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Original Article

Comparison between electrical muscle stimulation and faradic current stimulation among patients with facial nerve palsy: a randomized controlled trial

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ABSTRACT

Objective*:* The aim was to evaluate the effectiveness of electrical muscle stimulation (EMS) and faradic current stimulation (FCS) with facial exercise program on facial nerve function and physical and social/well-being function in patients with unilateral facial nerve palsy.

Methods*:* Patients with non-traumatic unilateral facial nerve palsy aged 30-45 years were randomly divided into two groups: Group A (three motor points of the facial nerve, n=30) and Group B (facial nerve trunk, n=30). Both groups were stimulated and then practiced facial exercises, and they had four 30-minute sessions weekly for 6 weeks. House-Brackmann Scale (HBS) and Facial Disability Index (FDI) were evaluated at the baseline, mid-treatment and post-treatment. Generalized estimating equations, repeated measures ANOVA and independent samples t-tests were performed.

Results*:* 51 patients (Group A = 26, Group B = 25) finished the study. This was the case for both groups and there was a significant improvement over time on all outcomes ($p<0.01$). There were time × group interactions which favoured EMS for FDI physical ($p=0.019$) and social/well-being function ($p=0.004$). There were time × group interactions which favoured EMS for FDI physical ($p=0.019$) and social/well-being function ($p=0.004$). At post-treatment, Group A scored higher on FDI physical (77.31±13.36 vs 69.40±13.72, $p=0.042$) and social/well-being function (75.08±13.54 vs 66.88±14.03, $p=0.039$).

Conclusion: Electrical muscle stimulation, in addition to performing facial exercises, gave the greatest improvement in functional and psychosocial recovery as compared to faradic current stimulation.

Keywords: Electric Stimulation Therapy, Facial Disability Index, Facial Muscles, Facial Paralysis, Faradic Current, House-Brackmann Scale, Muscle Denervation, Physical Therapy Modalities, Rehabilitation.

1. INTRODUCTION

Facial nerve palsy is a neurological disease characterized by dysfunction of the seventh cranial nerve resulting in partial or complete paralysis of facial nerve movement leading to flattening of the nasolabial fold, difficulty in eye closure, mouth angle droop and difficulty in eating, drinking and speaking.{Walker, 2023 #2714} Facial nerve disorders have been steadily increasing in recent years. [2] Apart from the idiopathic and infective causes, facial nerve palsy has been recently reported in SARS-CoV-2-infected patients and may be caused by the viral neurotropism, immune-mediated inflammation or microvascular thrombosis, [3] and can occur at various stages of the infection.[4] Despite recovery there may be long lasting sequelae, such as the aberrant regeneration of injured motor fibres to inappropriate target muscles,[5] which is one of the most distressing consequences of facial palsy,[6] known as synkinesis. Many people who are affected by a facial wound will have a tendency to feel self-conscious,[7] socially anxious or depressed and depressed about themselves, and these feelings can persist even if recovery is incomplete, as the face plays a key role in emotional expression, communication and identity.[8]

Physical therapy is one of the most important aspects of facial palsy treatment and facial exercise therapy has been used to enhance facial function, especially in the early stages of treatment.[9] A recent meta-analysis found that physical therapy has been shown to be strongly linked to improved recovery rates compared to no intervention;[10] however, there was significant heterogeneity in treatment procedures and outcome measures. [11] A randomized trial presented better results with novel exercise for the face instead of conventional exercise, and early neuromuscular retraining has been found to reduce synkinesia in extreme instances of Bell's palsy.[12] Facial function has also demonstrated improvement with proprioceptive neuromuscular facilitation (PNF) and enhanced by using electrical stimulation along with the PNF.[13] The stimulation of electric current is useful to maintain the bulk of the muscle and to prevent denervation atrophy and reinnervation during nerve recovery.[14] A recent meta-analysis has shown that there was a beneficial effect of electrical stimulation in the acute phase of Bell's palsy, and home-based functional electrical stimulation has enhanced facial muscle function in long-term palsy, without increasing synkinesis.[15] There are two common types of stimulation modalities, electrical muscle stimulation (EMS) and faradic current stimulation (FCS),[16] which are fundamentally different: EMS involves use of longer pulse duration, which can directly depolarize denervated muscle fibres at the motor points,[17] whereas short faradic pulses (0.1–1 millisecond) require at least partially functional motor nerve fibres to induce muscle contraction.[18] However, few published studies have included a comparison between different electrical stimulation modalities and other physical therapy modalities, but not with no stimulation.[19] Clinicians therefore have little evidence on which to base the choice between EMS and FCS.

