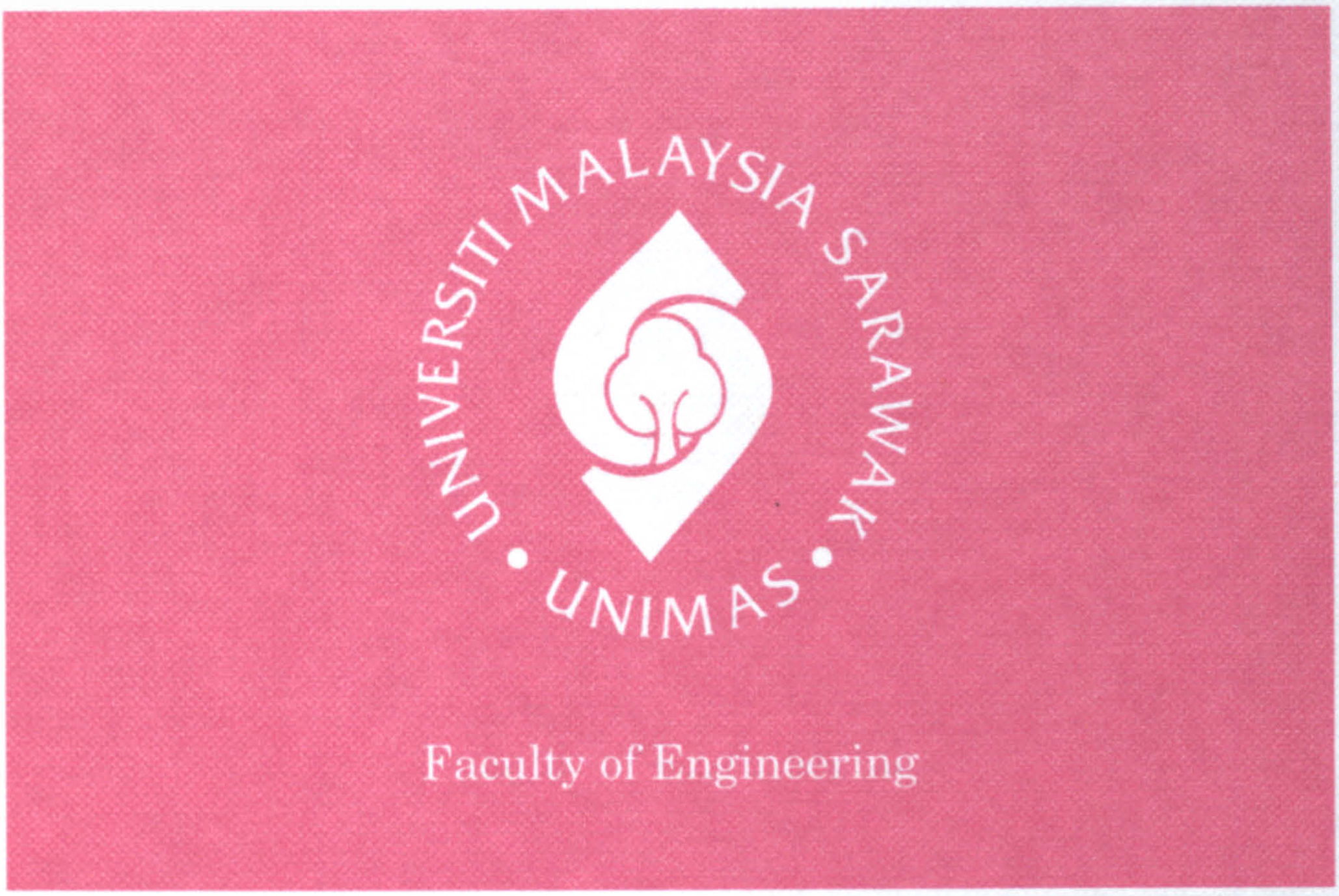

DEVELOPMENT OF FINGER REHABILITATION DEVICE FOR POST-STROKE PATIENT

Uh Chee Siang

Bachelor of Engineering with Honours
(Mechanical and Manufacturing System Engineering)
2010

