UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT PROSTHETIC KNEE MECHANISM OF ANTERIOR CRUCIATE LIGAMENT (ACL)

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Manufacturing Engineering Technology (Product Design) with Honours.

by

MOHAMMAD AMIRUL BIN ABD HAMID
B071410574

951228-01-5051

FACULTY OF ENGINEERING TECHNOLOGY

2017

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **DEVELOPMENT PROSTHETIC KNEE MECHANISM OF ANTERIOR CRUCIATE LIGAMENT (ACL)**

SESI PENGAJIAN: **2016/17 Semester 7**

Saya **MOHAMMAD AMIRUL BIN ABD HAMID**

Mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

☐ SULIT (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)

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

☐ TIDAK TERHAD

Disahkan oleh:

____

____

Cop Rasmi:

Alamat Tetap:

NO 23 JALAN KILAT

TAMAN PALM GROVE

41200 KLANG, SELANGOR

Tarikh: _______________________

Tarikh: _______________________

**Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

FAKULTI TEKNOLOGI KEJURUTERAAN
Tel : +606 234 6623 | Faks : +606 23406526

Rujukan Kami (Our Ref) :
Rujukan Tuan (Your Ref) :

10 JANUARY 2018

Pustakawan
Perpustakaan UTeM
Universiti Teknikal Malaysia Melaka
Hang Tuah Jaya,
76100 Durian Tunggal,
Melaka.

Tuan/Puan,

PENGKELASAN LAPORAN PSM SEBAGAI SULIT/TERHAD LAPORAN PROJEK SARJANA MUDA TEKNOLOGI KEJURUTERAAN PEMBUATAN (Reka bentuk produk): MOHAMMAD AMIRUL BIN ABD HAMID

Sukacita dimaklumkan bahawa Laporan PSM yang tersebut di atas bertajuk ***"*Development Prosthetic Knee Mechanism of Anterior Cruciate Ligament (ACL)*"*** mohon dikelaskan sebagai *SULIT / TERHAD untuk tempoh LIMA (5) tahun dari tarikh surat ini.

2. Hal ini adalah kerana IANYA MERUPAKAN PROJEK YANG DITAJA OLEH SYARIKAT LUAR DAN HASIL KAJIANNYA ADALAH SULIT.

Sekian dimaklumkan. Terima kasih.

Yang benar,

____
Tandatangan dan Cop Penyelia

DECLARATION

I hereby, declared this report entitled "Development Prosthetic Knee Mechanism of Anterior Cruciate Ligament (ACL)" is the results of my own research except as cited in references.

Signature	:	………………………………………….
Author's Name	:	…………………………………………
Date	:	…………………………………………

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Product Design) (Hons.). The member of the supervisory is as follow:

………………………………

(Project Supervisor)

ABSTRAK

Projek ini bertujuan untuk membangunkan mekanisme lutut prostetik ligamen anterior cruciate (ACL) dan menentukan kehidupan keletihan untuk implan lutut stabil di bahagian belakang dengan menggunakan perisian Solidworks. Daripada model asal implan lutut akan diimbas untuk pendua untuk model CAD sebelum meneruskan proses percetakan 3D. Bahan yang digunakan untuk menghasilkan model semasa ialah termoplastik (ABS). Oleh simulasi ujian keletihan, bahan yang akan dipilih ialah Titanium Ti-8Al-1Mo-1V. Akan ada kajian tentang kehidupan keletihan pada bahan yang digunakan.

Bahan-bahan yang akan dianalisis pada simulasi akan menjadi beban yang berbeza yang bertindak. Beban akan digunakan pada bahan untuk menentukan apa batasan bahan yang dapat ditahan sebelum kelelahan. Data dari masa kitaran dan pemuatan bahan akan dikumpulkan dan akan dianalisis yang merupakan hasil kajian keletihan untuk simulasi produk. Kehidupan keletihan akan diperhatikan melalui graf lengkung S-N yang menghasilkan dari proses simulasi, dari grafik yang dapat menentukan berapa bilangan kitaran produk akan berlaku kerosakan. Selain itu, nilai yang menyebabkan keletihan bahan dapat ditentukan dari plot kontur.

Keputusan ramalan akan dibandingkan dengan beban yang berbeza untuk menentukan jangka hayat. Dari data yang telah dikumpulkan, ia akan menunjukkan masa kitaran dan jumlah tekanan bagi bahan untuk kegagalan keletihan.

ABSTRACT

This project was aimed to develop prosthetic knee mechanism of anterior cruciate ligament (ACL) and determine fatigue life for posterior stabilized knee implant by using Solidworks software. From the original model of knee implant will be scanned to duplicate for the CAD model before proceed to the 3D printing process. The material that is use to generate current model is the thermoplastic (ABS). By the simulation for fatigue test, the material that will select is Titanium Ti-8Al-1Mo-1V. There will be studies about fatigue life on the material that are used.

