UNIVERSITI TEKNIKAL MALAYSIA MELAKA

TO IMPROVE THE CRUTCHES DESIGN FROM THE EXISTING PROTOTYPE

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in fulfilment of the requirements for the degree of
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DECLARATION

I declare that this choice an item entitled " To Improve The Crutches Design From the Existing Protoype" is the result of my own research except as cited in the references. The choice an item has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

Name : Nur Sarah Farisya Binti Md Isa

Date : 20 January 2023

APPROVAL

I hereby declare that I have checked this thesis, and, in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology with Honours.

Signature :

Supervisor Name : Hamzah Bin Mohd Dom

Date : 20 January 2023

DEDICATION

To my beloved parents,

My respectful lecturers,

Also, my faithful friends,

Your prayers always accompany me on my every journey.

ABSTRACT

Crutches are very important for patient with leg injuries and crutches are very useful as an aid to users or patients to walk and perform daily activities. If viewed in terms of a crutch, it is a long stick with a crosspiece at the top that a person with an injury or handicap uses as a support under the armpit. The main problem often faced by users of crutches is discomfort on the handle part and the crutch tip is less stable. The purpose of this project is to design improvements to an existing forearm crutch and analyse the displacement, factor of safety and Von Mises stress using Solidwork software. The method used was survey conducted in several private hospitals in Negeri Sembilan and design the improved crutches using SolidWorks software. The result for this study, Aluminium Alloy is used for the shaft and the knee rest. The material used for the hand cuff and handle is Nylon and Neoprene is used as the padding for the hand cuff, handle, and knee rest. For the results, the maximum and minimum value of Von Mises stress on the handle is 9.713e+07 N/m^2 and 3.852+04 N/m^2, shaft is 1.506e+07 N/m^2 and 1.116e+00 N/m^2, knee rest is 2.944e+08 N/m^2 and 1.763e+05 N/m^2. The maximum displacement value for handle is 7.435e+10 mm and minimum 1.493e+09 mm, shaft is 1.001e+02 mm and 1.000e+02 mm, and knee rest is 1.269e+00 mm and 1.000e-30 mm. The factor of safety for the handle is 1.4, shaft is 1.9 and knee rest is 0.094. In conclusion, the improvements on the forearm crutch can be made by changing the design, material, and mechanisms.

ABSTRAK

Tongkat amat penting bagi pesakit yang mengalami kecederaan kaki dan tongkat amat berguna sebagai bantuan kepada pengguna atau pesakit untuk berjalan dan melakukan aktiviti harian. Jika dilihat dari segi tongkat, ia adalah kayu panjang berpotongan silang di bahagian atas yang digunakan oleh orang yang cedera atau cacat sebagai penyokong di bawah ketiak. Masalah utama yang sering dihadapi oleh pengguna tongkat ialah ketidakselesaan pada bahagian pemegang dan hujung tongkat kurang stabil. Tujuan projek ini adalah untuk mereka bentuk penambahbaikan pada tongkat lengan bawah sedia ada dan menganalisis anjakan, faktor keselamatan dan tekanan Von Mises menggunakan perisian Solidwork. Kaedah yang digunakan ialah tinjauan yang dijalankan di beberapa hospital swasta di Negeri Sembilan dan mereka bentuk tongkat yang ditambah baik menggunakan perisian SolidWorks. Hasil untuk kajian ini, Aluminium Alloy digunakan untuk aci dan rehat lutut. Bahan yang digunakan untuk cuff tangan dan pemegang adalah Nylon dan Neoprena digunakan sebagai pelapik untuk cuff tangan, pemegang, dan rehat lutut. Untuk keputusan, nilai maksimum dan minimum tegasan Von Mises pada pemegang ialah 9.713e+07 N⁄m^2 dan 3.852+04 N/m^2, aci ialah 1.506e+07 N/m^2 dan 1.116e +00 N/m^2, rehat lutut ialah 2.944e+08 N/m^2 dan 1.763e+05 N/m^2. Nilai anjakan maksimum untuk pemegang ialah 7.435e+10 mm dan minimum 1.493e+09 mm, aci ialah 1.001e+02 mm dan 1.000e+02 mm, dan rehat lutut ialah 1.269e+00 mm dan 1.000e-30 mm. Faktor keselamatan pemegang ialah 1.4, aci ialah 1.9 dan rehat lutut ialah 0.094. Kesimpulannya, penambahbaikan pada tongkat lengan bawah boleh dibuat dengan mengubah reka bentuk, bahan, dan mekanisme.

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LIST OF SYMBOLS AND ABBREVIATIONS

ATFL	-	Anterior Talofibular Ligament
ACL	-	Anterior Cruciate Ligament
MCL	-	Medial Collateral Ligament
FEA	-	Finite Element Analysis
FEM	-	Finite Element Method
cm	-	Centimetre
mm	-	Millimetre
kg	-	Kilogram
2D	-	2-Dimension
3D	-	3-Dimension
N	-	Newton
m	-	Meter

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CHAPTER 1

INTRODUCTION

1.1 Background

Crutches have been around for a long time. They have progressed from fallen tree branches used for balance and ambulation to their modern underarm and forearm crutches designs. A crutch is a medical device that supports a patient's complete body weight or a portion of it. Crutches are often made of wood or metal alloys (most commonly steel, aluminium alloys, and titanium alloys) and extend from the patient's underarm to the walking surface. Although the materials have evolved, the overall design of the crutch has stayed practically same. They are basically sticks with supports for the hand, forearm, and underarm.