UNIVERSITI MALAYSIA SARAWAK

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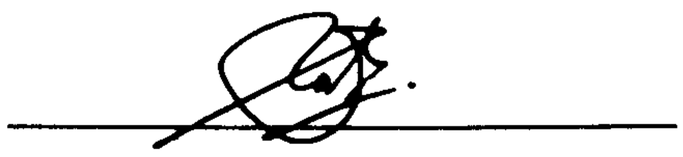

Mr. Shahrol Bin Mohamaddan

(Supervisor)

25/5/2010

Date

Mr. Abang Mohd. Nizam Abang Kamaruddin

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Date

DEVELOPMENT OF FINGER REHABILITATION DEVICE FOR POST-STROKE PATIENT

UH CHEE SIANG

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

To my beloved friends & family

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I would like to take this opportunity to express my thanks and appreciation for several people who played an important role in accomplishing this project.

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ABSTRACT

The aim of this research is to design and fabricate a home based, economical and user friendly finger rehabilitation device to provide a repetitive movement of intensive exercises for post-stroke patients. Clinical studies stated that stroke is one of the major factors that lead to the human finger paralysis and immobilization. The loss of normal hand functions or abilities of stroke patients cause various inconveniencies in the daily life. Rehabilitation treatment is crucial for post-stroke disabilities recovery. Thus, a physical therapy device for finger rehabilitation is required. This project consists of three main processes, which are: studied and developed the existing device, designing process, and fabrication process of new finger rehabilitation device. The CAD software (Solid Works) is used to design and simulate the finger rehabilitation device. Whereas, NC machine is used to fabricate the prototype and simple testing is conducted. As a conclusion, further improvement and development of the device may offered to increase the performance and efficiency of the device and able to bring benefits to stroke patients with a low cost, effective and repetitive treatment.

ABSTRAK

Tujuan penyelidikan ini dijalankan adalah untuk merekacipta dan membina alat pemulihan jari yang dapat membantu dalam proses rawatan, kos yang rendah, dan senang digunakan dengan mengerakkan kepada jari pesakit stroke. Penyelidikan klinikal menyatakan stroke merupakan salah satu faktor utama yang menyebabkan kelumpuhan jari dan imobilisasi. Kegagalan atau ketidakupayaan tangan untuk berfungsi secara normal bagi pesakit stroke membawa banyak masalah dalam kehidupan harian. Rawatan pemulihan adalah penting bagi menyembuhkan kecacatan akibat stroke. Oleh itu, alat terapi bagi pemulihan jari diperlukan. Projek ini melibatkan tiga proses utama, iaitu: mempelajari dan mengembangkan model rekacipta yang wujud kini, proses untuk merekacipta,dan proses untuk membina alat pemulihan jari yang baru. CAD perisian (Solid Works) digunakan untuk merekabentuk dan membuat stimulasi alat pemulihan jari. Selepas itu, prototaip untuk alat pemulihan jari dibina dengan menggunakan mesin NC dan ujian mudah diadakan. Kesimpulannya, perbaikan dan pembangunan lebih lanjut dapat ditawarkan untuk meningkatkan lagi prestasi dan kecekapan peralatan tersebut dan dapat membawa manfaat kepada pesakit stroke dengan kos yang rendah, berkesan dan rawatan yang berulangan.

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LIST OF ABBREVIATION

ASA	*American Stroke Association*
DOF	*Degree of freedom*
MCP	*Metacarpophalangeal joint*
PIP	*Proximal interphalangeal joint*
DIP	*Distal interphalangeal joint*
CMC	*Carpometacarpal joint (Thumb)*
EMG	*Electromyography*
HWARD	*Hand-Wrist Assisting Robotic Device*
RC servos	*Radio-controlled servos*
DC	*Direct current*
CAD	*Computer Aided Design*
NC	*Numerical control*
VR	*Virtual Reality*
EEG	*Electroencephalography*
ADHD	*Attention-Deficit Hyperactivity Disorder*

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

According to the American Stroke Association (ASA), about 795,000 people of United States every year suffering from stroke. Stroke is a leading cause of long-term disability among American adults and also third leading cause of the death in United States ***(American Stroke Association (ASA), 2009)***. Factors that increase the probability of experiencing a stroke including previous family history of stroke, increased age, high blood pressure, high cholesterol, cigarette smoking, diabetes, obesity, and cardiovascular disease. Currently, there is 2/3 of stroke patients' still suffering with stroke disabilities. While the other 1/3 of stroke patients' are suffering with paralysis ***(National Stroke Association (NSA), 2009)***.

