UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND DEVELOPMENT OF ASSISTIVE DEVICE FOR TENODESIS REHABILITATION PEOPLE

Submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons.)

by

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2019

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: **DESIGN AND DEVELOPMENT OF ASSISTIVE DEVICE FOR TENODESIS REHABILITATION PEOPLE**

Sesi Pengajian: **2018/2019 Semester 2**

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I hereby, declared this report entitled “Design and Development of Assistive Device for Tenodesis Rehabilitation People” is the results of my own research except as cited in reference.

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Author’s Name : MOHAMAD ZAKUWAN BIN BAHARI

Date : 31 MAY 2019

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering with Honours.

The members of the supervisory committee are as follow:

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(RUZY HARYATI BINTI HAMBALI)

ABSTRAK

Penghidap penyakit tendon yang mengalami kerosakan tisu penghubung pada bahagian jari di Pusat Pemulihan PERKESO (PRC) mempunyai masalah untuk menggerakkan mahupun menggenggam jari tangan. Sebahagian besar daripada pesakit memerlukan alat bantuan yang mampu membantu pesakit untuk memegang sesuatu objek dan dalam pada masa yang sama menggalakkan penggunanya untuk berdikari. Dilaporkan bahawa, produk alat bantuan ini tidak disediakan oleh PRC. Tambahan pula, produk yang sedia ada di pasaran semasa tidak mampu milik dan sukar diperolehi kerana kos yang tinggi untuk mengeluarkan produk dan pada masa ini hanya terdapat di pasaran asing. Selain itu, sebahagian besar daripada reka bentuk yang sedia ada tidak mudah alih dan sukar untuk dipakai oleh pesakit tanpa bantuan. Malah, jirim produk tersebut menyebabkan ianya terlalu berat dan sukar untuk dikendalikan oleh pesakit. Projek ini bertujuan untuk menghasilkan alat bantuan yang dapat membantu pesakit memegang atau menggenggam sesuatu objek. Selain mudah alih dan ditanggalkan, reka bentuk ini lebih menjimatkan dan ergonomik yang memenuhi keperluan pengguna. Produk ini telah diuji dan disahkan oleh ahli terapi dan pesakit di PRC. Hasil ujikaji produk ini menunjukkan produk ini telah mencapai objektif untuk membantu penggunanya sebagai alat bantuan yang menyokong pergerakan jari pesakit yang mengalami masalah tendon pada bahagian jari dalam menjalani kehidupan seharian mereka, termasuk senaman terapi dan aktiviti harian. Selain itu, reka bentuk produk ini mempunyai peranan penting yang boleh membantu pesakit sebagai alat bantuan senaman di mana ini adalah salah satu ciri tambahan untuk membantu pengguna untuk memulihkan otot bahagian tangan mereka.

ABSTRACT

People of tenodesis who suffer flexor tendon injuries at PERKESO Rehabilitation Centre (PRC) having problem in moving their fingers to grab and hold. Most of them require an assistive device which able to help them to do daily activities such as grabbing which also encourage them to be independent. Reported that this assistive device useful to promote independency but it is not provided by PRC. Moreover, existing product in the market is not affordable since it is costly to manufacture and only available at the abroad market. Besides that, most of the existing product concept is not mobile and difficult for patients to wear. In addition, the product is quite heavy which resulted to difficulty to use by patients. This project aims to develop an assistive device which able to help patients to hold or grab an object. Other than mobile and detachable, it is more affordable and ergonomic which satisfy the requirements needed. This product undergo anthropometry, survey and design requirements and will be tested and validate by the therapists and patients themselves. The results of the design and analysis of the product achieve all of objectives to help the end user to assist the movement of patient fingers who suffer flexor tendon injuries in their daily activities and therapy session. Hence, the design of this product plays important roles which help the patient to do exercise to regain their muscles.