A concave surface fits beneath the arm, and a cross bar supports the hand, both of which are utilized to support the body weight. A patient may wear crutches for a few days or for the rest of his or her life. Patients who require bilateral upper extremity assistance with intermittent weight bearing utilize forearm crutches, also known as Canadian or Lofstrand crutches. Bilateral upper limb training (BULT) is another stroke motor rehabilitation strategy in which the subjects are required to perform motor tasks with both upper limbs (Chen et al., 2019).

Forearm crutches have the advantage of allowing the hands to be free without having to disengage the crutch from the forearm. Forearm crutch is less heavy and easier to use than axillary crutches when climbing stairs. It can be used in people who are very active but have paraplegia due to spinal stenosis (Weiss, 2003).

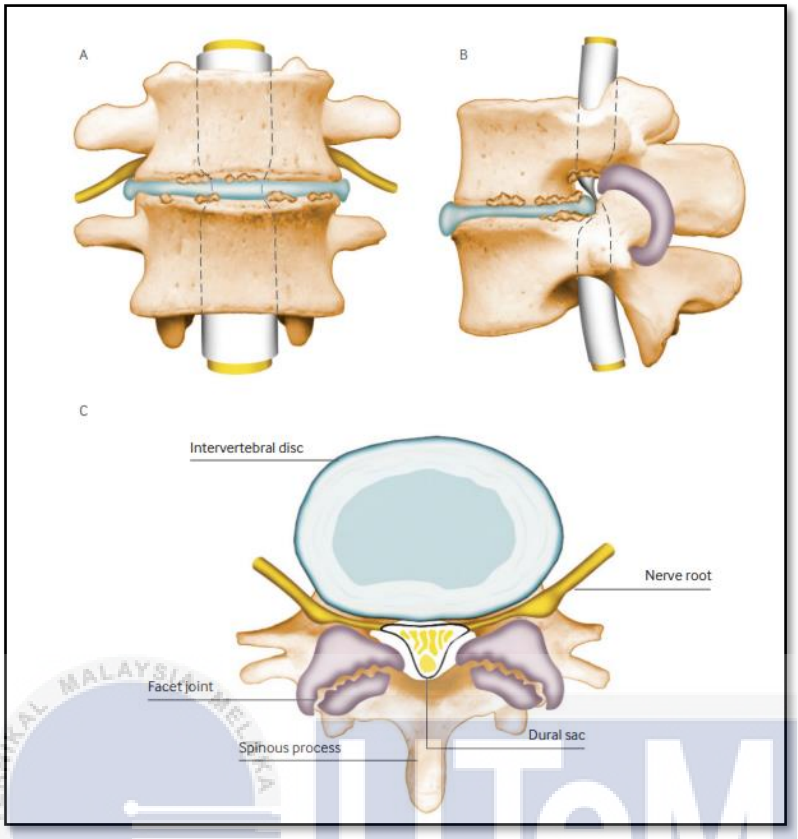

Figure 1.1: Degenerative Spinal Stenosis (Lurie & Tomkins-Lane, 2016)

Figure 1.1 above shows the degenerative spinal stenosis with 3 views frontal (A), sagittal (B) and axial views (C). Thickening of the tissue surrounding the Dural sac is shown in purple. The axial figure depicts only a relatively minor degree of stenosis to allow visualization of the different structures (Lurie & Tomkins-Lane, 2016). A narrowing of the spinal canal that results in clinical symptoms attributable to spinal cord or radicular impairment is referred to as spinal stenosis. Since a physically small canal is frequently asymptomatic, a difference must be established between anatomic findings and clinical complaints (Postacchini, 1996). Spinal stenosis can affect the cervical, thoracic (rarely), or lumbar spine, and it can be unilateral, bilateral, or multisegmented (Melancia et al., 2014).

A forearm crutch is a type of crutch that differs from ordinary crutches. A forearm crutch is used to transfer part of a patient's body weight on the hands and arms when walking, similar to a full-sized conventional crutch. Forearm crutches, as the name implies, reach from the patient's forearm rather than the underarm. When a patient can cope without the need of a full-length crutch, forearm crutches are frequently used. Forearm crutches are superior for long-term usage. The majority of the user's weight is shifted to the upper arms. The user must have adequate upper body strength to properly utilize these crutches. For people with a long-term impairment who desire to be more active or participate in sports, forearm crutch is a possibility (Warees, 2022).

1.2 Problem Statement

Crutches provide various physiological and psychological benefits to those who use crutches because it allows them to walk instead of relying on wheeled mobility. However, while walking on crutches has numerous advantages, it also has a number of disadvantages that prevent some people from using the crutches. Customers complain about the weight, noise, and durability of typical forearm crutches. Customers think that reducing the weight of forearm crutches by a little amount would greatly minimize crutch user fatigue.

