

**DEVELOPMENT OF FINGER REHABILITATION DEVICE FOR POST-
STROKE PATIENT**

NOR RASHEKAR BINTI ABDUL HALIM

This project is submitted in partial fulfilment of
the requirements for the degree of Bachelor of Engineering with Honours
(Mechanical and Manufacturing Engineering)

Faculty of Engineering
UNIVERSITI MALAYSIA SARAWAK

2010

UNIVERSITI MALAYSIA SARAWAK

BORANG PENGESAHAN STATUS TESIS

Judul: **DEVELOPMENT OF FINGER REHABILITATION DEVICE FOR POST-STROKE PATIENT**

SESI PENGAJIAN: 2006 - 2010

Saya **NOR RASHEKAR BINTI ABDUL HALIM**
(HURUF BESAR)

mengaku membenarkan tesis * ini disimpan di Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hakmilik Universiti Malaysia Sarawak.
2. Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Membuat pendigitan untuk membangunkan Pangkalan Data Kandungan Tempatan.
4. Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
5. ** Sila tandakan (✓) di kotak yang berkenaan

SULIT (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972).

TERHAD (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/ badan di mana penyelidikan dijalankan).

TIDAK TERHAD

Disahkan oleh

(TANDATANGAN PENULIS)

(TANDATANGAN PENYELIA)

Alamat tetap: LOT 179, KG.BINJAI,
71600,KUALA KLAWANG,
NEGERI SEMBILAN.
.

EN. SHAHROL BIN MOHAMADDAN
(Nama Penyelia)

Tarikh: 20th MAY 2010

Tarikh: _____

CATATAN

- * Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah, Sarjana dan Sarjana Muda.
- ** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT dan TERHAD.

Approval Sheet

The following final year project:

Title: Development of Finger Rehabilitation Device for Post- Stroke

Patient

Author: Nor Rashekar Binti Abdul Halim

Matrics Number: 16884

Is hereby read and approved by:

Mr. Shahrol Bin Mohamaddan

(Supervisor)

Date

**DEVELOPMENT OF FINGER REHABILITATION DEVICE FOR POST-
STROKE PATIENT**

NOR RASHEKAR BINTI ABDUL HALIM

This project is submitted in partial fulfilment of
the requirements for the degree of Bachelor of Engineering with Honours
(Mechanical and Manufacturing Engineering)

Faculty of Engineering
UNIVERSITI MALAYSIA SARAWAK

2010

Dedicate to my beloved mom, family and friends

ACKNOWLEDGEMENT

I would like to give full appreciation to those who had given assistance and support in making this project until accomplished. I thank my mom for her love, support and encouragement. I would like to express my sincere thanks to my supervisor, Mr. Shahrol Bin Mohammadan for all advice, guidance, patient and moral support that was given during the whole time to finished the project. I am very thankful for the opportunity to handle this project under his supervision.

I also thank Mr. Nazeri Bin Abdul Rahman who thought and advice in using Autodesk Inventor 2008. I would like to express thank to my fellow friends that thought mostly about the use and function of the Autodesk also willing to help and give up their time. Special thanks to the fellow attendant of CAIS department who give lots of information on the previous thesis, journal and books.

ABSTRACT

Finger plays one of the most important roles in human daily life. Disabilities of finger may affect human's life to perform normal daily activities. There are several factors that contributing to the disabilities of human finger. Injured by accident, birth factor and physical disability since child also stroke leads to disabilities of finger. Stroke frequently happens to middle ages and above. Based on research conducted by the National Institute of Neurological Disorders and Stroke (NINDS), there are about more than 700,000 stroke patient over the world. Stroke patient needs to undergo rehabilitation exercise in order to recover the ability of the finger movements. Thus, rehabilitation device is needed to perform rehabilitation exercise. This project was carried out to design, develop and improvement of a robotic finger device. The design process involved only thumb, index and middle finger. The Autodesk Inventor 2008 software will be applied in the design.

