DESIGN RESEARCH ON HEALING DEVICE FOR FRACTURE FOREARM

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ABSTRACT

The purpose of this research is to study design research on healing device for fracture forearm like Plaster-of-Paris and fiberglass cast, which are normally used nowadays. A new design is developed to enhance for current features in order to help and improve patients' normal activities and lifestyle. Factors such as ergonomics, safety and reliability are seriously considered in the new design. This design research also studies the new potential material for the production purpose.

ABSTRAK

Kajian ini bertujuan untuk mengkaji tentang reka bentuk alat bantu pemulihan patah lengan bawah seperti acuan plaster dan acuan gentian kaca yang biasanya dipakai sekarang. Satu reka bentuk yang baru dikembangkan untuk menambahkan ciri-ciri semasa supaya membantu dan meningkatkan cara kehidupan serta menyenangkan aktiviti-aktiviti pesakit. Sifat-sifat seperti ergonomik, keselamatan, dan perihal akan diambilberat dalam reka bentuk yang baru. Kajian ini juga menyelidik tentang keupayaan bahan yang baru untuk tujuan pengeluaran.

CHAPTER 1 INTRODUCTION

1.1 Introduction

Hand is a marvelously complex part of human anatomy. Our hand may divide into two parts which are upper arm and lower arm. Upper arm also may call arm. It is within a bone call *Humerus*[1]. On the other hand, lower arm also may call forearm. It is consist of two bones. These are *radius*[2] and *ulna*[3]. *Radius* is the larger of the two bones that runs along the thumb side of arm. *Ulna* is the smaller of the two bones that runs along the little finger side of arm.

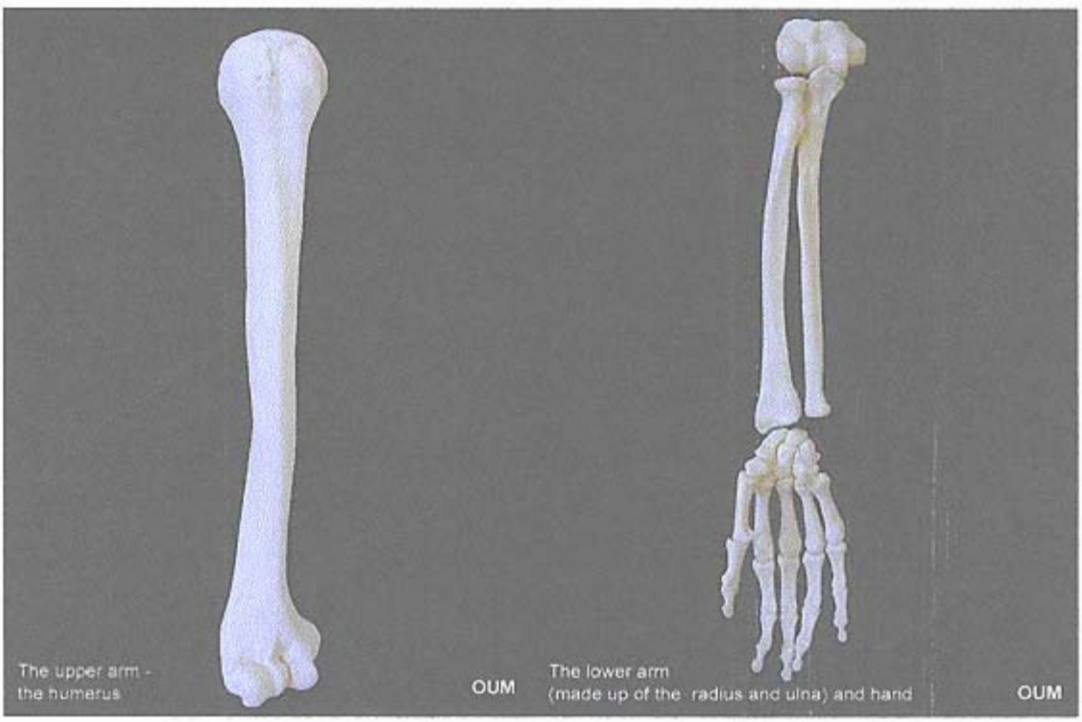

Figure 1: The upper arm bone (*Humerus*) and the lower arm bones (*radius and ulna*)

[1] Upper arm bone
[2] Larger bone for lower arm
[3] Smaller bone for lower arm

Hand is very important in our daily activities such as sweeping, mopping, writing and others. If our hand has a small loss of function can cause a difficulty in our daily activities. There are millions of people experience fracture bones within their hands. When the bone is broken, there were few symptoms and signs. For example, a visibly out-of-place or misshapen limb or joint, swelling, intense pain, bruising, numbness and tingling, bleeding, broken skin with bone protruding, limitation or unwillingness to move a limb.