A stroke, is also known as *celebrovascular accident*, occurs when the blood is blocked, stopped or interrupted to supply to the human brain. Human brain needs adequate amount of glucose and oxygen that supply from blood to operate. The portion of the brain dies and neuronal function is lost due to loses blood supply ***(Stroke or celebrovascular accident, 2009)***. Usually, stoke will happen immediately. Some symptoms or impacts of stroke are numbness, paralysis, weakness on the face,

leg, or arm; difficulty speaking or understanding speech, blurred, dizziness, problems with memory, confusion, and loss of balance or coordination may happen to the stroke patients. Therefore, physical rehabilitation plays an important role and has a great demand among the stroke patients ***(Types of stroke, 2009)***.

In this project, the focus is more on paralysis of upper extremity, especially for hand and forearm. This paralysis may limit the range of motion for the upper limbs and affected patient daily live activities. Active-assisted movement is used when the patient cannot complete a desired movement independently. Some of the external assisting forces are applied to help the patient to move the upper limbs such as manual manipulation from a therapist, or from the patient's contra lateral limb. Besides that, physical therapists and occupational therapists also play important role to conduct an intensive rehabilitation therapy in order to help the patient to relearn physical task, daily skill, communication skill, and regaining normal life ***(Bruce H. Dobkin, April 21, 2005)***. However, physical rehabilitation treatment is a time consuming process and charged with high cost. Many patients cannot afford and neglecting the important of rehabilitation treatment. The increasing of population of stroke patients also causes the limitation of in-patient rehabilitation unit due to the increasing demand. Many patients are unable to receive treatment therapy because the limiting of availability ***(Hara, 2008)***.

Due to the availability and cost problems, a low cost home-based rehabilitation solution is in great demand. Therefore, robotic finger rehabilitation system is introduced and published in order to assist and support therapists to recover partially

or totally the finger motor abilities of a stroke patient. The application of robotic rehabilitation device enables therapists to carry out automated and high frequency repetitive motions of rehabilitation treatment. Research results point to the fact that intensive movement training has a positive influence on the therapy course ***(Butefisch C, 1995)***.

The aims of device design are reliable, user friendly, economical, light weight, and home-based. The developing device is expected to facilitate at high repetitive and active-assisted movement training for more severely impaired patients is introduced, especially for those stroke patients that in the acute and sub-acute phases of recovery.

1.2 Objectives

The objectives or goals of this project are:

1. Studies on:
    a. The effect of stroke towards human hand.
    b. The existing of finger rehabilitation devices.

2. Designing a finger rehabilitation device.

3. To fabricate the prototype of the finger rehabilitation device.

CHAPTER 2

LITERATURE REVIEW

2.1 Background of Stroke Rehabilitation

Stroke is the third leading cause of death and also adult disability in Europe countries and United States. The stroke patient needs proper treatment or promptly diagnosed because the stroke may cause permanent neurological damage and death. Stroke can also be concluded as a medical emergency case that needs to be taken seriously ***(Stroke or celebrovascular accident, 2009)***.

There are two main types of stroke, which is Ischemic stroke and Hemorrhagic stroke. *Ischemic stroke* or *brain attack* is the most common types of stroke that happen among human beings. Nearly 80% of strokes are ischemic stroke ***(Types of stroke - Ischemic stroke, 1998-2009)***. This type of stroke occurs when a blood vessel in the brain is blocked, either by a clot that is gradually built up within the brain, or a traveling particle or debris that originates elsewhere but is eventually lodged in the brain. The blood flow is blocked and restriction causes the brain lack of blood intake, thus resulting in the stroke. On the other hands, *hemorrhagic stroke*, occurs when a blood vessel is ruptured and bleeds into the skull and the surrounding tissues. The surrounding brain tissue cells are damaged by the resulting bleeding, and parts of the

brain beyond the leak are also affected by the lack of blood to reach the brain ***(Types of stroke - Hemorrhagic Stroke, 1998-2009)***. This kind of stroke will bring dangerous impact and carries a high risk for death. Figure 2.1 show that the differences between two main types of the stroke, which is hemorrhagic stroke and ischemic stroke.

