaired taste sensation, and presence of pain around the ear. If eye closure is incomplete, Bell's phenomenon occurs (upward diversion of the eyeball on attempted closure of the eyelid) **(Finsterer, 2008).**

Several tools exist that analyze function of facial nerve. The House Brackmann (HB) facial nerve grading system is one of the most common tools for the clinical evaluation of facial nerve function **(Ernst et al., 2006)**. It was proposed by House in 1983 (**House, 1983**). After minor modifications, the system was presented by House and Brackmann in 1985 (**House and Brackmann, 1985a**) and was selected as the standard for clinical evaluation of the facial nerve by the Facial Nerve Disorders (FND) Committee in 1985. The HB system provides a gross evaluation of the facial by dividing the motor function of the nerve into 6 grades. Due to the convenience and simplicity of the HB scale, it remains the most widely used facial nerve grading system (**House and Brackmann, 1985b**)

Another accurate method used to evaluate facial nerve function is nerve conduction (NC) studies. It provides an objective quantitative evaluation of facial nerve function. (**Finsterer, 2008**). Electroneurography (ENoG) is considered one of the most valuable tests used to predict prognosis of facial nerve function. It is used mainly in acute complete facial paralysis. Both percentage of degeneration and rate of degeneration are prognostic indicators (**Kimura, 2006).**

The treatment of Bell's palsy aims to speed recovery and reduce long-term complications Physical therapy, uses methods that improve muscle and nerve function either through exercise or electrotherapy. Thermal methods and massage help in decreasing swelling and increasing oxygenated blood flow to the damaged, hypoxic tissues, thus promoting recovery **(Lockhart et al., 2011).**

Pulsed Electromagnetic Field Therapy (PEMFT) therapy is a safe and non-invasive tool that uses electromagnetic waves to improve health. Benefits of using PEMFT includes increased energy and circulation, reduced muscle spasms, improved sleep, enhanced healing of bone fractures, and reduction of pain and inflammation (**Meyers, 2013)**.

Pulsed Electromagnetic Field Therapy stimulates biologic response such as cell proliferation which underlies nerve regeneration and fast recovery **(Graak et al., 2009)**. Additionally, PEMFT affects blood vessels (improves blood circulation and oxygenation, decreases deposition of toxins and cholesterol plaques on walls of blood vessel, and relaxes the wall of the blood vessel due to its effect on calcium-channels). It also affects the nervous system, reduces fluid retention, increases

endorphins, and relaxes muscles, (like the suggested activity of acupuncture needles) (**Basford, 2001**).

Therefore, this study was designed to investigate the effect of electromagnetic therapy on patients with chronic bell's palsy.

Materials and Methods:

This was a single blind randomized controlled clinical trial. The study protocol was explained in detail to each patient and a signed written consent was obtained before enrollment in the study.

Consented patients were randomized by sealed, opaque, identical envelopes into two groups: group (A) and group (B). Each patient drew an envelope containing the group he/she was in, whether it was group (A) or (B). The number of patients in each group was (n=15). The anonymity and confidentiality of each patient was assured.

Thirty (male and female) patients diagnosed with chronic bell's palsy were recruited from the outpatient clinic of the Faculty of Physical Therapy, Cairo University as well as the Neurology outpatient clinic - Kaser Al-Ainy Teaching Hospital, Cairo University.

All patients were diagnosed and referred by a neurologist. Inclusion criteria were a confirmed clinical diagnosis of chronic bell's palsy, duration of illness three-six months, age range from 25-45 years, scored less than three on the HB facial nerve grading system and percentage of facial nerve degeneration measured by ENog was less than 50%.

Patients were excluded from the study if they had idiopathic unilateral facial paralysis, other neurological disorders that affect the facial muscles (e.g., hemiplegia, Parkinsonism, Motor Neuron Disorders, Myasthenia Gravis), presence of any cognitive impairment.

