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# ROBOTIC HAND TRAINING IN PATIENTS WITH STROKE: A PILOT STUDY FROM INDIA

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Conflicts of Interest: Nil

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**Abstract:**

**Background:** Impaired hand function is the most disabling motor deficit in stroke patients.

**Purpose of the study:** To evaluate efficacy of robot-assisted training in hand function recovery of stroke patients.

**Study Design:** Prospective, interventional study of 8 participants.

**Methods:** Eight stroke patients underwent 3 week training program and received 15 sessions (30 minutes each) of robotic hand training using Amadeo robotic system (Tyromotion GmbH Graz, Austria). The training was as follows: passive modality (10 minutes), passive-plus modality (10 minutes), and assisted therapy (10 minutes). The impairment evaluation was done using upper extremity Fugl-Meyer scale (UEFM) and muscle strength for affected upper limb was assessed with Medical research council (MRC) scale, at the beginning (T1) and at the end of treatment (T2). The hand flexion and extension strength performed by robot were assessed at T1 and T2.

**Results:** Eight (male) patients with mean age 43.1 years (20-60years), mean duration of symptoms 19 months (6-36 months), 7 ischemic and 1 hemorrhagic stroke, lesion side left hemisphere in 6 and right in 2 cases, were recruited. There was statistically significant improvements for UEFM Motor domain (P = 0.01), Amadeo force assessment in flexion (P = 0.01) and extension (P = 0.02), MRC shoulder (P =0.02), finger flexion (P = 0.006),extension (P = 0.02), abduction(P = 0.02), adduction (P = 0.02).

**Conclusions:** Robot hand training is a safe and feasible treatment option for hand motor recovery in chronic stroke patients.

**Keywords:** Stroke, Amadeo robotic system, hand function recovery

## Introduction

Though stroke causes deficits in many neurological domains, the most commonly affected is the motor system[1]. Nearly 50% of stroke survivors suffer hemiparesis of the upper arm[2] and impaired hand function is reported as the most disabling motor deficit[3]. A number of longitudinal studies indicate that up to 62% of hemiplegic stroke patientsfailed to achieve some dexterity at 6 months whereas only 11.6%

demonstratedcomplete functional recovery[4] in dexterity of the paretic arm at 6 months.

Robot-assisted neurorehabilitation has been an active area of scientific investigation for the last 15 years[5].Earlier studies had focused on proximal upper extremity training showing a positive trend toward robot-assisted therapy for the proximal upper limb when compared to conventional treatment modalities with regard to motor recovery[6]. Since 2003, there has been a steady increase in the number of devices that assist and train distal upper extremity movements such as wrist and/or finger movements[5]. Robotics may offer stroke patients an opportunity to train independently in an intensive functional fashion and at home[6].

Studies in the recent past have shown improvement in multiple measures of motor performance of hand with good tolerance of treatment without any complications in both acute and chronic stroke patients using hand robot[7,8].

The purpose of this pilot study was to test the effectiveness of Amadeo hand robot in recovery of the motor performance of distal upper extremity in chronic stroke patients.

**Amadeo hand robot**

Amadeo robotic system (Tyromotion GmbH Graz, Austria) is a modern mechatronic Finger-Hand-Rehabilitation device for the rehabilitation of patients with motor functional disorders of the distal upper extremity. It provides robot-assisted exercise for the finger flexors and extensors combined with visual feedback.

The device is attached to the tips of fingers and measures aligned multiple joints movements of the fingers. The robot is free from the anatomical limitations of joint alignment with 5 DOFs (degrees of freedom) and provides the motion of one or all five fingers, due to a passive rotational joint placed between fingertip and an entity moving laterally; (the thumb has got two passive rotational joints). The wrist is immobilized using a velcro strap so that the elbow and shoulder would be inhibited from moving.

**Evaluation procedure**

During the robotic therapy the patient is positioned directly in front of the device in a comfortable upright posture. The Hand-Arm support is brought into position and supports the weights of the upper and lower arm as well as that of the hand during the therapy. The arm strapped into an adjustable stabilizing splint is attached to the robotic device with wrist in approximately neutral position and with the forearm pronated. Each of the digits is attached to a robotically controlled slide using small permanent magnets taped to the distal phalanx of each finger. After the fingertips are attached to the finger and thumb pads provided and the respective limit position had been set, an automatic movement sequence is carried out. Depending on the requirement the patient can take a passive or an active part in the therapy. The integrated sensors enable quantitative recording and evaluation of the fingers strength occurring. The following functions during therapy with the system were used in the present study:

CPM- continuous passive motion: sequence of movement of the finger slides, moving the patient's fingers passively

CPM plus: extension of the CPM function by a biological feedback, providing a feedback about his own influence on the movement exercise.

