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"Comparison between Electrical Stimulation over Motor Point and TENS over Acupuncture Point in Reducing Spasticity and Improving Function after Stroke: Randomized Clinical Trial"

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Abstract

Purpose: To compare the effectiveness of electrical stimulation over motor point and TENS over acupuncture point for reducing spasticity and improving function in stroke patients.

Methodology: This was an experimental study of 30 stroke patients having first ever unilateral stroke. The subjects were divided into three groups: group A (ES + Conventional PT), group B (TENS + Conventional PT) and group C (Control group with Conventional PT), comprising 10 in each group. All the groups received training 5 times a week for 4 weeks. Outcome measurements included Modified Ashworth Scale, Timed up and go test and Dynamic gait index.

Results: At baseline, patients in each group were closely similar in all important prognostic variables. All groups, Group A, Group B and Group C showed statistically significant improvement ($p < 0.05$). But Electrical Stimulation with Conventional PT and TENS with Conventional PT showed significant improvement when compared with Control group. Whereas Electrical stimulation with conventional PT was more significant when compared with TENS with conventional PT.

Conclusions: Electrical stimulation over motor point is more effective than TENS over acupuncture point in reduction of spasticity in stroke rehabilitation.

Keywords: Stroke; Electrical stimulation; TENS; Conventional physiotherapy

Introduction

A stroke, or cerebrovascular accident (CVA), is the rapid loss of brain function due to disturbance in the blood supply to the brain. Stroke is defined by the World Health Organization (WHO) as a "rapidly developing syndrome with clinical signs of focal or global disturbance of cerebral function, with symptoms lasting 24 hours or longer or leading to death, with no apparent cause other than vascular origin" [1].

It is the commonest neurological disorder worldwide, the second commonest medical condition in the developed world and the leading cause of disability among adults [2]. Incidence of stroke ranges from 0.2 to 2.5 per thousand per year according to WHO [3]. The incidence of stroke rapidly increases with age, doubling for each decade after age 55 [4].

Stroke can lead to various types of motor, sensory, cognitive, perceptual and psychological problems. Motor problem in stroke are often accompanied by spasticity, which is defined as a velocity dependent increased resistance to passive lengthening of muscles or tendons caused by a hyper excitability of the stretch reflex [5,6]. Spasticity present either in the form of flexor synergy or extensor synergy, which involves various group of muscles in which spasticity in calf muscle is very common. Plantarflexor Spasticity or spastic foot, may cause uneven weight-bearing with less body weight support on the affected leg [5]. Such asymmetric weight distribution could further decrease postural control and lead to unstable and inefficient gait. As a result, walking becomes a challenge because of the patient's inability to control the foot, and the decrease in walking speed with gait asymmetry may be significant [7,8]. Walking after stroke is characterized by slow gait speed, poor endurance and changes in the quality and adaptability of walking pattern. Although 60% of stroke survivors regain walking independence after 3 months, many have continuing problems with mobility due to impaired balance, motor weakness and decreased walking velocities [7].

Spasticity increases resistance to normal movement, interrupts motor performance, and induces gait disturbances, pain, and contracture in joints and muscles, impedes self care activities and results in balance disorders.9 Therefore, spasticity intervention is important for improving the quality of life of people with Upper Motor Neuron (UMN) diseases and for achieving functional recovery.

Many treatments are available for spasticity reduction. Oral medication, intrathecal baclofen pumps, physical therapy and even surgery is applied to reduce spasticity or treat fixed contractures as a result from spasticity [10,11].

Common physical therapy treatment of spasticity often involves early mobilizations, combined with elongation of spastic muscles and sustained stretching through various positioning.

There are various electrotherapeutic modalities. This included transcutaneous electrical nerve stimulation (TENS) on acupuncture points, and electrical stimulation (ES) on the motor points. These stimulation protocols were found to decrease spasticity that leads to improvement in lower limb motor function of patients after stroke [12-14]. There is some evidence that electrical stimulation of the antagonist muscles can reduce spasticity immediately following treatment [15-17]. Bogataj et al. found that neuromuscular electrical stimulation may increase sensory inputs into the central nervous system and so accelerate nervous plasticity and lead to faster motor learning [18]. It has been claimed that electrical stimulation may reduce muscle tonicity via the reduction of the stretching reflex, causing lower spasticity and allowing a larger range of motion [19] and preventing soft tissue stiffness and contracture [20].