This study aimed to examine the effects of two types of electrical muscle stimulation (electrical muscle stimulation plus facial exercises and faradic current stimulation plus facial exercises) on facial nerve function and on physical and social/well-being function in patients with unilateral facial nerve palsy. The study aimed to determine if there were any significant differences between the two modalities in improving functional recovery.

2. METHODOLOGY

This was a Randomized Controlled Trial in Physical Therapy Department of Faisal Hospital, Multan,

Pakistan, which lasted for about 4 months, including recruitment of participants, treatment for 6 weeks, follow up evaluation, and data analysis. Sample size was determined for a two-tailed independent samples t-test in G*Power software.[20] The number of participants needed for each group was 30 with a significance level (α) of 0.10 and a statistical power (1-β) of 0.60. Simple random sampling technique was used and the participants were divided into 2 equal groups using a random number sequence, Group A: EMS + Facial exercises, Group B: FCS + Facial .

Patients, both male and female aged 30-45 years with non-traumatic unilateral facial nerve palsy and medically stable condition. Exclusion criteria: Open wounds in the face, bilateral facial weakness, metal implants in the facial region, recent surgery in the facial region, or any other neurological disorder like stroke, multiple sclerosis or Parkinson's disease.

Both groups did the same facial exercise after each stimulation session such as raising the eyebrows, closing the eyes forcibly, smiling, pursing the lips and puffing the cheeks. The intervention consisted of 6 weeks (24 sessions) of 30-minutes per session of both groups.

Measurement method for collecting data: Age and gender were documented at baseline. The House-Brackmann Scale (HBS), a six-grade clinician-rated scale from 1 (normal function) to 6 (total paralysis), was used to assess the function of the facial nerve and has been proven to be a reliable instrument for peripheral facial paralysis.[21] Facial disability was assessed using the Facial Disability Index (FDI), a 10-item self-reported questionnaire with a physical function subscale (items 1-5) and social/well-being function subscale (items 6-10), each scored on a 100-point scale, higher scores indicating better function. Both the outcomes were measured both at baseline and at middle (3-4 weeks) and at end of treatment (6 weeks) in patients suffering from Bell's palsy in Pakistan.[22]

SPSS 26.0 was used for data analysis. Data participant characteristics were summarized by descriptive statistics (mean, standard deviation, frequency and percentage) and normality assessed by the Shapiro-Wilk test. Independent samples t-test and chi-square test were used to test baseline comparability. Considering the HBS was ordinal, generalized estimating equations (GEE) with an ordinal logit link were used to model change over the three time points, and within-group changes were evaluated using the Wilcoxon signed-rank test. Repeated measures ANOVA with Greenhouse Geisser correction was used to analyze differences in FDI subscales if the assumption of sphericity was not met and independent samples t-tests were used to compare differences between groups at each time point. Results with a p value of < 0.10 were considered statistically significant.

3. RESULTS

Sixty patients were randomly divided equally into Group A (EMS) and Group B (FCS). By mid-treatment 2 patients were lost in Group A and 3 in Group B and by post-treatment 2 patients continued in each group resulting in 51 patients (Group A=26; Group B=25) who finished the 6 weeks of intervention and completed the final assessment. There was no difference in the rate of attrition between the two groups. The mean age was 37.53±4.22 years in Group A and 38.83±4.65 years in Group B, which was not statistically significant (p=0.261), and all the patients were between 30 and 45 years. Gender distribution was almost identical, with 15 (50.0%) females and 15 (50.0%) males in Group A and 16 (53.3%) females and 14 (46.7%) males in Group B (p=0.796). Baseline FDI physical function (47.67±13.57 vs 43.50±16.36, p=0.287) and social/well-being

function scores (43.73±13.57 vs 40.13±16.46, p=0.360) were also comparable. The baseline HBS differed between the groups (p=0.012) with most patients in Group A having HBS Grade III (20, 66.7%) and Group B had a higher proportion of patients with HBS Grade III (17, 67.4%).

Table-1: Distribution of House-Brackmann grades and within-group comparisons over time

HBS grade	Group A Baseline (n=30)	Group A Mid (n=28)	Group A Post (n=26)	Group B Baseline (n=30)	Group B Mid (n=27)	Group B Post (n=25)
Grade I, n (%)	0 (0.0)	0 (0.0)	3 (11.5)	0 (0.0)	0 (0.0)	1 (4.0)
Grade II, n (%)	0 (0.0)	4 (14.3)	9 (34.6)	0 (0.0)	2 (7.4)	5 (20.0)
Grade III, n (%)	20 (66.7)	19 (67.9)	13 (50.0)	10 (33.3)	13 (48.1)	12 (48.0)
Grade IV, n (%)	7 (23.3)	5 (17.9)	1 (3.8)	13 (43.3)	10 (37.0)	7 (28.0)
Grade V, n (%)	3 (10.0)	0 (0.0)	0 (0.0)	7 (23.3)	2 (7.4)	0 (0.0)