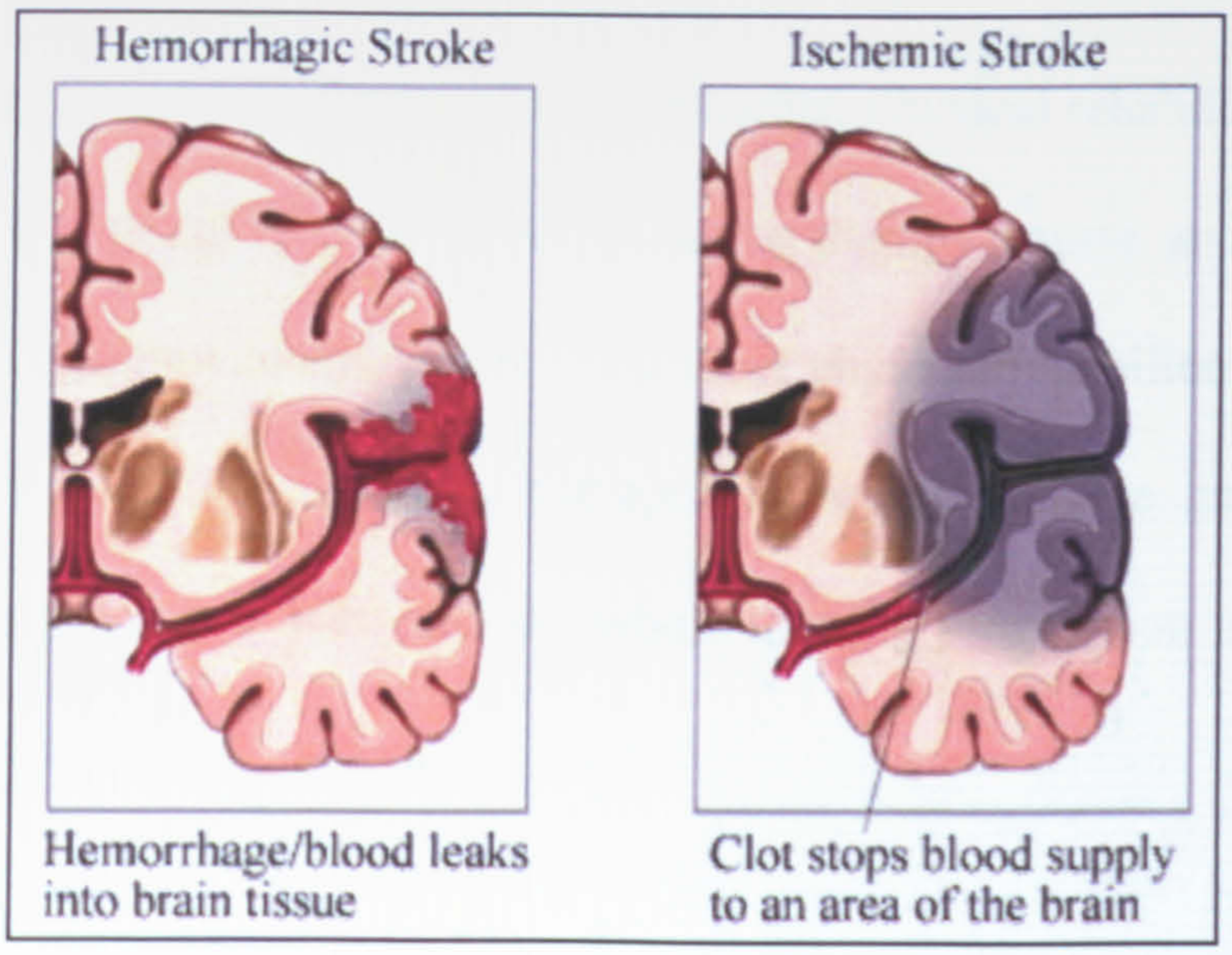

Figure 2.1: The Two Main Types of Stroke *(Hemorrhagic and Ischemic stroke)*

Although the stroke may bring to death, but there are a lot of survivors that successfully pass the death line and most of them are fight with stroke to regain back the normal life. Rehabilitation therapy is used to rehabilitate the stroke patient and strongly recommended by many therapists. The goals of rehabilitation are to help stroke survivors become as independent as possible and to attain the best possible quality of life. From the rehabilitation sessions, stroke patients are helped and taught to relearn the lost skills due to the damaged parts in the brain. The independent, repetitive rehabilitation therapies will cause human brain to rebuild the lost skills and recovered from stroke.

2.1.1 Physical Rehabilitation

Stroke brings different effects to different peoples; the effect of the stroke may cause hemiplegia, paralysis or more seriously can even cause death to human beings. Paralysis patients are either paralyzed or seriously weakened. But, the hemiplegia is a common disabilities resulting from stroke, which may cause difficulty to complete the daily activities such as walking, grasping, or etc. Physical rehabilitation is usually being used to help to recover the hemiplegia patients. Physical rehabilitation training is given to those patients to undergo an intensive therapy course and rebuild their muscles strength and movement speed. To conduct physical rehabilitation training, a physical therapist or an occupational therapist is needed to give guidance to the patient about the training process and the whole training progression is recorded for further references and examination.

Physical therapist examines patient' medical history and later test and measure the patient' strength, posture, range of motion, and performances ***(Occupational Outlook Handbook - physical therapists, 2008/09)***. Physical therapist is responsible to teach the patient to relearn the basic physical activities such as walking, moving arms, hands or legs, sitting and etc. Besides that, physical therapist also needs to come out a new treatment strategy and planning in order to treat and help those patients to regain the normal life back. Physical therapy is a repetitive movement treatment, therefore physical therapist need to spend more time in order to train their patients.

On the other hands, the occupational therapists are concentrating on developing the stroke patients' daily living and work skills. Some intensive treatments are used to help stroke patients to relearn their daily skills such as eating, dressing, cooking and etc. ***(Occupation Outlook Handbook, occupational therapists, 2008/09)***. Evaluation for each session of treatments is noted and progression will be carried on to treat their patients.