The materials that will be analyzed on the simulation will be different load that acted. The load will be applied to the material to determine what are the limitation of the material can hold before it fatigue. The data from cycle time and loading of the material will be collected and it will be analyzed which are the result of the fatigue study for the product simulation. Fatigue life will be observed through S-N curves graph which generate from the simulation process, from the graph able to determine at what number of cycles the product will occur damage. Besides that, the value that causes the fatigue of the material can be determined from the contour plot.

The result of the prediction will be compared from the different load acted to determine the lifespan of the. From the data that have been collected, it will show that which cycle time and number of stress for the material for the fatigue failure.

DEDICATION

Firstly thank to Allah S. W. T for the opportunity to finish this project. Next thank to Beloved parent and family. Since the day I started going to this university until today, they are very caring and supporting for me.

ACKNOWLEDGEMENT

This report teaches and provides me a basic knowledge of engineering and helps me to understanding more about Fatigue life studies. This report inevitably involves many helping hands. First of all, I am extremely grateful and thanks to my supervisor, Mr. Mohammad Khalid bin Wahid for all the guidance and critics given to me directly or indirectly, and also his friendly and encouragement in time to teach and explain to me. Once again thanks you for your idea, knowledge and guidance that make me more understand and can develop further thinking for this project. Next, I would like to grateful and thanks to Mr.Ismail bin Abu Shah for all his help borrow the original product of prosthetics knee from Hospital Pantai, Melaka.

Finally, I would like to thank to all my family and friends, thank you for all the encouragement,support, love and helping me during the whole period which gave me the strength I need in order to carry on and finally finish this report.

TABLE OF CONTENT

CHAPTER 3: METHODOLOGY

CHAPTER 4: RESULT AND DISCUSSION

LIST OF TABLES

LIST OF FIGURES

LIST ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

ACL	-	Anterior Cruciate Ligament
N	-	Newton
Kg	-	Kilogram
CAD	-	Computer Aided Drafting
Ti	-	Titanium

CHAPTER 1

INTRODUCTION

1.1 Background

The anterior cruciate ligament (ACL) is one of the most study topics in orthopaedics nowadays. Supported by basic science, the ACL remnant is increasingly gaining prominence in reconstructive surgery, but there is still no consensus regarding the various reconstructions techniques and its preservation, a topic that will be addressed in this article. New ligament of the knee, the anterolateral ligament, has recently gained prominence and explains old concepts and theories that justify its increased restrictive effect on pivoting due to the greater lever arm relative to the central position of the ACL. Finally, also driven by the rediscovery of ACL anatomy, different techniques of femoral tunnel preparation have been developed, each with its own characteristics, turning necessary a detailed analysis of the most used options. Therefore, this update on the ACL aimed to address some of the most interesting and current topics on the subject. In this stratified approach, the following sections are: ACL remnant; anterolateral ligament and extra-articular combined with intra-articular reconstructions; fixation devices; and techniques for creating the femoral tunnel (Marcus Vinicius Malheiros Luzo, 2015)

Knee injuries and arthritis can be treated through both non-surgical (physical therapy and medication) and surgical methods. Based on the type and extent of damage to the knee, will develop a treatment plan taking into consideration the individual patient’s goals, such as continued participation in athletic activities. Therefore, one of the knee injuries can be treat by cruciate retaining knee implant. Prosthetic implants, also known as prostheses, are composed of metal and plastic, and are designed to recreate the natural pain free movement of the knee joint. Prosthetic implants for total knee replacement surgeries have up to three components. A rounded metal component with a groove on the front is placed on the bottom of the thighbone, allowing the kneecap to slide up and down easily during movement. A second metal and plastic component covers the top of the shinbone. This component may also have a metal stem that is inserted into the centre of the shinbone to help increase the joint's stability. For patients who also have damaged to areas of the kneecap, it will also be replaced by a plastic prosthesis. The amount of damage to the knee's components varies for each patient. If the anterior and posterior cruciate ligaments are still healthy and strong, a cruciate retaining knee implant will be used. The cruciate retaining knee implant does not require the removal of either the anterior or posterior cruciate ligaments for attachment. Using a cruciate retaining knee implant during a total knee replacement procedure allows for less disruption to the surrounding areas during surgery, a more natural movement after surgery, and allows patients to maintain the full stability of the joint after surgery.