Evaluation Procedures:

Each patient was evaluated, twice, pre- and post-treatment, by the same evaluator using:

1- The House Brakmann (HB) facial nerve grading system to evaluate function of the facial muscles. The system is based on 6-grade score from I to VI that it is used to evaluate facial nerve motor function. Each grade is reported as a fraction (i.e., 1/6 = grade one) as follows **(table 1)** (**House, 1983**):

Table (1). House Brakmann (HB) facial nerve grading system (House, 1983):

Grade I	**Normal**	- Normal facial function in all areas
Grade II	**Slight Dysfunction**	- Gross: slight weakness noticeable on close inspection; may have very slight synkinesis - At rest: normal symmetry and tone - Motion: forehead - moderate to good function; eye - complete closure with minimum effort; mouth - slight asymmetry.
Grade III	**Moderate Dysfunction**	- Gross: obvious but not disfiguring difference between two sides; noticeable but not severe synkinesis, contracture, and/or hemi-facial spasm. - At rest: normal symmetry and tone - Motion: forehead - slight to moderate movement; eye - complete closure with effort; mouth - slightly weak with maximum effort.
Grade IV	**Moderate – Severe Dysfunction**	- Gross: obvious weakness and/or disfiguring asymmetry - At rest: normal symmetry and tone - Motion: forehead - none; eye - incomplete closure; mouth - asymmetric with maximum effort.
Grade V	**Severe Dysfunction**	- Gross: only barely perceptible motion - At rest: asymmetry - Motion: forehead - none; eye - incomplete closure; mouth - slight movement
Grade VI	**Total paralysis**	- No movement

Testing procedures were as follows:

- Patients sat on a chair with back support, in a quiet room to concentrate during the testing procedure.
- Testing procedures were explained fully to each patient.
- The affected side of the face was observed grossly, at rest and during movement.
- Patients were asked to perform various facial movement with the affected side such as raise eyebrows, close eye normally, close eye forcefully, close eye only on affected side, wrinkle nose, blow out cheeks, whistle, grin, depress lower lip. Movements were then compared with the non-affected side.
- Each patient was given a score based on HB scale.

2- **Electroneuronography (ENog):** to evaluate facial nerve degeneration and predict prognosis (**Finisterer, 2006**). A Trutrace Electromyography (EMG) Deymed diagnostic system was used for the measurement. Testing procedures were as follows:

- Patients sat on a chair with back support, in a quiet room to concentrate during the testing procedure. Any jewelry patients were wearing was removed.
- Testing procedures were explained fully to each patient.
- Areas of electrode placement were identified, and the skin was cleaned with alcohol to decrease skin impedance.
- The negative electrode was placed on the area of the frontalis muscle and the positive electrode was placed on the nasal area near to the eyebrow. The stimulating electrode was placed near the nerve trunk, behind the ear at the stylomastoid foramen.
- Values of compound motor action potential (CMAP) were recorded.
- The same process was performed on the non-affected side of the face, and the percent of degeneration was calculated using the following equation (**Beck and Hall, 2001**):

$$\text{Facial nerve degeneration} = [1-n] \times 100\% ;$$
$$n = \frac{\text{affected facial nerve CMAP amplitude}}{\text{normal facial nerve CMAP amplitude}}$$

Treatment Procedures:

Both groups received three sessions per week for six weeks. The duration of each session was approximately one hour for (group A) and 45 minutes for (group B). Treatment program was as follows:

1- **Group A (experimental group)**: received standard physical therapy program for 45 minutes **(Novak, 2004, Prabasheela et al., 2017)** and Pulsed Electromagnetic Field Therapy (PEMFT) for 15 minutes as follows:

- Massage therapy for five minutes **(Prabasheela et al., 2017)**.
- Superficial heat therapy (i.e. hot packs or infrared rays) for 15 min **(Prabasheela et al., 2017)**.
- Faradic stimulation, 10 minutes (**Novak, 2004)**.
- Neuromuscular reeducation facial exercise for 15 minutes (**Novak, 2004).**
- Pulsed Electromagnetic Field Therapy (PEMFT) for 15 minutes using pulsed electromagnetic unit ASA magnetic field (Automatic PMT Quattro pro, serial number: 00001543) **(fig. 1)**. It consists of an appliance, motorized bed and solenoids. The appliance is connected to electrical mains supplying 230V at a frequency of 50 or 60 Hz with earth connection. It generates pulsed magnetic field up to 100 Hz and

intensity varies according to the type of solenoid. The appliance, motorized bed, and solenoids are built to operate correctly at room temperature between 0°C and 40°C and relative humidity from 30% to 75% **(Elsisi et al., 2015)**.