Assistive therapy: prompting the patient to carry out the movement that can be supported by the finger slides, if necessary.

**Materials & Methods**

The study was a prospective, interventional, pilot study conducted at Department of Neurological Rehabilitation of a tertiary care Institute for 8 months. It was approved by Institute Ethics Committee. The patients diagnosed with cerebrovascular accident with residual hemiparesis of either side, who met inclusion criteria and provided informed consent were enrolled for robotic hand therapy and data was recorded.

The inclusion criteria were: both in-patients and out-patients of Neurological Rehabilitation, in the age group of 18 to 65 years of either sex, diagnosed with a unilateral, first-ever clinical, ischemic or hemorrhagic, arterial stroke, confirmed with computed tomography (CT) scan and/or Magnetic resonance imaging (MRI); patients with persistent hemiparesis of either left

or right side; duration since stroke at least 3 months; with at least grade 1 muscle contraction on Medical Research Council (MRC) scale in the finger flexors of affected hand and be able to follow therapists' instructions.

The exclusion criteria were: patients with dystonia or grade 3 spasticity even after optimal treatment, botulinum toxin injection in the affected upper limb during in past 3 months, patients with contractures, patients with global aphasia, patients with impaired consciousness or cognitive disorders, neglect, upper limb apraxia and patients with poor skin condition over affected hand and wrist.

Eight patients fulfilling the inclusion criteria were recruited in the study. Demographic and clinical details were recorded. All subjects underwent rehabilitation treatment for 3 consecutive weeks, consisting of one hour of physiotherapy session, according to individually tailored exercise scheduling. In addition, all subjects received 15 sessions of Amadeo robotic training for 3 consecutive weeks (5 days/week) by an experienced occupational therapist trained in the use of the device. Each session lasted for 30 minutes (consisting of 10 minutes of CPM, 10 minutes of CPM Plus and 10 minutes of assistive therapy). There was a short rest period between each set to prevent muscle fatigue. In CPM therapy the hand was stimulated in continuous passive motion therapy modality for 10 minutes. In assisted therapy, the hand motion was assisted by robot and adjusted to the individual limit of function and performance of each patient for 10 minutes

Prior to the first therapy session, a preliminary test session was performed to ensure that subjects were able to interact with the robot and understand the exercises. No patient participated in any other conventional occupational therapy during the study period.

The patients were evaluated before (T1) and at the end of the robot treatment (T2). The outcome measures for this study were: Upper Extremity component of the Fugl-Meyer[9,10] (UEFM) (upper extremity motor, range of motion and pain components), Medical Research Council (MRC) scale[11] for muscle strength of upper limb and the hand strength for flexion and extension assessed by robot. Force assessment by robot was done by taking the mean of three readings, before and after 15 sessions of training and was recorded.

**Statistical analysis**

Outcome measures were analyzed using Wilcoxon matched-pairs signed-ranks test of baseline values compared with values at the completion of treatment. Results were considered significant at $P < 0.05$.

**Results**

Eight patients with mean age 43.1 years (20-60years), and mean duration of symptoms 19 months (6-36 months), were recruited during the study period and were assigned to robot-assisted therapy. No dropouts were recorded and all subjects completed the training program.

There were seven ischemic and one haemorrhagic stroke. The lesion side was left hemisphere in six cases and right in two cases.

The UEFM scores improved from a mean (SD) of 39.1 (27.1) at start of study to 50.9 (14.93) at completion of study. The statistical analysis using the Wilcoxon matched-pairs signed-ranks test showed statistically significant improvements for UEFM Motor domain ($P = 0.01$), Amadeo force assessment in flexion ($P=0.01$) and extension ($P=0.02$), MRC shoulder ($P=0.02$) Finger Flexion($P = 0.006$),Extension ($P=0.02$), Abduction($P=0.02$), Adduction ($P=0.02$). Weakly significant improvements on UEFM ROM domain (FM) ($P=0.04$) , MRC elbow ($P=0.04$) and MRC wrist ($P=0.04$) were noted. No statistically significant improvements on UEFM Pain domain ($P = 0.1582$) were found. Table I summarizes the observed values of scales at start of study and after completion of study.