1.2 Problem statement

We know that the actual price of prosthetic knee is very high cost. From the original design of their parts also can be classify as a complex parts. The materials to form of the product one of the reason too why this product is very expensive. But for person who needed they required to buy for their own benefit. From the design of the product, there is some parts that very complex to design from the original part. Besides that, prosthetic knee need to undergo some experimental test. By this, we able to determine the strength reliability of the product. Lifetime of the prosthetic knee, one of issue that contributed.

1.3 Project objective

From the background and the problem statement that have been stated, the objectives of this research are:

1. To generate model from current product using 3D Scanner.
2. To produce the prototype by using 3D printer.
3. To run the fatigue test simulation on the CAD model.

1.4 Work scope

In order to achieve the objectives, several scope have been determined:

1. Using 3D scanner to scan the actual product of prosthetic knee

2. From the design, proceed with fabricating of the parts by using 3D printer.

3. Run the fatigue test simulation to record the data analysis.

Chapter 2

LITERATURE STUDY

2.1 Introduction

Literature reviews are all about carried out the information for whole project in order to completing this project. It will focus on study of prosthetic knee fatigue strength of anterior cruciate ligament (ACL). Besides that, the method in design phase and selected phase will discuss on this chapter to give a background implementation method function. The sources that been used to complete this project such as books, journal and article

2.2 Anterior cruciate ligament (ACL) injury

Anterior cruciate ligament injury can be define as is the over-stretching or tearing of the anterior cruciate ligament (ACL) in the knee. A tear may be partial or complete. Athletes who participate in high demand sports like soccer, football, and basketball are more likely to injure their anterior cruciate ligaments. Anterior cruciate ligament (ACL) injured require surgery to regain full function of knee. This will depend on several factors, such as the severity of injury and activity level (M.M. Murray 2014). As shown in figure 2.1 is normal anterior cruciate ligament and figure 2.2 injured anterior cruciate.

Figure 2.1: Normal anterior cruciate ligament

https://medlineplus.gov/ency/article/001074.htm (6.5.2017)

Figure 2.2: Injured anterior cruciate ligament

https://medlineplus.gov/ency/article/001074.htm (6.5.2017)

There are four main ligaments connect with these two bones. For the first ligament, Medial collateral ligament (MCL) as shown in figure 2.3 runs along the inside of the knee. It prevents the knee from bending in. Second ligament which is Lateral collateral ligament (LCL) as shown in figure 2.4 runs along the outside of the knee. It prevents the knee from bending out. Next, the third ligament is Anterior cruciate ligament (ACL) as shown in figure 2.5 is in the middle of the knee. It prevents the shin bone from sliding out in front of the thigh bone. Lastly, Posterior cruciate ligament (PCL) as shown in figure 2.6 works with the anterior cruciate ligament (ACL). It prevents the shin bone from sliding backwards under the femur (Chloe Wilson, 2016)

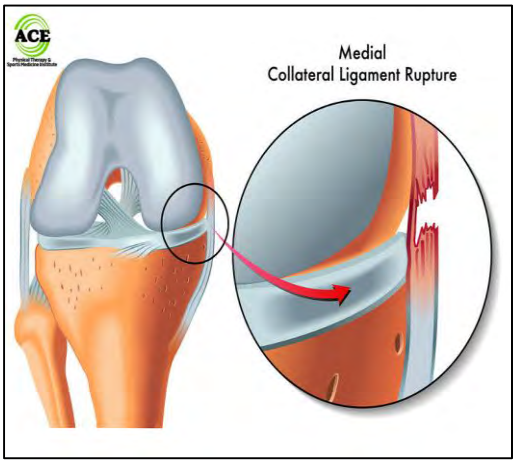

Figure 2.3: Medial collateral ligament (MCL)

http://www.ace-pt.org/wp-content/uploads/2015/10/MCL_tear.jpg (5.5.2017)

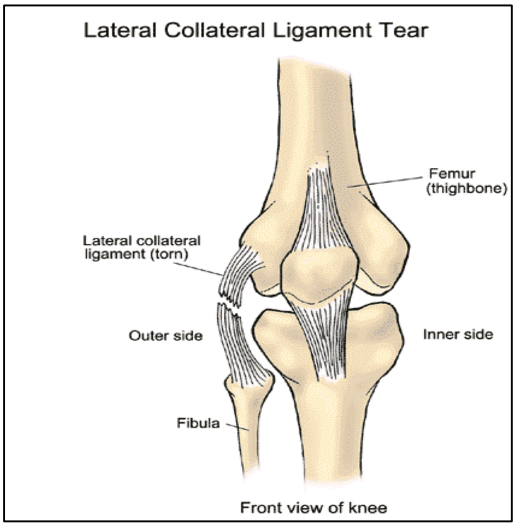

Figure 2.4: Lateral collateral ligament (LCL)

https://sites.google.com/site/activecarephysiotherapyclinic/_/rsrc/1472868019822/lcl-injury/Lcl_Tear1.gif (5.5.2017)