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Figure 1. Electromagnetic unit ASA magnetic field. Adapted from **(Mahmoud et al., 2015)**

2- **Group B (control group)**: received standard physical therapy program for 45 minutes **(Novak, 2004, Prabasheela et al., 2017)** as follows:

- Massage therapy for five minutes **(Prabasheela et al., 2017)**.
- Superficial heat therapy (i.e. hot packs or infrared rays) for 15 min **(Prabasheela et al., 2017)**.
- Faradic stimulation, 10 minutes (**Novak, 2004)**.
- Neuromuscular reeducation facial exercise for 15 minutes (**Novak, 2004).**

Statistical Analysis:

Data was screened for normality assumption, homogeneity of variance, and presence of extreme scores. Kolmogorov-Smirnov test for normality showed that demographic and clinical characteristic data, were normally distributed while data obtained by the House Brakmann (HB) facial nerve grading system and Electroneuronography (ENog) were not normally distributed. Paired t-test was used for statistical analysis of demographic and clinical characteristic in both groups (group A and group B) pre-treatment. Data of the HB and ENog was analyzed by Wilcoxon test for within subjects' comparison and Mann-Whitney test for between groups comparison. Statistical analysis was conducted using Statistical Package for the Social Science (SPSS, Chicago, IL, USA) for windows, version 20 (SPSS, Inc., Chicago, IL). The p-value was set at < 0.05.

Results:

A total of 30 male and female patients, divided into two equal groups (A and B) participated in the study **(fig. 2)**. Results of this study are presented as 1- Demographic and clinical characteristics and 2- Clinical evaluation (House Brakmann (HB) facial nerve grading system to evaluate function of the facial muscles and Electroneuronography (ENog) to evaluate facial nerve degeneration and predict prognosis).