DEDICATION

Only

my beloved father, Bahari Bin Ali

my appreciated mother, Zaimah Binti Husin

my adored brothers and sister, Hairi, Helmi, Zakri and Syima

for giving me moral support, money, cooperation, encouragement and also understandings

Thank You So Much & Love You All Forever

ACKNOWLEDGEMENT

In the name of ALLAH, the most gracious, the most merciful, with the highest praise to Allah that I manage to complete this final year project successfully without difficulty.

My respected supervisor, Madam Ruzy Haryati Binti Hambali for the great mentoring that was given to me throughout the project, kind supervision, advice and guidance as well as exposing me with meaningful experiences throughout the study.

Last but not least, I would like to give my special thanks to my fellow friends who guided me, giving moral supports when I am at my lowest point in completing this project report.

Finally, I would like to thank whoever that have involved and helping me either direct or indirectly.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

PERKESO	-	Social Security Organization
PRC	-	PERKESO Rehabilitation Centre
ROM	-	Range of Motion
EQD	-	Extensor Quinti Digital
MCP	-	Meta-Carpophalangeal
IP	-	Interphalangeal
FDP	-	Flexor Digitorum Profundus
FDS	-	Flexor Digitorum Superficialis
FPL	-	Flexor Pollicis Longus
PIP	-	Proximal Interphalangeal
DIP	-	Distal Interphalangeal
CTR	-	Cubital Tunnel Retinaculum
QFP	-	Quality Function Deployment
HOQ	-	House of Quality
CAD	-	Computer-aided Design
CAE	-	Computer-aided Engineering
3D	-	3 Dimensional
2D	-	2 Dimensional
FEA	-	Finite Element Analysis
FDM	-	Fused Deposition Modeling

FKP	-	Fakulti Kejuruteraan Pembuatan
UTeM	-	Universiti Teknikal Malaysia Melaka
ABS	-	Acrylonitrile Butadiene Styrene
PLA	-	Polylactide

CHAPTER 1

INTRODUCTION

This chapter gives a brief introduction of project's background based on the general information regarding the people of rehabilitation centre who suffer flexor tendon injuries and implication of using assistive device to improve the impairment affected part. The problem statement, objectives and scopes will also be explained in this chapter. Project planning and execution of this project, rationale of the project also will also include in this project.

1.1 Project Background

As indicated by Haraldson (2018), a tendon is the fibrous tissue that attaches muscle to bone in the human body located near the surface skin. The mechanism is called as tenodesis grasp as fingers will curl or grip when wrist is extended and released when wrist is flexed. The forces applied to a tendon may be greater than five times your body weight. In some rare cases, tendons can snap or rupture (Shel, 2017). If not treated, a tendon rupture can be a serious problem and may result in extremely pain and permanent disability of movement of fingers. Patient might be able to bend wrist but have difficulty on the nerves around fingers. Most patients able to move their arms and normal movement of their shoulder.

Patient whom suffer tendon injuries will be referred to any rehabilitation centre that offers physiotherapy. After a fully inspection by the physiotherapist, patient will go through rheumatic exercises (Inpatient Rehab/LTLD Referral Guidelines, 2009). With this limitation, patient will be provided an assistive device to help them improve their quality of daily activities. However, some issues depicted with current tool includes the weight of the tool, cost and size. PERKESO Rehabilitation Centre (PRC) Melaka have problems on providing their patients with assistive device due to high cost of product. Most of the product only available abroad market.

In order to overcome this problem, this project have been assigned to design and develop an assistive device that meet the requirements needed by the patients and validate by the physiotherapists. The purpose of this assistive device is for the patient to do their routine without relying on someone else. Therefore, with this improvement, it is expected that the device is mobile, detachable, low cost and light weight to comfort the tenodesis patient.