TENS excites large diameter A (α, β) afferents, which would include sensory and motor fibers. Numerous studies have revealed that cortical representation areas are constantly modified by sensory inputs and motor experiences, which play a major role in the subsequent physiological reorganization that occurs in the adjacent intact brain tissues after brain injuries [21-30]. Evidence showed that afferent inputs evoked by TENS reach both sensory and motor cortices. There are various methods of applying TENS, application over acupuncture point is one of them, acupuncture itself is a different method of treatment and having their own proven effectiveness in various musculoskeletal and neurological disorders, and so application of TENS over acupuncture point have been used in various previous studies and proven effective [18,27].

So there is need to find out the better strategy to reduce spasticity and improve function after stroke.

The recent evidence suggest that in alone both the electrotherapeutic modalities have their effectiveness in reducing spasticity. There is lack of evidence to allow conclusions to be drawn about the efficacy of ES when compared with TENS for reducing spasticity in stroke patients. This study aimed to compare the efficacy of ES when compared with TENS for reducing spasticity in stroke patients will add to the growing body of knowledge that if these two modalities yield comparable outcomes and if one modality is superior to the other, which should be the alternate choice of therapy.

Methodology

Total 30 patients of stroke from MGM hospital and private clinics in Aurangabad who met the inclusion criteria included in this study. For patient selection simple random sampling was done. The patients were divided into three equal groups (10 patients in each group) as group A (ES + Conventional PT), group B (TENS + Conventional PT) and group C (control group).

Inclusion Criteria

- Between 40-70 years of age both male and female
- First stroke
- 3 months after stroke
- Presence of spasticity (Modified Ashworth Scale (MAS) grade 1 or higher),
- Able to walk independently with minimal support or without support
- Full passive Range Of Motion (ROM) for ankle dorsiflexion.
- EXCLUSION CRITERIA
- Sensory loss or oversensitivity to ES.
- A history of orthopedic or other neurologic disorders that would affect the ability to walk.
- Any cognitive or perceptual impairment.
- Previous neurological, psychiatric, or other disorder making it difficult to pursue the treatment or evaluations
- Concurrent participation in another trial of interventions supposed to affect long-term neurological and functional outcome

Method

A written/informed consent taken from subjects diagnosed by neurophysician with stroke. After which they were screened for inclusion and exclusion criteria. Subjects fulfilling the criteria included in the study. Baseline measurements were taken for all patients for modified ashworth scale (MAS), timed "up and go" test (TUG) and dynamic gait index (DGI). Subjects divided into group A (ES + Conventional PT), group B (TENS + Conventional PT) and group C (Control Group).

Group A: ES + conventional physiotherapy

One electrode was positioned just below the head of the fibula and the second electrode was positioned over the motor point of the tibialis anterior muscle of the paretic leg to achieve balanced ankle dorsiflexion. The electrode positions were adjusted until full balanced dorsiflexion was achieved without discomfort.

ES parameter: Microcontrol diagnostic and therapeutic muscle stimulator was used. Pulse width (μs): 300, Pulse rate (Hz): 30, Burst duration (s) : 4, Ramp-up time (s) : 1, Pause duration (s) : 4, Total duration (min) : 45 and Intensity - upto patient tolerance [22].

Group B: TENS + conventional physiotherapy

TENS: Microcontrol 4 channel TENS was used.200 μs pulses, at 100 Hz in the constant mode for 60 minutes within the subject's tolerance level, via electrodes attached to the following acupuncture points on the affected lower extremity: St 36, Lv 3, GB 34, and Bl 60. These acupoints were selected according to traditional Chinese medicine and a previous stroke study [14,23] (Figures 1 and 2).