ABSTRAK

Jari memainkan peranan penting dalam kehidupan seharian manusia. Kecacatan jari dapat menyukarkan aktiviti normal harian manusia. Terdapat beberapa faktor yang menyebabkan kecacatan pada jari manusia. Kecelakaan ketika kemalangan, faktor kelahiran dan kecacatan ketika masih kecil dan juga lumpuh menyumbang kepada ketidakupayaan jari. Lumpuh terjadi pada usia pertengahan dan ke atas. Berdasarkan kajian yang dilakukan oleh Institut Kebangsaan Stroke dan Gangguan Neurologi (NINDS), terdapat hampir 700,000 penderita sakit lumpuh di seluruh dunia. Pesakit lumpuh perlu menjalani latihan pemulihan untuk menyembuhkan keupayaan pergerakan sesebuah jari tersebut. Oleh itu, alatan untuk pemulihan amatlah diperlukan untuk menjalankan latihan pemulihan jari. Projek ini dijalankan untuk merekacipta, membangunkan dan membaiki alatan jari robotik. Rekabentuk proses adalah melibatkan ibu jari, jari telunjuk dan jari tengah. Perisian Autodesk Inventor 2008 diaplikasikan dalam rekabentuk ini.

TABLE OF CONTENTS

Acknowledgement	ii
Abstract.....	iii
Abstrak	iv
Table of contents	v
List of Table	viii
List of Figure	ix
CHAPTER 1 INTRODUCTION.....	1
1.0 Background of study.....	1
1.2 Objectives	4
CHAPTER 2 LITERATURE REVIEW	5
2.1 Stroke Rehabilitation	5
2.2 Background study	6
2.2.1 Hand Disabilities	6
2.2.2 Rehabilitation Physical Therapy.....	6
2.2.3 The Rehabilitation Therapy and Exercise for Finger Disabilities	8
2.3 Human Hand Anatomy	12
2.3.1 Degree of Freedom (DOF) and Human Hand Motion	14
2.4 Hand Rehabilitation Devices	17
2.4.1 Hand- Wrist Assisting Robotic Device (HWARD)	17
2.4.2 Wrist Robot	18
2.4.3 Virtual reality 3By6	19

2.4.4 EMG Controlled Exoskeleton	20
2.4.5 Hand Compressible Palm Glove	22
CHAPTER 3 METHODOLOGY	24
3.0 Introduction	24
3.1 Data collection.....	24
3.1.1 Problem statement	24
3.1.2 Study of Existing Device.....	25
3.2 Design Consideration	25
3.2.1 Design Boundary Conditions	25
3.2.2 Apparatus Setup.....	27
3.2.3 Preliminary design of robotic finger device	28
3.2.4 Design in 3D and simulations.....	28
3.2.5 Expected problems	29
3.3 General features and goals.....	29
CHAPTER 4 CONCEPTUAL OF ROBOTIC FINGER DEVICE	31
4.0 Introduction	31
4.1 The Design concept and Dimensions	31
4.2 Design parameter.....	34
4.3 Summary.....	37
CHAPTER 5 RESULTS AND DISCUSSION	38
5.0 Introduction	38
5.1 First Index and Middle finger Design	39
5.1.1 Design Problems and Corrective Action	40
5.2 The Index and Middle Finger Mechanisms Design	41
5.2.1 Mechanisms Improvement to The Index and Middle Finger	42

5.3 The First Thumb Finger design	44
5.3.1 The Second thumb finger design	45
5.3.2 The thumb design problem and Corrective action	46
5.4 The Full Assembly of Robotic Finger Device.....	47
5.4.1 Improvement to Assembly Trial/ Final Design Assembly	49
5.5 Summary.....	50
CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS.....	51
6.0 Conclusions	51
6.1 Recommendations	52
REFERENCES	53
APPENDIX	56

LIST OF TABLE

Table 2.1 Average Normal ROM's for Foreman and Hand.....	15
--	----

LIST OF FIGURE

Figure 2.1 Mallet Finger Exercises	10
Figure 2.2 Human Hand Skeleton	12
Figure 2.3 Human Hand Motion	16
Figure 2.4 Howard Developed by University of California	18
Figure 2.5 Three Sensors applied to the three fingers	20
Figure 2.6 The apparatus setup for the EMG Controlled	22
Figure 2.7 Sketch and idea of the Hand Compressible Palm	23
Figure 4.1 Materials considerations	33
Figure 4.2 The pulley mechanisms.....	33
Figure 4.3 The index finger design dimension.....	35
Figure 4.4 The thumb finger design dimension.....	36
Figure 5.1 Index and middle finger design.....	39
Figure 5.2 Mechanisms assembly.....	41
Figure 5.3 Mechanism improvement.....	42
Figure 5.4 The thumb concept	44
Figure 5.5 The thumb finger design	45
Figure 5.6 The improvement done	46
Figure 5.7 Final assembly trials.....	47
Figure 5.8 Final assembly.....	49