Within-group comparison[a]	Group A: Z (p-value)	Group B: Z (p-value)
Baseline to mid-treatment	-2.828 (0.005)	-3.000 (0.003)
Mid-treatment to post-treatment	-3.606 (<0.001)	-3.000 (0.003)
Baseline to post-treatment	-3.879 (<0.001)	-3.900 (<0.001)

The distribution of HBS grades at each assessment and the within-group comparisons are shown in Table 1. None of the patients in either group were in Grade I and II at baseline. At the end of treatment 3 (11.5%) patients in Group A improved to Grade II, 9 (34.6%) to Grade II (Grade I=1, Grade II=5) and no patient in Group A was still Grade V. At the end of treatment 6 (24.0%) patients in Group B were Grade II (Grade I=1, Grade II=5). There were 1 (3.8%) patient(s) in Grade IV in Group A, 7 (28.0%) in Group B, and 0 in either group in Grade V. This gradual progression towards lower grades is shown in Figure 3. The Wilcoxon signed-rank test showed significant within-group improvement in Group A from baseline to mid-treatment (Z=-2.828, p=0.005), mid-treatment to post-treatment (Z=-3.606, p<0.001) and baseline to post-treatment (Z=-3.879, p<0.001), and in Group B at the same intervals (Z=-3.000, p=0.003; Z=-3.000, p=0.003; Z=-3.900, p<0.001). The GEE model had a significant main effect of time (Wald χ^2=54.861, p<0.001), and at mid-treatment (B=-1.032, p<0.001) and post-treatment (B=-2.784, p<0.001), there were lower grades than at baseline. The main effect of intervention was also significant (Wald χ^2=4.379, p=0.036), with lower HBS grades in Group A than in Group B (B=-1.103, 95% CI: -2.137 to -0.070).

FDI physical function improved progressively in both groups, from 47.67±13.57 at baseline to 63.39±14.66 at mid-treatment and 77.31±13.36 at post-treatment in Group A (a mean gain of 29.64 points), and from 43.50±16.36 to 56.67±15.81 and 69.40±13.72, respectively, in Group B (a mean gain of 25.90 points). There was a higher score in Group A than Group B at each time point, and the difference in scores increased from 4.17 points at baseline to 6.72 points at mid-treatment and 7.91 points at post-treatment (Figure 4). The difference was not significant at baseline (t=1.074, p=0.287) or mid-treatment (t=1.637, p=0.108), but was significant at post-treatment (t=2.086, p=0.042). Mauchly's test indicated a violation of sphericity (p=0.002) and the results of the repeated measures ANOVA with Greenhouse-Geisser correction showed a significant main effect of time (F=389.275, p<0.001) and a significant time x group interaction (F=4.574, p=0.019), and there was no significant main effect of group (F=2.282, p=0.137). Within subjects contrasts revealed a significant linear trend across time (F=534.387, p<0.001), and a significant linear time × group interaction (F=6.260, p=0.016), suggesting a greater rate of improvement for Group A.

The association between FDI social/well-being function and other variables was similar. Scores increased from 43.73±13.57 at baseline to 61.14±15.88 at mid-treatment and 75.08±13.54 at post-treatment in Group A (a mean gain of 31.35 points), and from 40.13±16.46 to 54.52±16.16 and 66.88±14.03, respectively, in Group B (a mean gain of 26.75 points).

Table-2: Comparison of Facial Disability Index scores between groups over time

FDI subscale	Time point	Group A (EMS), mean±SD (n)	Group B (FCS), mean±SD (n)	t	p-value [a]
Physical function	Baseline	47.67±13.57 (30)	43.50±16.36 (30)	1.074	0.287
	Mid-treatment	63.39±14.66 (28)	56.67±15.81 (27)	1.637	0.108
	Post-treatment	77.31±13.36 (26)	69.40±13.72 (25)	2.086	0.042
	RM-ANOVA[b]	Time: F=389.275, p<0.001	Time × group: F=4.574, p=0.019	Group: F=2.282	p=0.137
Social/well-being function	Baseline	43.73±13.57 (30)	40.13±16.46 (30)	0.924	0.360
	Mid-treatment	61.14±15.88 (28)	54.52±16.16 (27)	1.533	0.131
	Post-treatment	75.08±13.54 (26)	66.88±14.03 (25)	2.123	0.039
	RM-ANOVA[b]	Time: F=390.293, p<0.001	Time × group: F=6.375, p=0.004	Group: F=1.975	p=0.166

At both treatment timepoints (mid and post), the difference between the groups increased from 3.60 to 6.62 points and 8.20 points, respectively. The groups did not differ at baseline (t=0.924, p=0.360) or mid-treatment (t=1.533, p=0.131), but Group A scored significantly higher at post-treatment (t=2.123, p=0.039). However, there was a significant time × group interaction (F=6.375, p=0.004) and significant time main effect (F=390.293, p<0.001); the main effect of group was not significant (F=1.975, p=0.166), using Greenhouse-Geisser correction (Mauchly's test p=0.006). Results of within-subject contrasts revealed significant linear (F=578.944, p<0.001) and quadratic (F=4.669, p=0.036) trend over time, as well as a significant linear time × group interaction (F=9.364, p=0.004).