**Table I: The results of various scales used in study at T1 and T2 and their statistical significance**

| Scale | | T1 | T2 |
|---|---|---|---|
| MRC Shoulder | Flexion | 3.0 ± 0.76 | 3.6 ± 0.74 |
| | Extension | 3.1 ± 0.64 | 3.8 ± 0.71 |
| | Abduction | 3.1 ± 0.64 | 3.8 ± 0.71 |
| | Adduction | 3.1 ± 0.64 | 3.8 ± 0.71 |
| MRC Elbow | Flexion | 3.0 ± 0.93 | 3.5 ± 1.31 |
| | Extension | 3.0 ± 0.93 | 3.5 ± 1.31 |
| MRC Wrist | Flexion | 2.4 ± 0.92 | 2.9 ± 1.36 |
| | Extension | 2.4 ± 0.92 | 2.9 ± 1.36 |
| MRC Fingers | Flexion | 2.1 ± 0.99 | 3.3 ± 1.04 |
| | Extension | 1.4 ± 0.92 | 2.1 ± 1.55 |
| | Abduction | 1.3 ± 0.89 | 1.9 ± 1.36 |
| | Adduction | 1.3 ± 0.89 | 1.9 ± 1.36 |
| UEFM | Motor | 39.1 ± 27.1 | 50.9 ± 14.93 |
| | Hand &wrist motor | 14.75±5.41 | 22.75±9.30 |
| | ROM | 41.0 ± 4.11 | 42.9 ± 2.10 |
| | Pain | 41.9 ± 4.91 | 43.9 ± 0.35 |
| Amadeo force assessment | Flexion | 25.4 ± 19.1 | 39.9 ± 27.8 |
| | Extension | 3.9 ± 8.6 | 6.4 ± 11.8 |

Wilcoxon matched-pairs signed-ranks test. MRC: Medical Research Council
UEFM: Upper Extremity component of the Fugl-Meyer

## Discussion

This pilot study evaluated the efficacy of the Amadeo finger hand robot for hand rehabilitation of the affected arm in chronic stroke patients. All study participants with hemiparesis after stroke showed improvement after 15 sessions of training with the Amadeo robotic device. Improvement was noted in all the study outcome measures like UEFM, MRC scores and force assessment by Amadeo. The range of UEFM motor scores (18-57) with mean (SD) (39.1 ± 27.1) suggests moderate levels of motor impairment, and the most severely impaired individuals with hemiplegia were not included in this study.

The mean time between stroke and intervention was 19 months in the current study. There is generally very little hand function recovery over this chronic period. Therefore, the observed improvement could be result of comprehensive rehabilitation programme alongwith robot-assisted intervention rather than natural recovery. It supports the theory that use of focused, repetitive movement therapy can enhance motor recovery after stroke, even in chronic period[12].

The advantages of robot-assisted hand rehabilitation include that a robot can administer stereotyped and intensive repetitive exercises for longer and with greater precision than a human therapist[6].

Our study results are similar to the studydone earlier by Stein et al[7] on chronic hemiparetic individuals who received 18 sessions of robot-assisted motor retraining using Amadeo hand robot and showed improvements in multiple measures of motor performance. The Amadeo provides each finger with a single degree of freedom using an actuated linear slide and thus provides training of a simulated grasping activity. It does not provide specific training in other

functionally important hand movements, such as a lateral pinch or finger pincer grasp[7].

Another study done by Patrizio sale et al on 7 acute stroke patients using amadeo hand robot reported clinical improvement in all study participants although statistically significant results were seen only for MRC wrist and hand[8], unlike our study.

Mehrholz and colleagues included 11 trials in their study to assess the effectiveness of robot-assisted arm training in improving ADL independence and arm function in stroke patients. They concluded that patients who receive electromechanical and robot-assisted arm training after stroke are not more likely to improve their activities of daily living, but arm motor function and strength of the paretic arm may improve[13]. Our study did not use any ADL measures; however, none of the study participants reported any significant functional improvement.

The present study also found that chronic stroke patients can improve proximal upper limb function via robot-assisted rehabilitation (P value for shoulder MRC 0.02). Our findings support the study done by Olivier Lambercy, et al who in their pilot study suggested that whole-arm training, which is a commonly used approach in robot-assisted neurorehabilitation, may not be required, as distal training in a functional way could benefit the whole arm[14].

It would be relevant to find out whether robotic hand therapy can be more beneficial for hemiparetic individuals if given during the acute period to augment spontaneous neurological recovery. The duration and intensity of robotic therapy needs to be studied in correlation with clinical improvements in hemiparetic individuals.

The study participants did not receive any conventional occupational therapy and hence the FM hand and wrist component improvement can be attributed to the benefits of robotic hand therapy. However, all our study participants received comprehensive rehabilitation programme including optimisation of medical therapy alongwith conventional physiotherapy. Hence our resultsdo not solely reflect the benefits of robot-assisted intervention. Whether the improvement of robotic therapy persists in long termstill remains to be determined with follow-up study.

## Limitation

The study had small sample size and there was no follow-up, so long term effects of the intervention could not be determined. Since there was no control group, definitive statement regarding the efficacy of the robot or comparison with other standard training programs can not be made.

## Conclusion

It is a safe and feasible study. The lack of side effects and the good participation may suggest a large clinical use. Future positive results of the robotic treatment could be relevant for the advancement of knowledge in hand rehabilitation in subjects with stroke.

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