UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ULTRA LIGHTWEIGHT 3D PRINTED IMMOBILIZATION CAST FOR BONE FRACTURE TREATMENT IN ORTHOPEDIC

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

by

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Automotive) with Honours. The member of the supervisory is as follow:

Signature: ……………………………………………….

Supervisor: MOHAMMAD RAFI BIN OMAR

ABSTRAK

Ringkasan yang boleh dibuat daripada projek ini adalah untuk mencipta katalog berkenaan saiz kaki manusia mengikut kategori yang telah diciptaan yang berdasarkan berat dan saiz kasut. Produk ini juga merupakan inovasi untuk menambahbaikkan simen kaki sekarang. Terdapat beberapa masalah simen kaki sekarang iaitu terlalu berat dan akan membebankan pesakit terutama ketika ingin bergerak. Kemudian, simen kaki yang sekarang juga tidak mempunyai ruang udara yang akan menyebabkan keadaan dalam menjadi semakin panas dan membuatkan pesakit tidak selesa. Ia juga tidak kalis air. Projek ini juga menitikberatkan suhu semasa memakai simen kaki sekarang dan simen kaki Immobilization Cast serta membuat perbandingan suhu antara kedua-duanya. Akhir sekali, membuat analisis berkenaan reka bentuk yang baru bagi mendapatkan tekanan ketika meletakkan berat sebanyak 1000 N. Keputusan analisis ini menunjukkan reka yang baru ini mampu menampung berat sebanyak 1000 N iaitu bersamaan dgn 100 kg.

ABSTRACT

The summary of this project is to produce the catalogue of leg sizing for a set category of human body by taking the dimension of weight and shoe size. Then, this is the product of innovation to improve the current use leg cast that can easily be made by using 3D Printing. The design starts with reverse engineering using 3D scanner. There are a few problems of the current use leg cast which is heavy and this can lead to burdening the patients while moving. Then, the current use leg cast does not have any air flow through out it and this can affect the leg to contain more heat and less comfortable for the wearer. The current use cast is also not waterproof. This project focuses on the temperature result data of the inside of the both cast while wearing it. And the temperature difference between current cast and new immobilization cast is a lot. Produce the catalogue of leg sizing depending on the weight and the shoe size of people. The dimension measured is based on the anthropometry data. Lastly, running analysis of design part to obtain the maximum stress acting on the new design when putting a 1000 N of force. The analysis is done by using solidthinking. The result proves that the cast design with nylon as its material is strong enough to withstand load a high as 1000 N or approximately 100 kilograms.

DEDICATION

To my beloved parents,

Zanawati Binti Mat Hassan and Mohamed Zoefry Bin Hj. Tahir

Thank you for all your supports, patients, sacrifices and willingness to educate me.

To my honoured supervisor,

Mr Mohammad Rafi bin Omar,

Thank you for giving me guidance, supports and persistent help towards finishing this project.

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All praise belongs to Allah (SWT). Without the health, the strength, the perseverance and the patient that He gave me, I would not be able to complete this project thesis. I have been giving my efforts and spend my time wisely to finish this thesis. However, I would not be able to complete this project thesis without the help of others that keeps on supporting me and guide me throughout this semester. In specific, I want to thank everyone that have contributed to this project thesis whether they my family, my friends, my lecturers, my supervisor and my panel judges. They have been encouraging me and giving full thought during this project.

Firstly, I want to express my gratitude and deepest appreciation to my supervisor Mr. Mohammad Rafi bin Omar for his patient and endless support that continually provide me with knowledge throughout this project. He gave necessary suggestion and constant supervision as well as providing information regarding the project thesis. This project would not have been successful if it is not for my supervisor's guidance.

Besides that, he also introduced me to this project and support me with the idea of innovation and inspiration. He also shared his knowledge without any thought of his valuable time to give me full understanding to produce and improve this thesis. Next, I also want to express my gratitude towards my family and parents for their kind words and support of motivation to keep me going forward to complete the thesis. I am very grateful to those who giving me chances to ask information regarding the project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter consists of the background of the project of immobilization cast for bone fracture. The information of the 3D scanner, types of bone fracture, Catia V5, sizing of the leg cast and testing of the design of the 3D printed leg cast. This chapter also containing of problem statements, objective, and the scope of the project.

1.2 Background

Human leg contains 4 bones which is the femur, the patella, the tibia, and the fibula. Then it includes the bends at the knee and the ankle. Bone fractures can be differentiating by various characteristics. The fractures are divided into several types which are transverse, oblique, spiral, and comminute, based on the various shape or pattern of the fractured bones (Wang et al., 2016).

After an accident, these bones may break or fracture into more than one piece. On the off chance that a broken bone has been exposed to the outside, either by a cut over the fracture or by bone sticking out through the skin, it is called an open fracture. This is at times also called a compound fracture. The bone is broken through trauma where the leg has been on large force or injury such as vehicle crashes and falling from high height. Injury can make a bone fracture if the bones have been debilitated by disease, for example, cancer or other tumours, bone cysts, or osteoporosis. Sometimes, excessive and continuous over usage of the leg, such as the movements in long distance running, can produce in a stress fracture.

Plaster of Paris has been utilized to immobilise fractures, furthermore, treat orthopaedic conditions since 1850 when it was first utilized in the Dutch armed force. These days, there are an assortment of alternative materials, for example, resin impregnated bandages, ready-made orthoses and external fixators. An essential element of fracture healing is to maintain the bony alignment of the fracture in order to promote healing and enable maximum function of the limb once the fracture has healed. In many fractures bony alignment can be effectively maintained using a plaster cast (Williams, 2010).