4. DISCUSSION

In this randomized controlled trial, the electrical muscle stimulation and faradic current stimulation are compared in patients with unilateral facial nerve palsy with facial exercises. Both modalities improved House-Brackmann grades and both FDI subscales — Physical Function and Social/Well-being Function — over the six-week treatment period. However, statistically significant between-group differences favoring EMS were observed in House-Brackmann grades and in the rate of improvement on both FDI subscales. The marked difference noted between the groups is congruent with the findings of facial exercise being effective in improving recovery in facial palsy,[9] with the association of rehabilitation with higher recovery rates compared with no intervention.[10] Additionally, it is consistent with the positive results of electrical stimulation in a recent meta-analysis of acute Bell's palsy.[16] Both groups participated in the same structured facial exercises, and part of the improvement they achieved may be due to exercise, the results of which a systematic review have shown to be additive with electrical stimulation when combined with exercise-based approaches, favoring the combined approach employed in this study.[19]

The benefit of EMS on the House-Brackmann Scale is consistent to that reported by Di Pietro et al., which showed that the addition of selective EMS reduced the recovery time to maximal recovery from 5.2 to 2.5 weeks without increasing synkinesis.[15] Functional electrical stimulation of the facial muscles has also been beneficial in restoring muscle function in chronic paralysis.[17] Overall, 46.2% of the patients treated with EMS were assigned Grade I or II, whereas 24.0% of the patients treated with FCS were assigned Grade I or II. The results should be interpreted with caution however as the severity of HBS grade at baseline was greater in Group B, which may have contributed to the

difference between the groups. The difference in the superiority of EMS on the physical function of FDI might be due to the different electrical properties of the two modalities. In denervated muscle fibres the long pulses of EMS can directly depolarise the fibres and keep them contracted until the motor nerve fibres regenerate,[18] while the short pulses of the faradic current require some degree of integrity in the motor nerve fibres in order to elicit a contraction.[14] This would be predicted in a sample of varying degrees of denervation, resulting in similar early outcomes and a progressive divergence to patients with more severe denervation being less responsive to faradic current. This was seen in the large linear time × group interaction where the groups began with close FDI scores and the advantage of EMS was observed to develop slowly throughout treatment.

The time × group interaction was greater with social/well-being function (p=0.004) than with physical function (p=0.019). Facial palsy impacts a person's emotional expression, social interaction and identity,[7] as well as anxiety and lowered self-esteem which can last even if the palsy is not altogether recovered.[8] This is a patient-reported aspect of disability captured by the FDI.[22] From our hypothesis, we assume that patients might have to attain a threshold of visible face movement and face symmetry before they feel socially confident and from then on more benefits may come in faster—this hypothesis will need to be tested in future studies.

These results have important ramifications for rehabilitation practice.[23] Earlier treatment has been correlated with better long-term outcomes with less development of synkinesis, therefore EMS, which can act on denervated muscle, may be more beneficial in the early stages of recovery.[24] Further developments on stimulation devices which could selectively stimulate specific facial muscles are anticipated to enhance the accuracy of electrotherapy; and the use of electrical stimulation as part of a structured rehabilitation program, combined with neuromuscular retraining, may maximize functional and aesthetic results.[25]

There are some limitations to this study. Sample size was small, and calculated with significance level of 0.10 and power of 0.60, nine patients lost to follow up. The difference between groups in FDI scores post-treatment was small (p=0.042 and p=0.039), and would not be significant after correction for multiple comparisons. This introduces performance and measurement bias, as the groups were not matched for HBS grades or the participants were not blinded, nor was the assessor. The study was performed in a single center, with no follow-up beyond six weeks; no attempt was made to assess electrodiagnostically the degree of nerve injury; and the term "synkinesis" was not specifically evaluated. Future multicenter trials with larger numbers of patients, a level of significance of 0.05, blinded evaluation, and longer follow-up and stratification by severity of denervation are suggested to validate the results.

5. CONCLUSION

Electrical muscle stimulation and faradic current stimulation with facial exercises both resulted in an improvement in facial function for patients with unilateral facial nerve palsy. Electrical muscle stimulation, however, resulted in more functional and psychosocial recovery than faradic current stimulation and may be preferable in rehabilitation.

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