NEW DESIGN OF KNEE LOCKING SYSTEM FOR KNEE SUPPORT HEALTH DEVICE

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DECLARATION

I declare that this project report entitled " NEW DESIGN OF KNEE LOCKING SYSTEM FOR KNEE SUPPORT HEALTH DEVICE" is the result of my own research except as cited in the references.

Signature : .....

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Date : .....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (with Honours).

Signature	:	.....
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Date	:	.....

DEDICATION

To my beloved family, friends and teachers

ABSTRACT

Knee braces are supports to be worn when you have pain in your knee. These are usually used for a period of weeks right after an injury or surgery. They keep the knee stable but still allow limited movement while it is healing. Braces are made from combinations of metal, foam, plastic, or elastic material and straps. They come in many sizes, colours, and designs. ROM knee brace is one of the types of knee braces available in the market. ROM Knee Brace is a custom adjusted ROM brace, which controls and restrict flexion and extension of the knee joint through a hinge module to allow a ROM or immobilization to the knee. It is usually worn by knee injury patients for a certain period after they underwent knee surgery. The hinge module in the ROM knee brace plays an important role in controlling and restricting the ROM of the knee. The hinge module of currently available ROM knee brace in the market needs to be adjusted manually during ROM angle adjustment process. Hence, it is important to explore alternative options for the hinge module design that may serve the same purpose in an easy way. The purpose of this project is to provide an easy handling knee brace's hinge mechanism during adjusting a desired rotational range in the extension or flexion direction which can be user-friendly and convenient to the user. An easily adjustable solenoid hinge module was developed consisting of 22 components. The design of the solenoid hinge module was developed in Solidworks 2016 software. A set of 5v solenoids is used in this design as a locking mechanism which reduces the manpower during the knob locking process. This solenoid based hinge module concept for ROM knee brace is very new and not available in the market right now. This concept makes the angle adjustment process semi-automatic and easier. There are two types of analysis conducted on the design namely stress analysis and kinematic analysis. Based on the maximum stress and total deformation result from the stress analysis, the design is capable to withstand the external force that might be applied by the user during limiting ROM of their knee. Besides that, the motion of the hinge mechanism joints also has been identified from the kinematic analysis.

ABSTRAK

Pendakap lutut adalah suatu penyokong untuk dipakai apabila anda mengalami kesakitan di lutut anda. Ini biasanya digunakan untuk tempoh beberapa minggu selepas kecederaan atau pembedahan. Pendakap lutut menyimpan lutut dengan stabil tetapi masih membenarkan pergerakan terhad semasa ia menyembuhkan. Penyokong diperbuat daripada kombinasi logam, buih, plastik, atau bahan elastik dan tali. Ia datang dalam pelbagai saiz, warna, dan reka bentuk. Pendakap lutut julat pergerakan adalah salah satu jenis pendakap lutut yang ada di pasaran. Pendakap lutut julat pergerakan adalah suatu alat yang mengawal dan menyekat kelonggaran dan perpanjangan sendi lutut melalui modul engsel untuk membolehkan pelbagai gerakan atau immobilisasi ke lutut. Ia biasanya dipakai oleh pesakit kecederaan lutut untuk tempoh tertentu selepas menjalani pembedahan lutut. Modul engsel dalam pendakap lutut julat pergerakan memainkan peranan penting dalam mengawal dan menyekat pelbagai gerakan lutut. Modul engsel yang sedia ada di pasaran perlu disesuaikan secara manual semasa proses pelarasan sudut julat pergerakan. Oleh itu, adalah penting untuk meneroka pilihan alternatif untuk reka bentuk modul engsel yang boleh menjadi tujuan yang sama dengan cara yang mudah. Tujuan projek ini adalah untuk menyediakan mekanisme engsel pendakap lutut julat pergerakan yang boleh dikendalikan dengan mudah semasa menyesuaikan julat putaran yang dikehendaki dalam arah lanjutan atau fleksi yang boleh menjadi mesra pengguna dan mudah untuk pengguna. Modul engsel solenoid yang mudah laras terdiri daripada 22 komponen dibangunkan. Reka bentuk modul engsel solenoid telah dibangunkan dalam perisian Solidworks 2016. Satu set solenoid 5v digunakan dalam reka bentuk ini sebagai mekanisme pengunci yang mengurangkan tenaga manusia semasa proses mengunci lutut. Konsep modul engsel berasaskan solenoid untuk pendakap lutut julat pergerakan ini sangat baru dan tidak terdapat di pasaran sekarang. Konsep ini menjadikan proses pelarasan sudut separa automatik dan lebih mudah. Terdapat dua jenis analisis yang dilakukan pada reka bentuk iaitu analisis tekanan dan analisis kinematik. Berdasarkan tegasan maksimum dan jumlah ubah bentuk hasil daripada analisis stres, reka bentuk ini mampu menahan daya luaran yang mungkin dikenakan oleh pengguna semasa menghadkan julat pergerakan lutut mereka. Selain itu, gerakan sendi mekanisme engsel juga telah dikenal pasti dari analisis kinematik.