Conventional PT

The rehabilitation plan, essentially conventional physical therapy based on ADL skills included:

- Passive range of motion exercises
- Passive stretching
- Active assistive exercises
- Active exercises
- Resistive exercises
- Exercises in different functional positions
- Weight bearing exercises
- Weight shifting exercises
- Reaching exercises in sitting, kneeling and standing

Gait training

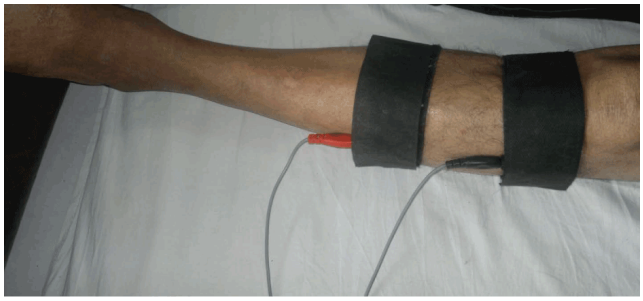


Figure 1: Positioning of electrodes for Electrical stimulation.

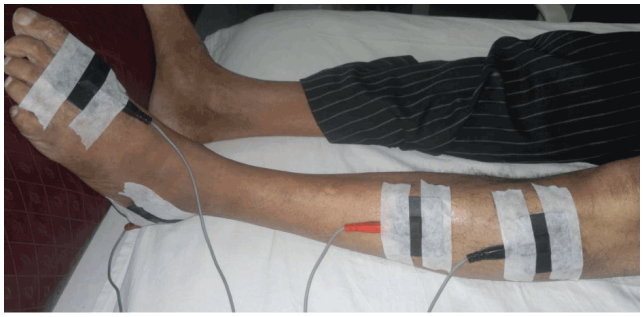


Figure 2: Positioning of electrodes for TENS.

These exercises prevent complications of immobilization and improve Activity of Daily Living (ADL) skill at the earliest. This helps in preventing contractures and development of abnormal postures. These exercises start with simple movements and subsequently complex movements and actions are tried. The subject's functional abilities, or abilities to perform different movements or tasks (eg, pattern movements, selective movements, standing up, maintaining standing, walking) were the basis for treatment. The same therapist worked with an individual subject throughout the program of conventional treatment.

Group C: Control group

In the control group, the subjects received general conventional physiotherapy as described above.

In addition, all patients, irrespective of the group they had been allocated to receive occupational therapy and speech therapy if needed. Drug therapy was not prespecified, except that experimental drugs in stroke trials were not allowed after inclusion into the study.

Ethical Approval and Informed Consent

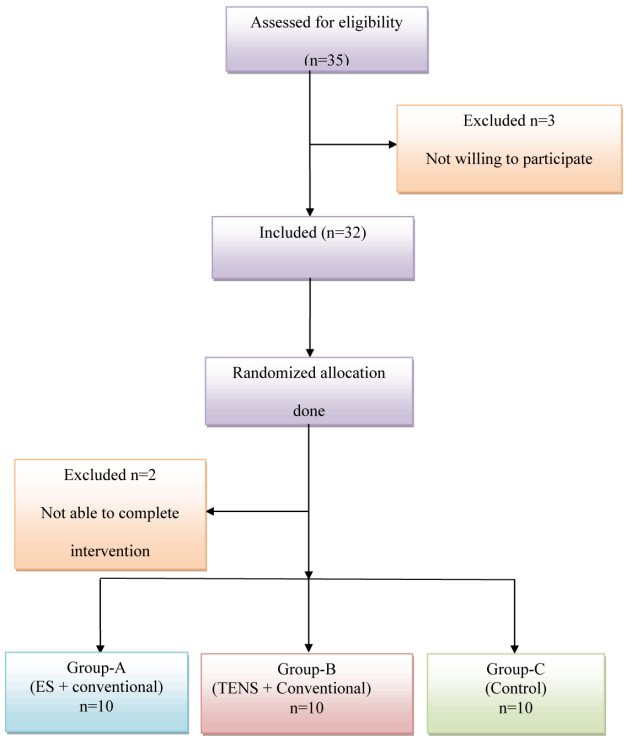
Before implementing the study, an approval from university ethical committee was taken. Also the Informed consent was taken from patients with Stroke, who were willing to participate in study.