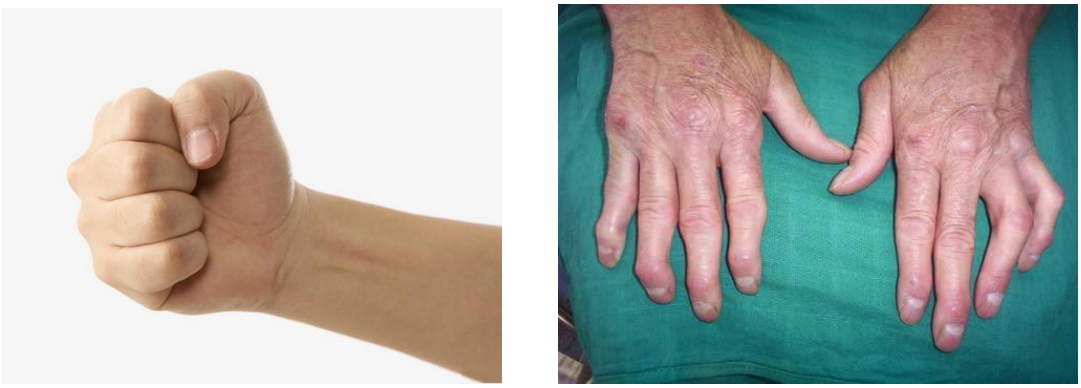
Besides that, this development of assistive device has to be easier to be installed without wasting any energy and time since the patient already have limited energy to move. To assists them in functional reaching activities and at the same time help the patient to have full motion during therapy session. This will intensely help and provide them in the therapist session as well to improve their quality of life.

1.2 Problem Statement

According to Gelberman *et al.* (1981), injured tendon often does not fully attain "normal" levels of tissue quality and function, particularly in torn tendons with pre-existing tissue degeneration. Tendon injuries can make movement of affected area become more difficult, while completely severed tendon prevents movement entirely. This limitation make patient who suffer tendon injuries facing trouble in performing exercises during or outside

therapy session including holding, grabbing and gripping. Tenodesis people suffer finger weakness in their ability to move which restraint the patient to curl or bend their fingers. They may very well be having difficulties and trouble grasping their hand like normal people do.

In order for them to be able to improve their ability to perform daily activities and therapy sessions, it is suggested to produce a device that is mobile, detachable which can support and assist them during therapy session. This is because, current design of product exist in the market is quite difficult for them to use as well as costly to be provided by the physiotherapist. Besides that, the product restraint them from using it functionally as the size of product did not meet the Malaysian people hand dimension. For better understanding, Figure 1.1 below shows an example of two different person, the range of motion (ROM) of (a) normal person and (b) disabled patients.



a) Normal ROM (Finger flexion) b) Abnormal ROM (Finger flexion)

Figure 1. 1: (a) The ROM of finger flexion for normal person (b) The ROM of finger flexion for abnormal or disabled patients.

Based on Figure 1.1, both people are in the position to grip their hand posture. There are differences between normal and abnormal range of motion (ROM) finger flexion posture. The normal person clearly can grip their hand easily while abnormal person is having difficulty to bend their finger. This is because they lose the ability to grip as their tendon is cut and pull far apart from the original position.

The certain existing design of hand assistive device have its own limitation in which device is hard to use independently by the end user. Heavily in weight caused the patient to have trouble in operating the device. In addition, high cost existing devices restraint them physiotherapists from having the devices for the use of patient. This factor caused the equipment required high cost to develop and have to sell in high price in the market since it is manufacture abroad. Therefore, this research focuses to design and develop an ergonomics and economical assistive device as well mobile and detachable that easier to be use by the end user.

1.3 Objectives

The broad objective is to design and develop an assistive device which can help the people of tenodesis who suffer tendon injury to perform their daily activities. The objectives of the study are:

a) To examine the affected area of injuries including the range of extension and compression of finger motion.
b) To design and develop a suitable, ergonomics and economical assistive device which also mobile and detachable that easier to be used by patient without the help of others.
c) To test and analyse the effectiveness and usability of the assistive device developed.