We must protect our forearm from injury or fracture such as broken bone. A fracture hand required treatment from a specialized doctor, and it may require months of rehabilitation care. Healing device is needed for the treatment. Devices that may be use to hold the bone in place while it heals. The type of devices are include a cast or splint (may be used with or without surgery), a metal plate with screws (requires surgery) or screws alone (requires surgery).

A cast holds a broken bone in place as it heals. Casts also help to prevent or decrease muscle contractions, and are effective on providing immobilization, especially after surgery. Functional cast is allows limited or "controlled" movement of nearby joints. This treatment is desirable for some but not all fractures. Casts immobilize the joint above and the joint below the area that is to keep the broken bone straight and without motion.

1.1.1 Types of Arm Cast

Most fracture bones can heal successfully with fracture treatment. A cast has been applied to keep the broken bone ends in proper position when it gets well. As below is a description of the various types of casts, the location of the body fracture arm patient are applied, and their general function.

Table 1: Various types of casts

Type of Cast	**Location**	**Uses**
Short arm cast	Applied below the elbow to the hand.	Forearm or wrist fractures. Also used to hold the forearm or wrist muscles and tendons in place after surgery.
Long arm cast	Applied from the upper arm to the hand.	Upper arm, elbow, or forearm fractures. Also used to hold the arm or elbow muscles and tendons in place after surgery.
Arm cylinder cast	Applied from the upper arm to the wrist.	To hold the elbow muscles and tendons in place after a dislocation or surgery.

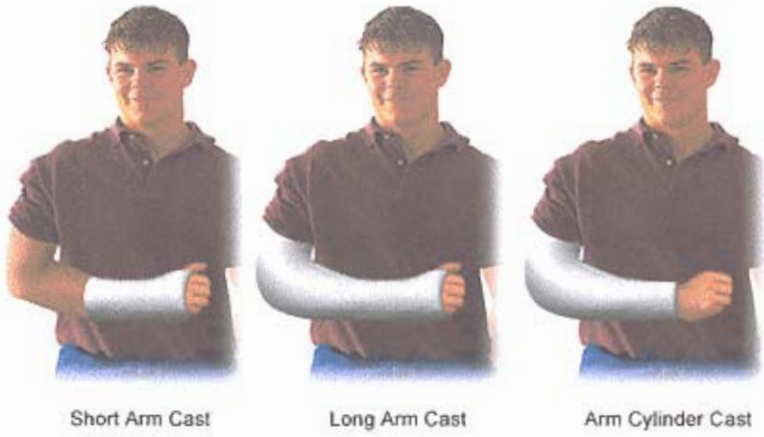

Figure 2: Image of patient with: short arm cast, long arm cast, arm cylinder cast.

1.1.2 Classification of Cast Material

Cast is able to classify into two most common types of material which is Plaster-of-Paris cast and fiberglass cast.

The outer part of cast technique which is made from plaster is only available in white color (please refer to figure 3). On the other hand, fiberglass is able comes in a variety of colors, patterns, and designs (please refer to figure 4).

Figure 3: Image of Plaster-of-Paris cast

Figure 4: Image of fiberglass cast

1.2 Definition

Researcher has study about the researches with basic understanding such as definition and terminology. Below are the definitions for researcher title "Design Research on Healing Device for Fracture Forearm".

1.2.1 Fracture

Refers to ***Oxford The Advanced Learner's Dictionary of Current English***, the keyword fracture can be defined as breaking or being broken (esp. of bone), break, crack.

According to Susan Morgan the book ***Plaster Casting***, Patient Problem and Nursing Care, a fracture is present when there is loss of continuity between none substance. Fracture also may define as "*If more pressure is put on a bone than it cannot stand, it will split or break. A break of any size is called a fracture.*"

Definiton fracture in ***Oxford Fajar Advanced Learner's English-Malay Dictionary*** is "*Pecahan; retak (tulang)*"

1.2.2 Forearm

In ***Oxford The Advanced Learner's Dictionary of Current English***, forearm means arm from the elbow to the wrist or finger-tips.