Data Analysis

Data analysis was done using SPSS version 20, software package. Mean and standard deviation were used as descriptive statistics. Unpaired t-test was performed to compare age, gender, risk factor and side affected. Comparison for the pre test and post test scores had been calculated for MAS, Dynamic gait index (DGI) and timed "up & go" test (TUG) using ANOVA test, Post hoc test. ANOVA was done for Inter-Group Comparison of Mean of MAS, TUG and DGI at Group A, Group B & Group C in between the group. Comparison of mean difference between groups was done using post hoc analysis for MAS, TUG and DGI. Intra-Group Comparison of mean for Group A, Group B & Group C using paired t-test within the group was done. The significant (probability-P) was selected as <0.05.

Results

Total 35 patients were selected and out of which 3 were excluded because they refused to participate in the study and 2 were not able to complete the intervention of 4weeks (from Group C), so total 30 subjects divided in group A, group B and group C, 10 patients in each group (Flow Chart).



Flow Chart

		Group A (n=10)	Group B (n=10)	Group C (n=10)
Age , years (Mean±SD)		54.10 ± 8.38	55.60 ± 9.53	54.30 ± 8.25
Gender	Male	07	07	06
	Female	03	03	04
Risk Factor	Hypertension (HTN)	05	03	04
	Diabetes Mellitus (DM)	00	01	00

	HTN+DM	01	01	04
	None	04	05	02
Paretic side	Left	05	05	06
	Right	05	05	04

Table 1A: Demographic Data of the sample.

Above table shows demographic data of the sample in group A, group B and group C.

A total of 20 males and 10 females participated in the study. In Group A, 70% were male and 30% were females whereas in Group B, 70% were males and 30% were females and in Group C, 60% were males and 40% were females (Table 1A).

Gender	Group A	Group B	Group C	Total	Chi-square test	p-value
Male	07	07	06	20	1.12	P = 0.425 NS
Female	03	03	04	10		
Total	10	10	10	30		

Table 1B: Gender-wise distribution of patients.

Above table shows gender-wise distribution among group A, group B and group C. p-value is 0.425 which shows the difference is non significant (Table 1B).

In Group A, 50% patients were right side affected and remaining 50% patients were left side affected, in Group B, 50% patients were right side affected and remaining 50% patients were left side affected and in Group C, 40% patients were right side affected and remaining 60% patients were left side affected.

Gender	Group A	Group B	Group C	Total	Chi-square test	p-value
Right	5	5	4	14	0.268	P = 0.875 NS
FLeft	5	5	6	16		
Total	10	10	10	30		

Table 1C: Distribution of patients according to Side affected.

Above table shows distribution of patients according to side affected. P-value is 0.875 which is non significant (NS) (Table 1C).

	Group	Baseline Score	After 4 week score	p-value
MAS	Group A	2.5 ± 0.53	1.30 ± 0.49	0
	Group B	2.6 ± 0.52	1.50 ± 0.49	0.001
	Group C	2.5 ± 0.53	2 ± 0.47	0.015
TUG	Group A	38.39 ± 2.92	29.69 ± 2.93	0
	Group B	37.09 ± 3.15	32.60 ± 2.96	0
	Group C	36.24 ± 4.57	34.32 ± 3.91	0
DGI	Group A	12.1 ± 0.74	15.90 ± 1.52	0
	Group B	12.2 ± 0.63	14.50 ± 1.51	0.003
	Group C	12 ± 0.67	12.70 ± 1.06	0.010

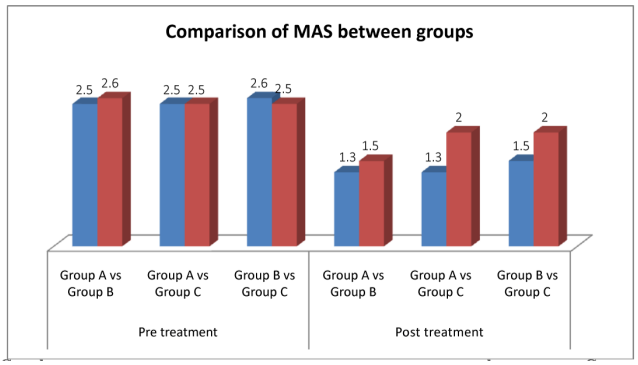
Table 2: Comparison of score between group A, group B and group C.