1.4 Scope of project

This project is focusing on developing an assistive device which help patients at PERKESO Rehabilitation Centre (PRC) Melaka who suffer flexor tendon injuries to do their daily activities. The finished product is mainly to assist the patients to grip, grab and hold. Since the patients are having trouble to move or bend their finger, the assistive device will only require them to move their wrist in order to use it. The scopes of the project are:

a) Survey/interview for tenodesis people at rehabilitation centre.

b) Anthropometric measurement for tenodesis people at rehabilitation centre.
c) Design assistive device using SOLIDWORK software.
d) Build a prototype of assistive device using 3D printing and manufacturing process.
e) Perform Finite Element analysis on the design to examine the behaviour of the critical parts using SOLIDWORKS software.
f) Test and analyse the usability of the design using validation from users by survey validation form.

1.5 Rational of the Research

The rational of this project is to help the tenodesis people at the rehabilitation centre. The functional product will help them to assist them in their daily activities and to regain their muscle through the therapy session. The product will help them to regain their hand muscle slightly faster than any other assistive device that exist in the market. Besides that, product developed is more affordable and have more function than existing product. In addition, PERKESO Rehabilitation Centre (PRC) Melaka have limited assistive device since the existing product is only available and manufacture at oversea. As the number of patients at the PRC increasing, it needs a lot of investment which can be reduce if the product is successfully developed. Hence, due to the problems occur, the idea of this project will be a great solution.

1.6 Project Planning and Execution

In this project, Gantt chart is constructed to list all the task and allocated time to finish the respective task from the beginning until the end of the project including the date of the submission of the report. The Gantt Chart is presented in Appendix A.

1.7 Thesis Organization

This final year project one consists of further for chapter as follows

Chapter II. Literature Review: This chapter provides a general classification of tendon, physical effect of flexor tendon injuries, and causes of flexor tendon injuries, tendon disabilities in term of range of motion and which muscles involve on the affected upper hand, technique recovery for tenodesis patient. Furthermore, it includes method to evaluate the muscle strength which is manual muscle testing and also the information regarding existing and the important of assistive device for patient with tenodesis condition.

Chapter III. Methodology: Describe the procedure and method involved in the development of the product. This chapter consists of data collection method, material used, product mechanism, manufacturing method, tools for selecting the final design, experimental analysis of Finite Element Analysis, types of software used to develop 3D model of the product and finally product testing.

Chapter IV. Results and discussion: The process of product development from design phase until the final phase of the development is describe more detailed. The result of survey analysis, anthropometry data analysis, Finite Element Analysis, and result of final product testing evaluation is discussed in this chapter to obtained the research findings.

Chapter V. Conclusion and Recommendation: This section will comprise the overall findings and discussion of the project and the recommendation for future works is outlined in this study are presented.

CHAPTER 2

LITERATURE REVIEW

This chapter shows a brief overview of tendon, flexor tendon injuries, muscle weakness, tendon rupture, flexor tendon zones in hand, involvement of ulnar nerve, motion involves in hand, manual muscle testing and technique involves in recovery for tendonitis. Other important aspects included in this review are the assistive device and its advantages for tenodesis patient.

2.1 Tendon Injuries

Tendon and ligament problems are the number one complaint that a patient seeks medical attention for. Tendon disorders have a very individual burden by limiting their daily activities and by placing an enormous economic burden on society. The most common condition of tendon injury is tendinopathy, which is related to the overuse of muscle by the underlying degeneration of the tissue, which is often painful (Snedeker *et al.,* 2017). Until today, tendonitis clinical treatment focuses on physiotherapy (passive or active movement) or anti - inflammatory drugs that are largely ineffective and potentially harmful to the patient (Waljee *et al.,* 2017). The result, however, results in prolonged patient suffering with loss of personal quality of life, reflecting that tendon plays a big role in human normal life.

For example, the foot flexor tendons of healthy humans can withstand up to 8 times the weight of the body and store up to 40 percent of the deformation energy during walks.