CHAPTER I
INTRODUCTION

1.1 Background

Hip joint degeneration is a common musculoskeletal problem that happens due to aging, injury, or degenerative diseases. This leads to structural damage and increases the demand for surgical treatment such as hip joint replacement, like Total Hip Arthroplasty (THA), which involves replacing the damaged part with an implant [1].

Nowadays, THA is shifting toward Minimally Invasive Surgery (MIS) to improve patient outcomes and speed up the recovery process [2]. One of the techniques is the Direct Anterior Approach (DAA), which uses the natural intermuscular pathway, allowing surgeons to access the hip joint with minimal muscle disruption [3] [4].

In order to obtain adequate exposure of the hip joint, the patient's leg must be positioned in specific orientations such as hyperextension, abduction, and external rotation [5]**.** This procedure commonly requires the use of a traction table**,** a specialized surgical table designed to apply mechanical traction to the patient's leg.

However, the use of a traction table and the manipulation of limb positions during surgery may introduce biomechanical effects on the femur and surrounding structures. Excessive traction force or improper limb positioning can lead to high stress concentrations on the pelvic bone or femur**.** If the stress exceeds the mechanical strength of the bone, it may result intraoperative fractures**,** which are fractures that occur during the surgical procedure [2].

Although the DAA technique is increasingly used in modern orthopedic surgery, studies that quantitatively analyze the effect of traction forces on stress distribution in the femur during the surgical procedure remain limited. Most existing studies focus primarily on postoperative clinical outcomes or general complication rates, while biomechanical investigations that examine the mechanical response of the femur under traction forces during surgery are still relatively scarce [6] [7] [8].

Therefore, an engineering-based analysis is required to better understand how mechanical loads influence stress distribution in the femur during the surgical procedure. One approach that can be used is Finite Element Analysis (FEA), a numerical method that enables the simulation of mechanical behavior of structures under specific loading conditions. By modeling the femur and applying loading conditions that represent traction forces and limb positioning during surgery, FEA can provide insights into stress distribution patterns and identify potential regions of stress concentration.

1.2 Problem Statement

In the DAA for THA, complex loading conditions exist due to traction forces and extreme lower limb positions that might raise the risk of stress concentration and intraoperative fractures. However, there remains a lack of quantitative knowledge concerning these effects on stress distribution in the femur and hip joint, and most studies are clinical rather than biomechanical. Therefore, a finite element–based analysis is needed to evaluate these effects and provide a scientific basis for safer surgical practice.

1.3 Research Objectives

The aim of this study is to know the stress distribution patterns in the femur resulting from the traction forces and lower limb positioning applied by the traction table.

1.4 Research Benefits

The results of this study can be used as a guideline for orthopaedic surgeons in determining safe operating limits of traction force and lower limb positioning angles during surgery, thereby improving patient safety by reducing the risk of intraoperative complications, particularly mechanical failure or fractures during the procedure.

1.5 Problem Scope

To ensure a focused and manageable analysis, this study is conducted within a defined scope and is subject to several limitations and assumptions:

1. The geometric model restricted to the lower skeletal anatomy. Only the sacrum, pelvis, femur, and cartilage bone of the right side of the hip joint are modelled, excluding all muscles and ligaments.
2. The analysis focuses on the limb positioning and traction phase, excluding bone cutting procedures (osteotomy) and implant insertion processes.

1.6 Writing Systematics

The structure of this research is organized into several chapters to ensure a clear and systematic presentation of the study. Chapter I presents the background of the study, problem statement, research objectives, research benefits, scope and limitations, and the overall structure of the final project. This chapter provides the fundamental context and justification for conducting the research. Chapter II presents the fundamental theories used in this research, obtained from relevant scientific literature. These theoretical foundations support the analysis conducted in this study. Chapter III describes in detail the research procedures and methods used in this study, including geometric modeling, finite element modeling, boundary condition setup, and simulation processes. Chapter IV presents the data collected from the simulation followed by the analysis and discussion of the results. Lastly, Chapter V summarizes the main findings of the study and the suggestions for further research of the relevant topic.

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