CHAPTER 1

INTRODUCTION

1.0 Background of Study

Fingers play an important role in our daily life but when there are presences of diseases, injured by accident or physical disability since child may give effect to the normal routine of our daily life. Stroke frequently happens to middle ages and above. Based on research conducted by the National Institute of Neurological Disorders and Stroke (NINDS), there are about more than 700,000 stroke patient over the world. Rehabilitation for stroke patient helps to enhance the relearn skill of brain. The rehabilitation process taken will maintain the skill and required specialist for a certain period of time depends on the patient conditions. Rehabilitation does not cure the stroke but can help patient with best possible long term outcome (National Institute of Neurological Disorder and Stroke, 2009).

Stroke can be divided into several types of disabilities which are paralysis or problems controlling movement, sensory disturbances including pain, problems using or understanding language, problems with thinking and memory, and emotional disturbances (National Institute of Neurological Disorder and Stroke, 2009). In this research, main focus is more on problems controlling movement which include the upperbody of human especially finger and hand called hemiparesis. Hemiparesis attack on the half of the body part thus allowed motor

disabilities to the damaged part. The damage part especially fingers usually need for grasping and hold things cannot be used anymore thus will effected routine life of patient.

In order to recover the problems, the stroke patient will need the rehabilitation process. The finger rehabilitation should concentrate on how the motor skill operates at the finger. A motor skill is a learned series of movements that combine to produce a smooth, efficient action. There are two types of motor learning which is fine motor skill and gross motor skill. Fine motor skill is more focused to dexterity in the movement of small muscle in contact with movement of eye to control the fingers, thumb and hand. The fine motor is suitable for drawing, writing and coloring as children refine their motor skills during child age (Fine motor skill , 2008). On the other hand, gross motor skill is more on grasping the large object.

Physical therapists and occupational therapists are suitable for handling rehabilitation process on the post-stroke patient. The physical therapist specializes in treating disabilities related to motor and sensory impairments. The physical therapist is well-known with anatomy and physiology related to normal function with an emphasis on movement. There are several strategies used by physical therapists to encourage the use of impaired limb include selective sensory stimulation such as tapping or stroking, active and passive range-of-motion exercises, and temporary restraint of healthy limbs while practicing motor tasks. The occupational therapist is focused with improving motor and sensory abilities. The therapist helps stroke survivor to perform self-directed activities-occupations-such as personal grooming, preparing meals, and housecleaning. The stroke patient will

be teach on how to develop compensatory strategies and how to change elements of their environment that limit activities of daily living.

Rehabilitation should be done 2 days after the patient had diagnosed to have stroke. At the time, patient will be given intensive care for several weeks. Many of the patient will do the further intensive care when go home and some will do the care at other facilities. There are several types of rehabilitation that helps to enhance the motor disabilities of post-stroke patient. There are inpatient and outpatient rehabilitation units, nursing facilities and home based rehabilitation. The home based rehabilitation is the best care because it provided a private place for patient to do their therapy. The patient also has their own time to perform the therapy. Sometimes, at the facility may requires hours of therapy and make the patient tired. In addition, if the therapy must do everyday also counting on the cost of transportation go and back to home (National Institute of Neurological Disorder and Stroke, 2009). There are also some disadvantages when done the therapy exercise at home such as lack of device and specialized equipment.

The combination of rehabilitation and specialized equipment or device would help the stroke patient to improve their daily life plus the motor ability of hand and fingers. The stroke patient will develop the motor skill functions and rehabilitation exercise helps more on brain relearn skill thus will enhance movement of disabilities part. However, every device has its own disadvantages or problem occur during rehabilitation practice. Thus, a new design should be created in order to make the device is user friendly to patient, durable, lighter and doesn't required much cost to fabricate.

1.2 Objective

1. To study the fact, main cause of stroke and to discuss the rehabilitation purpose along
the proper way to do the rehabilitation process.
2. To study, determine hand anatomy and its function, evaluate and discuss the existing
facilities and devices of physical therapy.
3. To discuss which device better, what device or actuator uses also the advantages and
disadvantages of the device.
4. To design finger rehabilitation device and further study this finger device as an
alternative for finger disability.