The above table shows there is statistical significant difference in the pre and post values for MAS, TUG and DGI (Table 2).

MAS	Groups	Mean Difference	p-value
Pre treatment	Group A vs Group B	0.10	P=0.905 NS
	Group A vs Group C	0.00	P=1.00 NS
	Group B vs Group C	0.10	P=0.905 NS
Post treatment	Group A vs Group B	0.20	P=0.642 NS
	Group A vs Group C	0.70	P=0.010 S
	Group B vs Group C	0.50	P=0.076 NS

Table 3: Pre and post intervention comparison of Modified Ashworth Scale between two Groups.

The above table shows that there is statistical difference in pre treatment values for MAS between all groups. In post treatment, there is significant difference in group A vs group C with p-value 0.010 (Table 3).



Graph 1: Pre and post treatment Modified Ashworth Scale score between two Groups.

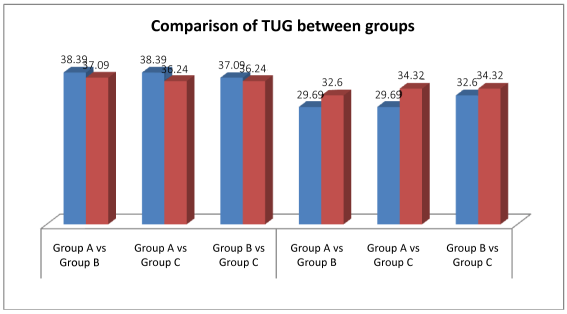
The above graph shows that there is no statistical significant difference in the pre values for MAS. Whereas significant improvement in MAS found in group A vs group C (Graph 1).

Time	Groups	Mean Difference	p-value
Pre treatment	Group A vs Group B	1.30	P=0.704 NS
	Group A vs Group C	2.16	P=0.390 NS
	Group B vs Group C	0.86	P=0.858 NS
Post treatment	Group A vs Group B	2.91	P=0.160 NS

	Group A vs Group C	4.99	P=0.008 S
	Group B vs Group C	2.09	P=0.376 NS

Table 4: Pre and post treatment comparison of Timed up and go test between two Groups.

The above table shows that there is statistical difference in pre treatment values for TUG between all groups. In post treatment, there is significant difference in group A vs group C with p-value 0.008 (Table 4).



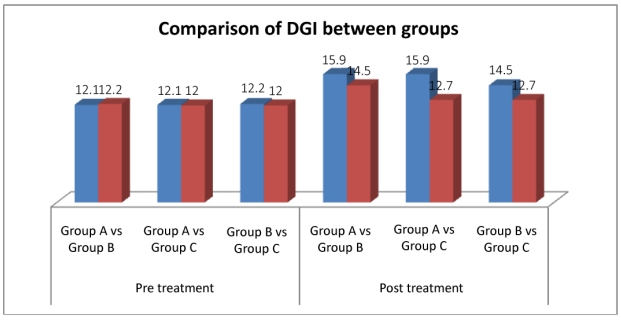
Graph 2: Pre and post treatment comparison of Timed up and go test score between two Groups.

The above graph shows that there is no statistical significant difference in the pre values for TUG. Whereas significant improvement in TUG found in group A vs group C (Graph 2).

Index	Groups	Mean Difference	p-value
Pre treatment	Group A vs Group B	0.10	P=0.942 NS
	Group A vs Group C	0.10	P=0.942 NS
	Group B vs Group C	0.20	P=0.790 NS
Post treatment	Group A vs Group B	1.40	P=0.048 S
	Group A vs Group C	3.20	P=0.000 S
	Group B vs Group C	1.80	P=0.019 S

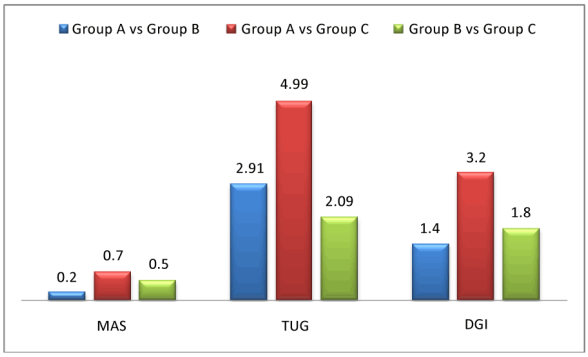
Table 5: Pre and post treatment comparison of Dynamic gait index score between two Groups.