1.2.3 Heal

Refers to ***Oxford The Advanced Learner's Dictionary of Current English***, the keyword heal can be defined as two meaning. First is defined as (cause to) become healthy and sound (esp. of wound). Second is defined as restore (a person) to health; cure.

1.2.4 Device

Device may defined as something thought out, invented, or adapted, for a special purpose in ***Oxford The Advanced Learner's Dictionary of Current English***.

1.3 Problems Identification of Existing Products

The common healing devices for fracture forearm are Plaster-of-Paris and fiberglass cast. Normally, patient will feel itchy on their injuries part while wearing those existing healing devices for a long period.

Existing products are heavy and difficult to apply to forearm. Moreover, it is also less aesthetic[4] and stylish in design. For example, the plaster cast is heavy, rigid and it does not allow for swelling and reduction in the limb.

Besides that, it will stimulate bad smell after long period wearing the exiting healing device. It is because those existing device cannot exposed to high content moisture and it will breed bacteria inside. If it accidentally gets wet, the fabric and cotton padding tape able to cause skin irritation. Mildew and bacteria thrive in such an environment and creates an unpleasant odor[5]. Since the plaster cast cannot get wet, washing and process of cleaning is very difficult. Further more, skin irritants and dirt cannot be washed out so injury part will easily get smelly and itchy.

[4] The appreciation of the beautiful (in nature, art, literature)
[5] Smell

1.3.1 Design and Material

Design plays an important role in element ergonomic for new design. Suitable materials are needed in design a new device. Hence, researcher had study those problems of existing products.

These existing devices does not allow for swelling and reduction in the limb. For example, the plaster cast most often cannot be made until the swelling in the limb has gone down. If placed before the swelling is reduced, the cast will become too loose and ineffective in immobilizing the limb. If the cast is place too early and the limb is still swelling, the cast will become too tight and create pressure. When swelling occurs or continues after the cast has been placed, the cast has to be split often to relieve pressure.

According to Ronald McRae "A disadvantage of plaster splint is that they soften if they are allowed to become wet[6]." Patients are facing troubles especially when they shower because the traditional cast is cannot get wet due to material restriction. Material for those existing healing devices is heavy such as Plaster-of-Paris cast.

[6] Reference : Practical Fracture Treatment, 3rd edition

1.4 Objectives of The Study

The research objectives are:

1. To study and explore potential new material for the new healing device for fracture forearm design.
2. To facilitate easy manufacturing and usage. For example, orthopaedic doctors, medical assistants, help care assistants, physiotherapists, occupation therapists, nurses, manufacturers, patients and patients' families.
3. To design a new innovative design that will help and improve patient's lifestyle during healing process.

1.5 Scope of Study

This research takes place at:

1. Hospital Umum Sarawak,
2. Alexandra Hospital (Singapore) ,
3. General Hospital Kluang

These few places have selected as a survey areas because they are consists of Department of Orthopaedic. There have a lot of orthopaedic patients in the department. They have the experience of fracture bone. Therefore, they will give more accurate information toward those healing devices such as cast.

1.6 Hypothesis

According to Nachmias dan Nachmias (1981) in ***Research Methods in the Social Sciences***, "Hypotheses are tentative answers to research problems."

The researcher hypothesis is to introduce a new innovative design of fracture healing device in helping patients to be more convenient with their daily activities such as easy to use, washable, and light in weight.

CHAPTER 2 LITERATURE REVIEW

2.1 Literature Review

The healing process is very important for a fracture forearm patient. An immobilizing cast will help the fracture bone patient during the healing period. Richard von Volkman says that: "fracture healing period is related to the durable level of immobilizing between the fracture parts[7]."

Hugh Owen Thomas also says that: "if there a space between the fractures bone, is hard to heal the fracture bone[8]." Besides that Jonathan Cluett, M.D. mentions that "a hand fracture occurs when one of the small bones of the hand is broken. There are several small bones that together make up the supporting framework of the hand[9]."

Therefore, to help a fracture arm or forearm patient recover more faster, we need an immobilizing cast. However, referred from Practical Fracture Treatment, 3rd edition, 1994: "A disadvantage of plaster splints is that they are softening if they are allowed to become wet. There are a number of plaster substitutes now available to overcome this problem, but none as yet combine the unique properties of plaster with moderate cost."