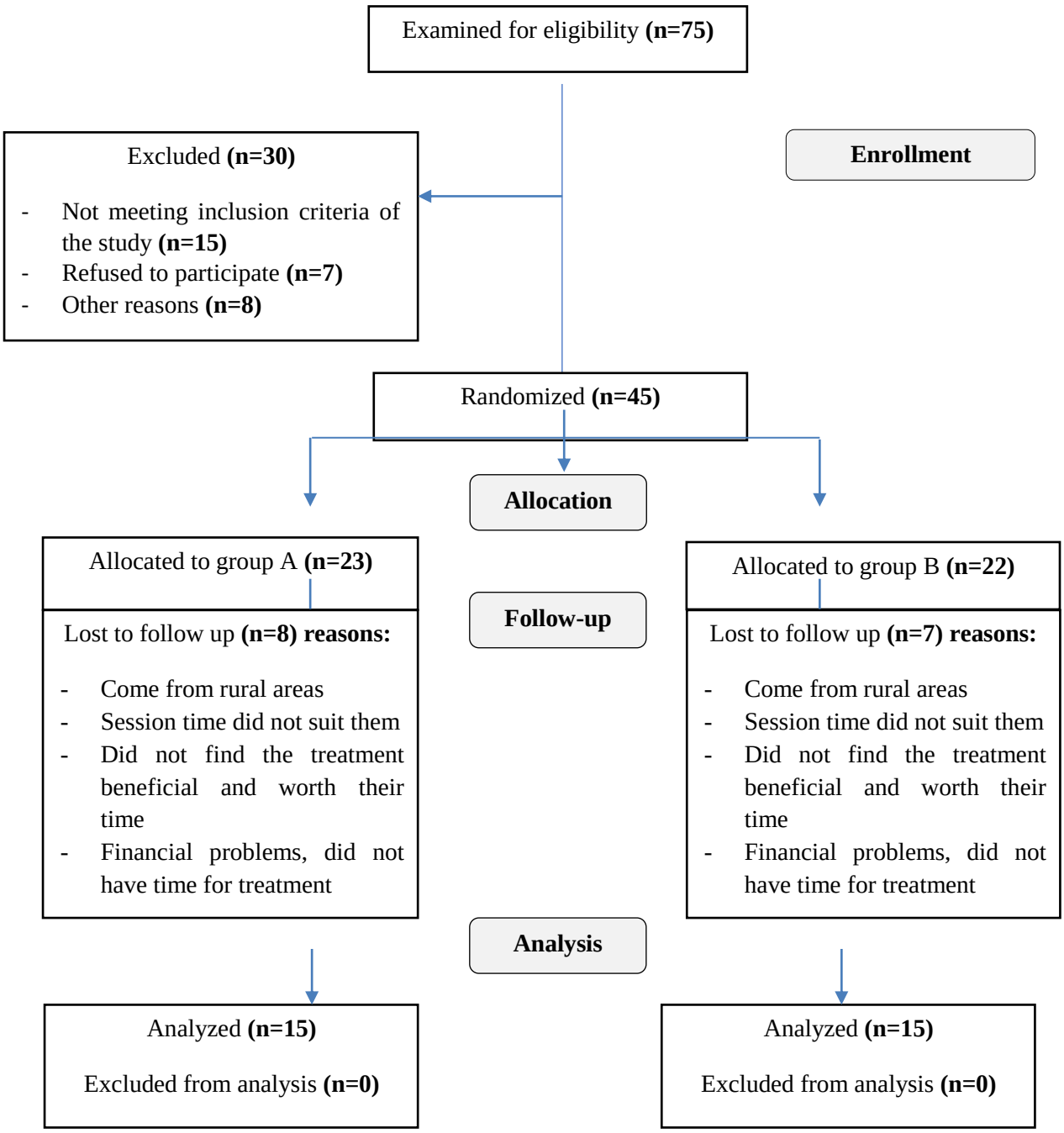

Figure 2. Flow Diagram of the study.

1- Demographic and clinical characteristics:

Statistical analysis using paired t-test revealed no significant differences in demographic and clinical characteristic between both groups (group A and group B), pre-treatment ($p > 0.05$) **(table 2)**.

2- Clinical evaluation:

a- House Brackman (HB) facial nerve grading system

- **Within groups comparison:**

In group A, frequency distribution of the HB grades, pre-treatment, was 3 patients with moderate-severe difficulty, with a reported percentage of 20%, 8 patients with severe difficulty, with a reported percentage of 53.3% and 4 patients with total paralysis, with a reported percentage of 26.7%. While post-treatment, 5 patients were normal, with a reported percentage of 33.3%, and 10 patients with slight difficulty, with a reported percentage of 66.6%. Statistical analysis using the Wilcoxon test revealed significant difference (p = 0.0001*), pre- and post-treatment **(table 3)**.

In group (B), frequency distribution of the HB grades, pre-treatment, was 3 patients with moderate severe difficulty, with a reported percentage of 20%, 8 patients with severe difficulty, with a reported percentage of 53.3% and 4 patients, with total paralysis, with a reported percentage of 26.7%. While post treatment, 4 patients were normal, with a reported percentage of 26.7%, 8 patients with slight difficulty, with a reported percentage of 53.3%, and 3 patients with moderate difficulty, with a reported percentage of 20%. Statistical analysis using the Wilcoxon test revealed significant difference (p = 0.0001*), pre- and post-treatment **(table 3)**.

- **Between group comparison:**

Statistical analysis using Mann-Whitney test revealed no significant difference between both groups (group A and group B) in HB scores pre-treatment (p = 1.00) while there was significant different post-treatment (p = 0.005) **(table 3)**.

b- Facial nerve degeneration (percent of degeneration):

- **Within group comparison:**

Statistical analysis using the Wilcoxon test revealed significant difference (significant reduction in percentage of facial nerve degeneration) within group A (P=0.001) and group (B) pre- and post-treatment (P=0.001) **(table 4)**.

- Between groups:

Statistical analysis using Mann-Whitney test revealed no significant difference between both groups (group A and group B) in the percent of facial nerve degeneration pre-treatment (p= 0.897) while there was significant different post-treatment (p= 0.001), in favour of group A (percentage of improvement 69.65%) in compared to group B (percentage of improvement 57.79%) **(table 4)**.

Table (2). Demographic and clinical characteristics in groups (A) and (B).

	Group A	Group B	t-value	P-value
Age (years)	34.8±5.16	31.29±15. 80	1.27	0.312
weight (kg)	76.65±12.79	80±17.62	-0.581	0.543
Height (cm)	172.06±11.47	169.43±6.12	-0.627	0.564
BMI (kg/m^2)	26.99±3.51	28.3±6.2	-0.487	0.342

p: probability value, ±: standard deviation, p<0.05* = significant, p>0.05 = non-significant.

Table (3): Frequency distribution of the House Brackman grades in both groups (group A and B), pre- and pot-treatment.