CHAPTER 2

LITERATURE REVIEW

2.1 Stroke Rehabilitation

Stroke happens when there is loss of blood at some part of the brain thus affected the system inside human body. Stroke change a person ability to live normal life where it can lead to paralysis, loss of speech, memory, vision, diminished reasoning and even death. Stroke rehabilitation or called 'stroke rehab' is the recovery for stroke patient after the stroke. Stroke rehabilitation help to enhance and counter the disabilities of patient by relearn skills due to the part of brain is damaged. The first step for stroke patient is to be able doing basic activities of their daily life. Stroke rehabilitation is continuous process to maintain and enhance skills and must be assisted by the presence of specialists for months or years after the stroke (National Institute of Neurological Disorders and Stroke, 2009), (Southwest Washington Medical Center, n.d).

2.2 Background Study

Stroke patients suffer with varies condition depends on the part of the brain damage. The stroke will be effect on the half side (unilateral) and opposite of body depending on which part of the brain damage.

2.2.1 Hand Disabilities

Most common disability by stroke is paralysis or problems controlling movement (motor control) (National Institute of Neurological Disorders and Stroke, 2009). Motor control is motor learning loosely or abnormal that encompasses motor adaptation, skill acquisition and decision making (Shadmehr & Wise, 2005). Half side paralysis of body called hemiparesis where the stroke suffer having difficulties of doing daily activities such as picking small objects, grasping or eating.

2.2.2 Rehabilitation Physical Therapy

Medical professional that involved in post-stroke rehabilitation are physical, occupational, physicians and rehabilitation nurses. There are three types of physical rehabilitation: Physical therapist, Occupational therapist and Home based therapy. The first two rehabilitations are for helping hemiparesis patients (Mayo Foundation for Medical Education and Research, 2009)

i) Physical therapist:

Physical therapist activities are more focusing on treating physical disabilities related to motor function and sensory impairments of stroke patients. The physical therapist will gain the information about patient disabilities, find strategy to reduce the effect of remaining deficits, and establish continuous exercise programs to help patient develop their newly learned skills. The continuous and repetitive program helps reduce disabilities of impaired limbs which it encourages brain to functional better. Brain wills trying to recover and activate the nerve system which makes impaired limbs become active by varies therapy activities such as active and passive range of motion and stimulation such as taping. Result from the rehabilitation will be evaluated in order to improve it time by time (Mayo Foundation for Medical Education and Research, 2009).

ii) Occupational therapist:

Occupational therapist is more focusing on improving motor function and sensory abilities. The patient will be teach daily skills such as buttoning, eating or grasping small and lighter thing. These therapists teach people to perform complete activity by divide it into part, practice each part and do the part sequent (Mayo Foundation for Medical Education and Research, 2009). Suitable self care method provided such as one handed method also contributing to improve coordination of the impaired limbs. Occupational therapist also teach patient to cope for limited movements and change the environment to safe condition and functional to them.

iii) Home based therapist:

Home rehabilitation gives flexibility to patients so that it can perform rehabilitation program at any time when they available. Patient will do the therapy concentrate and adding the time of therapy as long as they could hold out. This therapy is best for those patients who lack of transportation and time also involved treatment by only one type of rehabilitation therapist. Addition, whole family will give full support and encourage to patient while doing the rehabilitation at home and it is an important part for patient to recover. Home based therapist also provide comfortable environment for stroke patient to practicing and enhanced their skills (National Institute of Neurological Disorders and Stroke, 2009).

2.2.3 The Rehabilitation Therapy and Exercise for Finger Disability**i) Strengthening motor skills**

A motor skill is a learned series of movement that combine to produce efficient action [4]. Motor skill can be divided into two: Gross motor skills and fine motor skills. Gross motor skills are concerning for grasping large object, balancing, walking and lifting one's head. The motor development follows a pattern where large muscles develop before smaller ones as ignition to fine motor skills. Fine motor skills include the ability to grasping or picking small object, knitting, writing or transfer objects from hand to hand. These skills required very precise motor

movement in order perform delicate task. Combination of small muscle usually performs the task (Li, November).