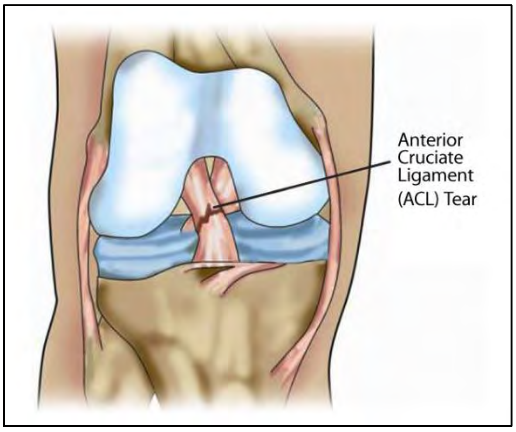

Figure 2.5: Anterior cruciate ligament (ACL)

http://www.getactivephysio.com.au/wp-content/uploads/2013/09/ACL-Tear.jpg (5.5.2017)

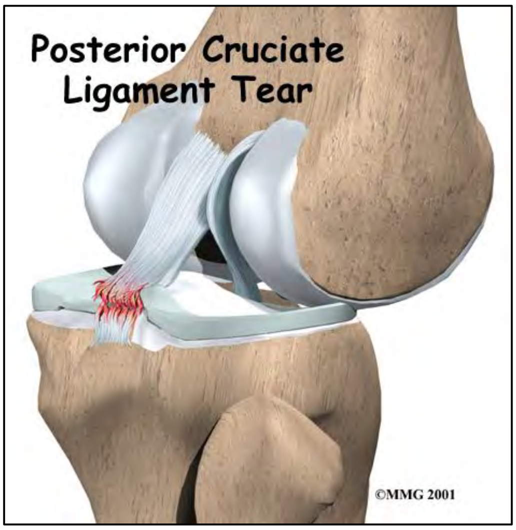

Figure 2.6: Posterior cruciate ligament (PCL)

http://www.eorthopod.com/images/ContentImages/knee/knee_pcl/knee_pcl_intro01.jpg (5.5.2017)

About half of all injuries to the anterior cruciate ligament (ACL) occur along with damage to other structures in the knee, such as articular cartilage, meniscus, or other ligaments. Injured ligament are considered "sprains" and are graded on severity scale. Anterior cruciate ligament (ACL) injuries are also associated with long-term clinical sequelae that include meniscal tears, chondral lesions and an increased risk of early onset post-traumatic osteoarthritis (OA) (A.M.Kiapour, 2014). Anterior cruciate ligament (ACL) has long been thought to have poor healing capacity with a substantially high rate of failure, even after surgical repair. The unsatisfactory outcomes of the anterior cruciate ligament (ACL) primary repair have led to unanimous abandonment of suture repair and widespread adoption of anterior cruciate ligament (ACL) reconstruction. Current surgical treatment of anterior cruciate ligament (ACL) injury is costly, with variable outcomes and is associated with high risk of post-traumatic within two decades of injury. While few athletes are able to resume sports at the same level without surgery, the surgical reconstruction is also not always successful at returning patients to their pre-injury activity level. Furthermore, those athletes who successfully return to activity are at high risk of a second knee injury with notably less favourable outcomes.

More than 70% of ACL injuries occur as non-contact (without a direct blow to the knee joint). They occur as a result of landing from a jump and lateral cutting manoeuvres that may occur in different athletic activities. Neuromuscular control deficit during dynamic movements has been hypothesised to be the primary cause for both primary and secondary anterior cruciate ligament (ACL) injury risk. The deficit in dynamic active neuromuscular control manifests as excessive joint loads and leads to detrimental The deficit in dynamic active neuromuscular control manifests as excessive joint loads and leads to detrimental anterior cruciate ligament (ACL) stress/strains and ultimate failure. Non-contact anterior cruciate ligament (ACL) injury mechanisms are multi-planar in nature, involving the tibiofemoral joint articulation as shown in figure 2.7 in all three anatomical planes. Anterior cruciate ligament (ACL) stress & strains and ultimate failure. Non-contact anterior cruciate ligament (ACL) injury mechanisms are multi-planar in nature, involving the tibiofemoral joint articulation in all three anatomical planes. Combination multi-planar loading including anterior tibial shear as shown in figure 2.8, knee valgus as shown in figure 2.9 and internal tibial rotation as shown in figure 2.10 to be the worst case scenario and primary mechanism of non-contact anterior cruciate ligament (ACL) injury had been identified (A.M.Kiapour, 2014).