	Group A						Group B					
Frequency distribution	**Normal**	**Slight difficulty**	**Moderate difficulty**	**Moderate Severe difficulty**	**Severe difficulty**	**Total paralysis**	**Normal**	**Slight difficulty**	**Moderate difficulty**	**Moderate Severe difficulty**	**Severe difficulty**	**Total paralysis**
Pre-treatment	0 (0%)	0 (0%)	0 (0%)	3 (20%)	8 (53.3%)	4 (26.7%)	0 (0%)	0 (0%)	0 (0%)	3 (20%)	8 (53.3%)	4 (26.7%)
Post-treatment	5 (33.3%)	10 (66.6%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	4 (26.7%)	8 (53.3%)	3 (20%)	0 (0%)	0 (0%)	0 (0%)

Wilcoxon Signed Rank tests (within groups analysis)				
	Group A		**Group B**	
	z-value	**p-value**	**z-value**	**p-value**
Pre-treatment vs. post-treatment	-4.213	0.0001*	-3.771	0.0001*

Mann-Whitney tests (between groups analysis)		
Group A vs Group B	**Pre-treatment**	**Post-treatment**
U-value	112.5	107
Z-value	0.000	-2.996
p-value	1.00	0.005*

p: probability value, ±: standard deviation, p<0.05* = significant, p>0.05 = non-significant.

Table (4): Percentage of degeneration grades in both groups (group A and B), pre- and post-treatment.

Percentage of degeneration	**Pre-treatment**	**Post-treatment**	**Mean difference**	**Percentage of change**	**p- value**
Group A	56.46 ±3.04	17.13 ±3.02	39.33	69.65%	0.0001*
Group B	56.53 ±3.15	23.86 ±5.95	32.67	57.79%	0.0001*
Mean difference	0.07	6.73			
p- value	0.794	0.0001*			

p: probability value, ±: standard deviation, p<0.05* = significant, p>0.05 = non-significant.

Discussion:

In this randomized, controlled clinical trial, adding electromagnetic therapy, in the form of PEMFT to the standard program of physical therapy of patients with chronic bell's palsy seemed to improve facial asymmetry and decreased the percentage of facial nerve degeneration.

These results can be explained by the work of **Jacobson** who stated that magnetic field decreases inflammation and pain, and improves circulation of structures such as connective tissue, muscles, and organs, hence improving function (**Jacobson et al., 2001**).

The significant reduction in the percentage of facial nerve degeneration, in the current study, can be attributed to the influence of electromagnetic therapy on motion of ions across the cell membrane, which results in charge transfer across the cell membrane and changes cellular metabolism **(Liboff and Jenrow, 2002**). Similarly, investigators found that exposure to PEMFT improves blood supply and increases utilization and energy turnover, in the tissues with rise in adenosine triphosphate (ATP), termed as the magneto hydrodynamic effect which occurs during the movement of charge carriers in the blood **(Keltner, 1990)**.

Pulsed Electromagnetic Field Therapy stimulates release of fibroblast growth factor beta–2 (FGF–2) **(Tepper et al., 2004)**, which stimulates neurotrophic factors and improves micro-environment of the tissues, leading to regeneration peripheral nerves **(Midura et al., 2005)**, which agrees with results of the current study.

Additionally, **Musaev et al., 2003** reported that application of PEMFT facilitates improves conductive function of peripheral nerves and the state of la afferents in patients with polyneuropathy (**Musaev et al., 2003**).

Novikov et al., 2008 reported that a weak magnetic field can result in changes in the excitability of the neuron (amplitude, excitability threshold, rate of action potential), as well as changes in the viscosity of the plasma membrane of the nerve and other cell organelles **(Novikov et al., 2008).**

Based on the previous mentioned results and results of the current study, we can say that PEMFT triggers a biologic response (e.g., cell proliferation). It also, enhances nerve regeneration and accelerates recovery.

Conclusion:

It can be concluded that adding PEMFT to the standard program of physical therapy of patients with chronic bell's palsy has a significant and superior effect compared to physical therapy program only. This effect was found in improved facial asymmetry and decreased percentage of facial nerve degeneration. There are no reported side effects, discomforts, or known health risks from PEMFT, and it is generally accepted that brief exposure to this modality is safe **(Colbert et al., 1999; Trock, 2000)**.

Limitations:

The current study had some limitations that must be addressed in future research, such as the small sample size. The literature lacks information about the the dose of standard PEMFT for chronic bell's palsy, so a comparison of different PEMFT doses is also required. In addition, the current study did not investigate the long-term effect of the interventions.

Abbreviations

ATP: adenosine triphosphate, ENoG: Electroneurography, HB: House Brackmann, Hz: Hertz, MS: Magnetic stimulation, NCV: Nerve Conduction velocity, PEMFT: Pulsed Electromagnetic Field Therapy.

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Conflict of Interest

The authors declare that there was no conflict of interest during performing the current study

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