The majority of crutches on the market are only intended for short-term usage and rapidly wear out. Crutch users typically need to replace their crutches every two or three years. This necessitates the development of forearm crutches that are durable, suitable for a wide variety of users, from light-weight people to those weighing up to 250 pounds and possessing significant upper-body strength, and who may use them aggressively on a regular basis (Wu et al., 2011).

Patients who are wearing crutches may experience a number of issues. First, blistering or hand pain from constant pressure between the hand and handle. Next, a bad grasping motion can result in carpal tunnel syndrome. In addition, because using crutches requires a lot of effort, users of forearm crutches frequently experience fatigue (Potter & Wallace, 1990). Additionally, the existing crutches are not diverse enough to handle environmental problems like unpaved roads or uneven terrain (Brown et al., 2020). The majority of participants reported that the hand grips were generally excessively harsh and left their hands calloused and blistered (Hall & Clarke, 1991).

1.3 Research Objective

The purpose of this project is to alleviate the obstacles that forearm crutch users confront, as mentioned above. The main aim of this project is to design an ergonomic forearm crutch that meet the needs of consumers. Specifically, the objectives are as follows:

1. To conduct a survey on problems faced by forearm crutch users at hospitals.
2. To design improvements on existing forearm crutches by using SolidWorks software.
3. To analyze the displacement, safety factor, strain and Von Mises Stress by using SolidWorks software.

1.4 Scope of Research

The scope of this research are as follows:

1. Compare the crutch with existing design and develop the best design selection through House of Quality and Pugh method.
2. Type of material used to upgrade existing forearm crutches. This material should have better mechanical properties like Nylon and Aluminum Alloy.
3. Project designs and analysis will be created using Solidwork software.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction and History of Forearm Crutches

By shifting the body's weight from the legs to the torso (the main section of the body that contains the chest, abdomen, pelvis and back) and arms, crutches are medical equipment that help with ambulation. They are mostly employed to help those who have suffered injuries to their lower extremities or neurological disability (Warees, 2022).

Religious images emerged on the embroidered clothing of a deacon in the 14th century, and a walking frame with wheels was utilized. The early crutches should be a piece of wood of adequate length that is placed under the arm and offers movement support while individuals walk. It has gradually evolved into a “T-shaped” crutch, with a horizontal beam inserted on top of a vertical wooden rod, to save people effort and rest. Later, the T-shaped crutches were progressively replaced with V-shaped crutches. The topmost hardwood is beginning to crack. On either side, it splits horizontally (Sally Madeley-Carr, 2022).

The V-shaped crutches evolved into the underarm support part, and a handled section supported under the armpit. Although it lacks cushioning to prevent friction in the underarm area, it does lessen vertical strain on the user’s legs, directing walking energy to the upper body (Sally Madeley-Carr, 2022).

Emile Schlicke, a French engineer, created and manufactured the first pair of forearm crutches, which were mass-produced in New England in 1917. For the first time, a metal bracelet wraps around the user's arm and has a sloping top in this design. When the First World War came out, many soldiers' desires for walking aids increased, and sales of the drug increased as well. Many troops who were injured in the battlefield healed slowly as a result of this type of walking aids. Later technological breakthrough in crutch design were achieved by Anders R Lofstrand Jr (Sally Madeley-Carr, 2022).

In 1945, the business submitted a patent application for an adjustable version of Schlick's original design, which it earned numerous lucrative government contracts during WWII. The most significant change made by Lofstrand was to make the crutch's forearm and lower axis adjustable, allowing the crutches to be customized to the particular user's frame. The patent was awarded just 10 years later in this case, and Lofstrand died of cancer two months later at the of 42. The forearm crutch is still known as the Lofstrand in many regions of North America. Because of the popularity of the design in Canada, they may also be referred to as "Canadian" crutches (Sally Madeley-Carr, 2022).

2.2 Types of Crutches

There are several different types of crutches available in the market. This is because each different type of crutches has its own speciality and patients need to use appropriate crutches depending on the patient's condition, the doctor's recommendations, and the patient's upper body strength. Axillary crutches and forearm crutches are the two most common forms of crutches.

2.2.1 Axillary Crutch

Axillary crutches (Figure 2.1), also known as underarm crutches, are the most prevalent form of crutch. These crutches go under the arm and may be adjusted to users' height. It is easy to use and balance, but it can be uncomfortable and exhausting to use (Behring, 2021). Axillary crutches can be made of wood, although aluminium is the most frequently used material today. It may be very unpleasant at longer distances or for long periods of time and has been linked to nerve damage in the armpit area.

Axillary crutches are ideal for temporary injuries, disability, and rehabilitation following surgical procedures such as ankle sprains and knee injuries. These crutches need little training and are quite affordable. Height and hand grip height modifications are two basic functions. Pressure on nerves in the armpit, or axilla, causes crutch paralysis, also known as crutch palsy (Crutch Palsy, 2003).

Figure 2.1: Axillary Crutch