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CHAPTER 1

INTRODUCTION

1.1 Background

In human anatomy, the knee is the part of the lower limb that lies between the lower leg and thigh. The femur, tibia and patella make up the bones of the knee. The knee joint keeps these bones in place. The patella is a small, triangle-shaped bone that sits at the front of the knee. The knee is the largest joint in the body, and its exposed position makes it vulnerable to injury during athletic activities. There are various injuries that can occur to the knee joint, the most common injuries are Anterior Cruciate Ligament (ACL), Medial Collateral Ligament (MCL), Lateral Collateral Ligament (LCL), Meniscus tears and knee dislocation. Usually, these kinds of knee injuries need to undergo surgery. Even though there are many types of knee braces which provides some support at the side of the knee and assist knee recovery post-surgery but Range of motion (ROM) or limited motion knee brace are often prescribed to assist mobilisation during recovery following surgery.

Usually, after knee surgery, the leg needs to be completely immobilised for a few days and then the leg is gradually allowed to move in a small range (0° to 30°). This can be done with the help of ROM knee brace which is in the market and this is the reason why this type of brace is often prescribed following surgery. ROM knee brace is designed to restrict the patient's range of knee flexion and extension to the desired degree during rehabilitation. Patients are progressively given more ROM as their healing progresses.

Figure 1.1: ROM knee brace (www.amazon.com,23/10/18)

Apart from ROM knee brace, there are many other knee braces in the market. Unloader knee brace, Functional knee brace, Prophylactic knee brace and Rehabilitative knee brace are those braces which are currently in the market. These braces have their own function. Figure 1.2 shows an unloader knee brace which is for people who suffer from medial compartment knee osteoarthritis. The design of this knee brace includes adjusting dial which will unload stress from the affected joint by placing pressure on the thigh bone and at the same time, it helps reduce bone on bone rubbing with pain, inflammation and helps in providing support.

Figure 1.2: Unloader knee brace (www.mmarmedical.com,23/10/18)

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Functional knee brace which is shown in figure 1.3 is similar to unloader knee brace except it doesn't have an adjusting dial. This knee brace's design is specifically made for ligaments or meniscus injured patients. This brace will help to provide stability of the knee joint and prevent unwanted knee motion for patients.

Figure 1.3: Functional knee brace (www.breg.com,23/10/18)

Figure 1.4 shows the prophylactic knee brace. The prophylactic knee brace is especially for athletes who play contact sports such as rugby where it will be used to give protection for knee and it is a preventative measure to reduce the chance of injury. The design of this brace protects medial collateral ligament against valgus knee stresses.

Figure 1.4: Prophylactic knee brace (www.shockdoctor.com,23/10/18)

The rehabilitative knee brace is for the people who recover from knee surgery where it will protect a reconstructed or repaired ligament to prevent future or recurring injury and allow early motion of the knee joint. The image of rehabilitative knee brace is shown in figure 1.5.