Weak muscles can effects the motor skill of the stroke patient. Therefore by strengthening motor skills using varies exercise will help improve muscle strength and coordination (Mayo Foundation for Medical Education and Research, 2009). Exercise of muscles involving finger extension and flexion to certain degree of movement. The exercise starting from proximal muscle group and extent the distal muscle group at the finger tips.

ii) Range of motion therapy (ROM)

Spasticity is one of the effects of stroke. It allows muscle to contract and cannot move anymore. The patient would get out of the way using the impaired hand and do activities using unaffected hand contributing to loss of fine motor control. The upper extremity become worse because of loss of control and increasing impaired. The activities of extent and flexion of finger and improvement of upper extremity will be analyzing by range motion therapy (ROM) also as indicator how the patient could compensate for stroke. Range motor therapy is a measurement of the extent and flexion of finger to which a joint can go through all of it normal range of movements (Li, November).

There are two types of motion exercise in rehabilitation therapy: passive and active range motion. The patient will be asked to move a limb repeatedly in passive range motion to avoid the contraction of muscles and active exercise perform by the

patient without physical assistance from the therapist usually at home (Li, November). The patient must do the strengthening and bending of thumb and finger also flexion and extension exercise according schedule in order to make the muscle regain the strength to operate.

iii) Physical Therapy (Mallet Exercise)

There are five recommendations for finger exercise to strengthen and recover the injured finger motion range (Tammy, MS, PT, & al, n.d).

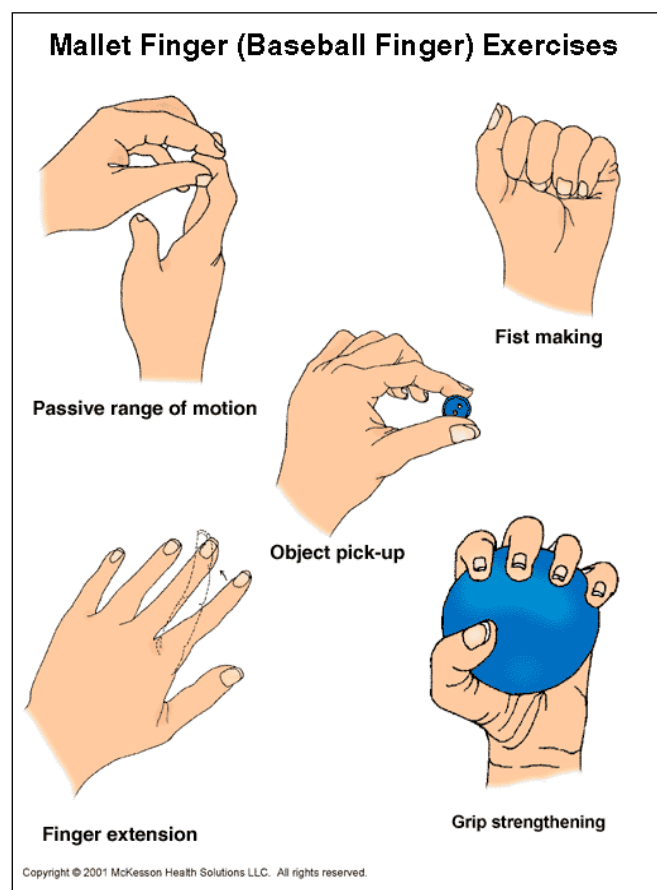


Figure 2.1: Mallet Finger Exercises.

- i) Passive range motion: Gently assist the injured joint by bending and straighten it with other hand. Do the exercise 10 times by repeating slowly and hold for 5 seconds at the end of each motion.
- ii) Fist making: Injured finger is assist by uninjured hand to help it bend into a fist. Hold the position for 5 to 10 seconds and repeat for 10 times.
- iii) Object pick-up: Practicing to pick-up small objects as coins, marbles, pin or button with one finger and the thumb.
- iv) Finger extension: Place the palm flat on a table and straighten the finger out. Lift each finger straight up one at a time and hold for 5 seconds before put it down. Repeat at each finger 10 times at once.
- v) Grip strengthening: Grasp and squeeze a rubber ball . Holds for 5 seconds.

iv) Constraint- Induce Therapy (CI)

Stroke survivors try to avoid using the effected limb when perform a job. This discourages them from using that side. In order to encourages them, the therapist using

Constraint -induce therapy also known as “forced-use” therapy by restricting use of unaffected limb during practice moving the effected limb. Survivors must be able to extend their wrist and move their arm and fingers. The therapist uses a sling as to restrict the patient using the unaffected arm. Forcing the survivors to use the effected arm repetitively and intensively for two weeks can help to improve its function (A