Due to shortage and unavailability of physical therapists and occupational therapists, most of the stroke patients are neglected to receive a full session of intensive rehabilitation therapy. Therefore, many researches and developments are come out with substitution of robotics to the human power. Thus, robot-assisted therapy devices are become popular among the patients so as to receive the same treatment from those therapists. In this project, our main focus is to come out with a prototype of robotic finger rehabilitation device that use to rehabilitate human hands and fingers to recover partially or totally from the effect of stroke.

2.1.2 Stroke Effects on Human Hand

Recovery process of neurological functionality of the hand will be more effective during the first three months of the onset of chronic stroke. During this period, stroke patients are encourage to train the disability hand more frequently so as to increase the rate of recovery process (***Reddy, p.1742)***. Unfortunately, most of the stroke patients could not withstand the feeling of pain and stop training the impaired hand. Most of the jobs are relied on the unaffected hand to settle up. This causes the affected hand to be even worst in conditions. The effects are as below:

(a) Limitation of range of motion

The chronic stroke causes the range of motion of human hand to be bonded. Therefore, an external force such as hand therapy device is required to help moving the hand in order to precede motion such as flexion or extension and adduction or abduction. Repetitive movement or treatment exercise helps to recover the neurological functionality of the hand. Unfortunately, due to the feeling of pain, fatigue, weakness or lack of endurance in practice of hand, many stroke patients give up and rejected to receive treatment ***(Rhodes, 2007)***.

(b) Uncontrolled flexion and extension synergy

Human muscle can be flexion or extension due to the signal operation from our human brain. Our functional movement of hand is controlled by the flexor and extensor of the muscles to operate the functionality of grasping and releasing. There is a study conducted to test on the stroke patients' hand grasping and releasing function. The results conclude that the stroke survivor could grip an object much quicker than releasing that object ***(American Physiological Society , 2009)***. In addition, the results show that once the muscle is activated, there is difficult to relax the muscle back.