Figure 1.5: Rehabilitative knee brace (www.donjoyperformance.com,23/10/18)

1.2 Problem Statement

ROM knee braces in the market currently is observed to be not user-friendly. Spring-loaded knob hinge mechanism in ROM brace seems to be difficult to adjust by the user. Therefore, it is important to come out with a new hinge design with ease of handling during adjusting the angular position of the knee and with a new type of spring-loaded knob which is resistant to unintended slippage from its selected rotation limiting position during rotation of the hinge.

1.3 Objective

The objective of this project is to provide an easy handling knee brace's hinge mechanism during adjusting a desired rotational range in the extension or flexion direction which can be user-friendly and convenient to the user.

1.4 Scope of Project

The scopes of this project are:

1. The ROM brace's adjustable hinge module will be designed by using CAD.
2. Design rigidity of hinge will be identified by using analysis software.
3. The motion of hinge mechanism joints will be identified by using kinematic analysis.

1.5 General methodology

The actions that need to be carried out to achieve the objectives in this project are listed below.

1. Literature review

   Patents, articles, or any materials regarding the project will be reviewed.

2. Survey

   A survey is one of the helpful tools to obtain information from people. So, in the early phase of this project, a survey will be conducted to obtain information from random people regarding ROM knee brace. The information will be about their requirements for ROM knee brace which will be considered as customer requirement for this project. This survey will be conducted through google form where the results will be converted into the graph at the end for the analysis process.

3. House of quality

   House of Quality is a chart utilised for analysing the connection between customer requirements and the product's engineering characteristics. Besides that, the competitor's product also will be compared with the customer requirements. For this project, HOQ will be discussed based on the information and result gathered from the survey.

4. Morphological chart

A morphological chart is in the early phase of the concept generation process. It provides a structured approach to concept generation. This chart consists of a list of product attributes and possible solutions. For each element of product attributes, there may be a number of possible solutions. Morphological chart for this project which includes attributes of the hinge mechanism and its possible solutions will be discussed.

5. Conceptual design

The conceptual design includes the sketch of concept, the components involves, how it will meet the objectives and how it will work. There are four conceptual design for the knee brace hinge mechanism will be discussed in this project.

6. Champion concept

Among the four conceptual design, one will be selected as the champion concept which will be the final concept. Weighted criteria method will be used for the concept selection process.

7. Detailed design

The champion concept of hinge mechanism will be designed by using CAD software.

8. Kinematics analysis

The kinematics analysis will be conducted at the area of the hinge mechanism of the knee brace to identify the motion of the related mechanism.

9. Design rigidity

The design rigidity of the hinge mechanism will be identified using analysis software. Materials in the hinge mechanism that displays less elastic deformation under load possess higher levels of rigidity. This analysis is very

important because to make sure the materials in the hinge mechanism can resist bending, stretching, twisting or other deformation under a load.

10. Report writing

A report on this study will be written at the end of the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A comfortable and convenient ROM knee brace is needed for human being following surgery in their knee to limit the ROM of the knee which will reduce and prevent unrestricted rotation of the knee. Specifically, they are regularly prescribed when somebody has harmed one of the four major structural tendons of the knee. The function of this type of knee brace is to limit the user's range of knee flexion and extension to the desired degree because usually the users are progressively given more ROM as their healing progresses. The interconnecting hinge module in the ROM knee brace plays an important role to provide the ROM. The users need to adjust the settings in the hinge module to set a different ROM. Therefore, it is important to have a ROM knee brace with an easily adjustable hinge module which will be convenient for the user. The type of adjustable hinge module and the locking mechanism of the hinge is very important to provide convenient and easy adjustment of the ROM for the user.

This particular chapter will review studies and researches carried out in relation to the mechanism of ROM knee brace's hinge module. This could provide more understandings on the working mechanism of the hinge module. It includes section 2.1 which explains the locking mechanisms of ROM knee brace's hinge from selected patents and section 2.2 which compare and review the different types of hinge modules explained in section 2.1.