According to Patrick S H Browne in his book Basic Facts of Fractures, 2nd edition, 1988, "The main disadvantages of treating fractures in plaster. Plasters are

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[7] Reference: The Journal of Traditional Chinese Orthopedics and Traumatology, Vol.12, No.8.
[8] Reference: Shanxi Medical Journal. Vol.29, No.2
[9] Reference: Rockwood and Greens Fractures in Adults, 3rd Edition, Volumes 1

heavy and inconvenient. Old people in particular find them difficult to manage. They tend to disintegrate and fragment, especially if wet."

However, the fiberglass cast which is also using today has some advantages over the plaster cast, but has several problem of its own, in addition to some of the same problems encountered with the plaster cast. William McKeel, which addresses these problems or disadvantage of fiberglass cast.

According William McKeel, "The fiberglass cast itself is lighter, air permeable, water resistant and more durable than the plaster cast. However, the fabric and cotton padding against the skin may become wet just as in the plaster cast. If this happens, the cast has to be removed to eliminate odors, mildew, and skin irritation just as in the plaster cast. The fiberglass cast is also rigid like the plaster cast. It does not adjust for swelling and reduction to provide a better and more comfortable fit[10]."

[10] Reference : Plaster Casting, Patient Problems and Nursing Care.

CHAPTER 3 RESEARCH METHODOLOGY

3.1 Introduction

Variety of methods can be used in conducting a research, but regardless of which methods used, the research must provide information or data that is valid and reliable through investigation, and supported by theory and hypotheses (Kerlinger, 1986).

Research data can be classified into two main categories; primary and secondary. Researching via primary data acquires first-hand information, and this method is usually expensive and time-consuming (William F. Aren, 2004).

Formal research is used when a researcher wants to collect primary data regarding an issue or problem, and it includes qualitative and quantitative research. Both quantitative and qualitative research were introduced in order for researchers to get the most reliable and valid results. Quantitative research includes method such as questionnaires and interview. Qualitative research consists of observation and also secondary data which is from literature review.

3.2 Primary Research

Primary data is the main and original researcher to study. It has two methods of study which is quantitative and qualitative.

3.2.1 Quantitative

Quantitative research is defined as attempts to contribute to scientist knowledge by measurement of elements or, research that uses statistics to describe consumers (Wells et. al. 1992). According to Gillham (2000), "Quantitative methods are those which involve counting and measuring".

"Questionnaires are research tools through which people are asked to respond to the same set of questions in a predetermined order[11]." (Gray, 2004: 187, Developing a Questionnaire). Moerover, "the questionnaire must translate the research objectives into specific question; answers to such questions will provide the data for hypothesis testing[12]." (Nachmias dan Nachmias, 1981: 209). Gillham (2000) advices that questionnaire should be limited to four to six pages, otherwise the return rate may be adversely affected. (Gray, 2004: 188-189)

According to William F. Arens (2004), there are ways to develop effective questionnaires. Questionnaires must be abort and clear and always avoid questions that suggest an answer or could be considered leading because respondents will be led to

[11] Reference : Doing Research in the Real World
[12] Reference : Research Methods in the Social Sciences

bias the results. Besides that, he also advises researchers to structure questions so that flow logically and include a few questions that cross-check earlier answer.

Researcher has considered many factors in choosing the research method. Methods that have been chosen would lead researcher accomplish the research objectives. Researcher has done quantitative research through questionnaires at hospitals. Respondents are fracture hand patients and medical professionals such as doctors, nurses, physiotherapists, and occupation therapists.

According to Gray (2004), he mentions that "method of interview is the most logical research". Cohen and Manion (1997) in his book Research Methods in Education also describe that *"temuramah*[13] *membolehkan pengkaji untuk memperoleh maklumat mengenai pengetahuan, nilai, kecenderungan dan kelakuan seseorang, mengkaji hipotesis atau mengenalpasti perubahan dan hubungan kedua-dua perkara tersebut serta ia boleh digunakan bersama teknik kajian yang lain seperti soal selidik untuk mengikuti sesuatu isu yang dikaji."*

Researcher having the interview with specialize professionals such as orthopaedic doctors and fracture forearm patients. Doctors have giving their specialized knowledge, suggestions and opinions toward the new design. Besides, patients have giving their suggestions for the new design. They also identified the problems for the existing healing devices. It helps researcher to identify those problems and improve it in new design.

[13] interview