The above table shows that there is statistical difference in pre treatment values for TUG between all groups. In post treatment, there is significant difference in group A vs group B, group A vs group C and group B vs group C (Table 5).



Graph 3: Pre and post treatment Dynamic gait index score between two Groups.

The above graph shows that there is no difference in the pre values for DGI. Whereas statistically significant improvement in post treatment DGI found in all groups (Graph 3).



Graph 4: Comparison of mean improvements of MAS, TUG and DGI values in Group A, Group B and Group C.

This graph shows the improvements in all the three measures in group A vs group B, group A vs group C and group B vs group C (Graph 4).

Discussion

The present study deals with the effectiveness of Electrical Stimulation when compared with TENS for reducing spasticity in stroke patients.

When analysis was done for demographic information of participants, no statistically significant difference was found showing that subjects are matched for baseline characteristics. Hypertension is the most common risk factor among stroke patients. Also there was no significant difference between pre MAS, pre TUG and pre DGI score in the groups.

When comparison was done at pre and post intervention level for all the groups, statistically significant difference was found between all the three groups for MAS, TUG and DGI score. This shows that Electrical stimulation, TENS and control group all are effective in reducing spasticity and improving lower limb function.

When comparison was done at post intervention level it was found that there is statistically significant difference between the groups for post MAS, post TUG and post DGI score, which shows that after 4 weeks of intervention, there was difference in the efficacy of group A (ES + Conventional PT), group B (TENS + conventional PT) and group C (control group).

When analysis was done between the groups at post intervention level i.e. group A vs group B, group A vs group C and group B vs group C, there was statistically significant difference in group A vs group C for MAS and TUG scores. While for DGI score there was significant difference in all the three groups. This shows that reduction in spasticity was significant in group A. Both group A and group B were effective when compared with group C; but group A was more effective when compared with group B.

Although lower extremity function improvements were seen in all the groups but it was seen in this study that a greater amount of improvement in lower limb function was noted in group A (ES with conventional therapy). Therefore the alternate hypothesis is accepted. Finding of this study is supported by the study of Shawn Robbins on "The Therapeutic Effect of Functional and Transcutaneous Electric Stimulation on Improving Gait Speed in Stroke Patients: A Meta-Analysis." In which, Prospective clinical studies were included and it was reported that FES is effective at improving gait speed in subjects poststroke [24].

In a study by Amir H Bakhtiary on "Does electrical stimulation reduce spasticity after stroke?" it was reported that a combination of Bobath inhibitory technique and electrical stimulation may help to reduce spasticity effectively in stroke patients [25]. In another study by Arjan van der Salm on "Comparison of electrical stimulation methods for reduction of triceps surae spasticity in SCI" reported that the significant change in the reflex-initiating angle indicating that antagonist stimulation is more effective to reduce spasticity [22]. However in contrast to the results of this study, Hines et al. reported no decrease in spasticity in hemiplegic patients by functional electrical stimulation [26]. Different parameters used for electrical stimulation may be the reason for the different reported result. The better prognosis in ES group may be due to its neurophysiological effect because stimulation of the antagonist initiates the reciprocal inhibition. Neurophysiological pathways provide inhibition of muscle tone. Contraction of the antagonist muscle will inhibit the α-motorneuron of the agonist. Due to the muscle contractions the blood flow will be increased in the stimulated area, agonist and antagonist, which, in turn, can decrease the muscle stiffness and spasticity. In a study by Smith reported that the artificial stimulation of muscles with FES during gait produces repetitive muscle contractions that can increase proprioceptive input to the brain. This effect is shown by changes in the hemodynamic responses to the sensorimotor regions of the brain after electric stimulation in healthy subjects [27]. To reduce spasticity by means of electrical stimulation has an instant effect and a carry-over effect (effect remains after stimulation has stopped) can be distinguished. The carry-over effect can be very useful in the treatment of gait, because the electrical stimulation can be used to reduce the spasticity before the actual gait (training) is performed. Thus, the gait impairment caused by spasticity will be reduced or eliminated, which can facilitate gait.