An orthopaedic cast is a shell covering partial parts of the human body to stabilize and immobilize broken or dislocated bones for restoration and healing. With the coming of the digitalize manufacturing ages, cutting edge technologies in 3D scanning and 3D printing have been connected in careful practices and orthopaedic treatment (Dai et al., 2017).

1.3 Problem Statement

When bones are broken or tissue becomes injured, it is sometimes necessary to apply a cast to protect the affected area. This intervention allows broken bones to be set in place as they heal and can also help to reduce pain and swelling.

Orthopaedic casts, or simply casts, are usually made from synthetic materials such as knitted fiberglass bandages, bandages of thermoplastic, or plaster bandages. Casting methods are simple and use a soft inner cotton layer with a hard-outer plaster of Paris or fiberglass layer. These materials have poor breathability and are not water resistant. As a result, skin can become irritated and, in some scenarios, cutaneous complications can occur as they are bulky and uncomfortable. If water entered the cast and started to moisturize, the patient might experience irritation, extremely itchy and even overheat (Dai et al., 2017).

Nowadays, there are casts that is waterproof. Due to their advanced and improved technology and better materials, waterproof casts tend to be more expensive than alternatives. While the lining is waterproof, it can still take a decent amount of time for it to dry completely when it does contact with water. Therefore, the presence of holes for the convenient of air flow is compulsory in speeding up to dry the inside of the cast.

Problem statement in this study: -

1. Fixed sizing of the cast based on previous project.
2. Not comfortable in temperature of Plaster of Paris cast.
3. Current use Plaster of Paris cast is heavy.
4. Not waterproof.

1.4 Objective

The objective of this study: -

1. To provide the catalogue of size of the leg cast for a majority patient.
2. To improve the design of the ultra-lightweight 3d printed immobilization cast.
3. To test the temperature to achieve standard comfort.

1.5 Scope

The scope of this project includes: -

1. Reverse engineering based on the previous project and scanning leg using 3D Scanner.
2. Redesign of the cast using Catia V5 to make it ultra-lightweight but maintaining its strength by using solidthinking software.
3. Testing the immobilization cast temperature by using thermocouple compare it with the PoP Cast.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will be focusing on the researches based on orthopedic leg cast. The researchers are related to with the types of bone fracture, Catia V5, testing on the 3D printed cast, and cast size. The type of instruments use for testing is suggested for comfortability of the leg cast. Then, the method for determining the sizing for the cast is introduced by creating a catalogue of leg size that is collected in a survey.

2.2 Types of Bone Fracture

2.2.1 Open Fracture

This type of fracture is very serious fracture. This is because the bone is piercing the skin and causing wounds (Figure 1). The wounds must be treated immediately before putting on a cast. And cannot wear cast without treatment for the injury. An open crack is one in which there is correspondence between the bone and the outside condition. This can go from a little skin cut or cut overlying the broke issue that remains to be worked out outrageous instance of a bone distending through the skin (Howard J McGowan, 2008).

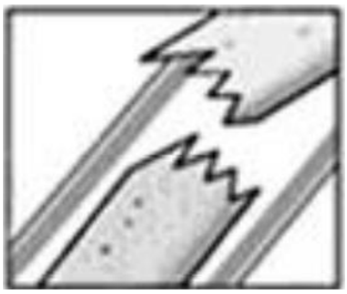

Figure 1: Open Fracture

2.2.2 Closed Fracture

Closed fracture is also known as a simple fracture. This meant that the fracture does not causing the skin to open or wounded (Figure 2). A light treatment needed before putting on a cast. The fracture example of closed tibial cracks is generally basic, with less serious delicate tissue damage than is seen with open tibial shaft fracture. The more complex fracture arrangements are much of the time seen in older, less fit patients with osteoporotic bone (Andrew H, 2003).

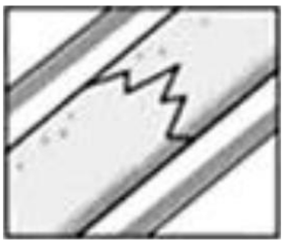

Figure 2: Closed Fracture

2.2.3 Transverse Fracture

Transverse fracture is fracture formed perpendicular to the long axis of the bone (Figure 3). The fracture usually straight across the bone. The crack appears across the bone at an angle less than 30 degrees to the long axis of the bone (Susan L. Schaefer, 2016).

Figure 3: Transverse Fracture

<https://www.emedicinehealth.com/>

2.2.4 Oblique Fracture

Fracture that is formed on an angle from the bone (not right angle) (Figure 4). This type of fracture usually is not displaced and can use cast for treatment. This fracture has an angle more than 30 degrees on the long axis of the bone (Susan L. Schaefer, 2016).

Figure 4: Oblique Fracture

<https://www.emedicinehealth.com/>

2.2.5 Spiral Fracture

A fracture that formed around the bone. This fracture is usually having a twisted part of a bone (Figure 5). Spiral fractures of the distal humeral shaft at the dimension where the radial nerve leaves the back compartment through the intramuscular septum are related with radial nerve paralyses. This crack example is known as the Holstein– Lewis humeral shaft break (J.D. Lindsey, 2015). This fracture is a rare case pf oblique fracture as the crack line curves around the diaphysis.

Figure 5: Spiral Fracture

2.2.6 Greenstick Fracture

This type of fracture is only occurred on the one side of a bone which mean it is an incomplete fracture (Figure 6). The bone is not broken completely. Frequently used to depict a fracture that disrupt just a single cortex, an incomplete break is known as a greenstick fracture (DeCamp, 2016).

Figure 6: Greenstick (Incomplete) Fracture

<https://www.emedicinehealth.com/>