Group B also reported improvement in gait and reduction in spasticity. Shamay S.M. Ng conducted a study on "Transcutaneous Electrical Nerve Stimulation Combined With Task-Related Training Improves Lower Limb Functions in Subjects With Chronic Stroke" reported that 20 sessions of a combined TENS over the acupuncture point along with TRT home-based program decreased plantarflexor spasticity, improved dorsiflexor and plantarflexor strength, and increased gait velocity.14 However in contrast to the result of this study, Barbro B. Johansson did a study on "Acupuncture and Transcutaneous Nerve Stimulation in Stroke Rehabilitation A Randomized Controlled Trial" and reported that treatment during the subacute phase of stroke with acupuncture or transcutaneous electrical nerve stimulation with muscle contractions had no beneficial effects on functional outcome or life satisfaction as compared with control group [28]. This may be due to use of different acupuncture points and parameter for TENS. Possible mechanisms underlying the improvements could be attributable to an enhancement of presynaptic inhibition of the hyperactive stretch reflexes in spastic muscles, decrease in the co-contraction of spastic antagonists, and disinhibition of descending voluntary commands to the motoneurons of paretic muscles as suggested. TENS electrodes were applied to the acupuncture points located on the anterolateral aspect of the affected lower limb, which are subcutaneous and close to the nerves (i.e. peroneal nerve) and blood vessels. Acupuncture points tend to be located where nerves enter a muscle, the midpoint of the muscle or at the enthesis where the muscle joins with the bone [14].

The results of this study showed significant beneficial effects of electrical stimulation on spasticity reduction, although these effects were assessed 4 weeks after the intervention and no long-term effect of the therapeutic protocol was assessed by the study. However, other studies showed that the reduction of spasticity due to electrical stimulation may last for up to six months in spastic patients secondary to cerebral vascular accident and head injuries [29,30].

The better prognosis in group A as compared to group B may be due to ES generates joint movements and stronger muscle contractions than TENS. These repetitive movements and additional sensory information make ES more effective at improving gait in subjects post stroke. Whereas TENS uses electric stimulation with an intensity that is sufficient for sensory level but it is insufficient to produce a tetanic muscle contraction.

From findings of this study, it can be recommended that both ES over motor point and TENS over acupuncture point are effective in reduction of spasticity. Electrical stimulation is better option to reduce spasticity in stroke patients so that they can receive more benefit from motor control program and improve their functional activity resulting in strength and gait improvement in subjects post stroke.

Clinical Implication

The results of this study have important clinical implication for developing effective intervention for patients with stroke by incorporating Electrical Stimulation when compared with TENS for reducing spasticity that can improve the motor functions for activities of daily living. They can be easily incorporated in any rehabilitation technique.

Limitations

Sample size was small, so the result cannot be generalized.

The carry over effect of ES and TENS was not given by the study. Treatment effectiveness was examined only 4 weeks after treatment. No follow up was taken, whether improvements in motor functions can be attained after cessation of treatment.

Future Research

Future clinical trial study can be carried out on a larger sample size with long term follow up. A similar study can be conducted including acute, sub acute and chronic (in 3 different groups) stroke patients.

Further studies are needed to investigate the long-term effects of electrical stimulation on spasticity when compared with TENS and also on the functional activity of spastic patients. A similar study can also be conducted on other neurological conditions with spasticity. Efficacy of ES and TENS can be calculated in upper limb spasticity in stroke patients.

Conclusion

The result obtained from the study demonstrated that both Electrical stimulation over motor point and TENS over acupuncture point showed significant results as compared to control group and displayed efficient improvement in motor function of the lower extremity after 4 weeks of treatment. When compared with TENS group, Electrical stimulation group showed significant improvement in spasticity and lower limb function. Therefore proving that electrical stimulation with conventional therapy is more effective than TENS with conventional therapy in stroke rehabilitation.

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