

An Investigation on the Strain on a 4-bar Linkage Transfemoral Prosthesis during the Gait Cycle

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Abstract

The ideal configuration for artificial knee prosthesis (AKP) is movement flexibility, comfort, usefulness, and leg ease. The goal of this research is to look at the stress distribution of a prototype of four-bar linkage mechanical joints, with an emphasis on the shaft buffer, which is similar to the knee joint. The knee joint reaction to dynamic loads when a transfemoral prosthesis is driven for one cycle of motion (cycle gait cycle) is studied using a finite element approach based on commercial software Solidworks®. In order to perform the tasks of the AKP, it is necessary to acquire technical information on the position and profile of von Misses stress of the knee joint for each position. The highest value of von Misses stress is found at the angle of 14.57° in the phase of mid stance single support, while the smallest value is found at the angles of 0° at the phase of first contact and 30° at the phase of terminal stance, according to the analysis.

Keywords: *Prosthetic Arm, Biomechanics, Gait Cycle, AKP Joint Mechanism*

INTRODUCTION

Biomechanics is a scientific approach to mechanics that studies the movement of living beings. Mechanics is the field of physics that examines movement and how force affects it. Biomechanics explains

how living things move using diverse ideas and mathematical calculations. The most essential aspect of the prosthetic's running movement is balancing the amputee's body weight. Load balancing is

possible using prosthetics. A typical human is moving, demonstrating how the second leg balances each weight displacement body in motion. The body weight caused by the effects of the Earth's gravitational pull will create an upward response force while walking and feet hit the floor. The prosthesis and force transfer on the other foot is regarded to be good in amputees if the prosthetic stepping is typical during the running process, which does not happen with healthy feet.

Walking clones are walking aids for those who have had their legs amputated due to disease or congenital limitations. Artificial knee joints are good in the case of amputation above the knee movement mechanism is required artificial knee joints are good in the case of amputation above the knee movement mechanism is required artificial knee joints are good in the case of amputation above the knee movement mechanism is required users feel comfortable when using it In addition, when worn for walking, foot imitation items should be able to sustain the body's weight.

Imported products continue to dominate the market for product imitation leg above the knee or above the knee prosthesis (AKP), which has a performance-based

clone knee joint mechanical has a high setting flexibility. The traditional joint system is still the focus of AKP's domestic product.

METHODOLOGY

The current study is divided into two parts: first, the modelling method, and second, the stress analysis. SolidWorks® is used in every one of them. The design of the knee prosthesis is the initial step (AKP). A four-bar connection is utilised in the AKP joint mechanism. The stress analysis of 3D models using the finite element method is conducted in the second step to identify the stress distribution. The key observations made to the buffer rod in this design are that it is comparable to a knee and that it will accept the human body's load.

The flow chart of the present work is shown in Figure 1. The first phase of the design of the product showed that the dimensions have been established based on the measurements of the dimensions of the AKP products sold in the market and Figure 1 depicts the flow chart for the current project.

The dimensions of the product were developed in the initial phase of the design process based on measurements of the

dimensions of AKP goods offered on the market and observations of AKP patients. The AKP's joints are designed in 3D using

the biomechanics of the human knee joint. Figure 2 depicts the design model that was created.

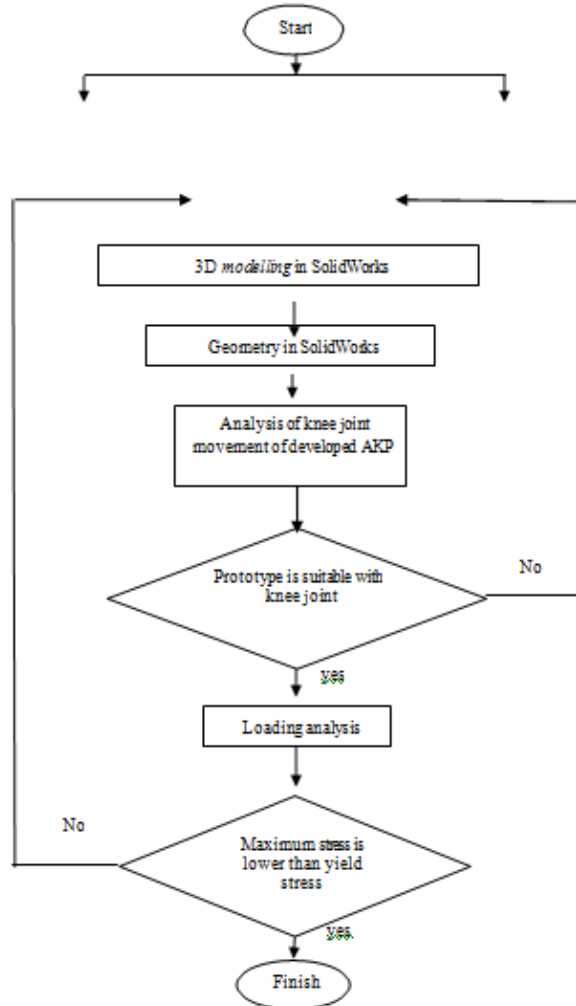


Figure 1: Flow chart of the present research

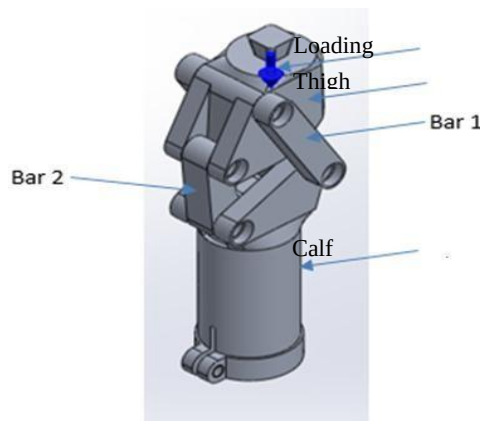


Figure 2: The developed design of above knee prosthetic (AKP)

The designed AKP is made out of 6061 T6 aluminium alloy. The yield strength is 276 MPa, with a modulus of elasticity of 68.9 GPa, a Poisson's ratio of 0.33, and a modulus of elasticity of 68.9 GPa. The AKP model is estimated to receive a maximum load of 1,000 N. After that, the meshing procedure for the 3D model is carried out as shown in Figure 3. The load was simulated using a 3D model while the knee moved from 0° - 15° , 15° - 0° , and 0° - 30° . During the first phase of contact, loading response, and midstance, the positions are created. The body weight will be accepted by the buffer rod throughout these periods.

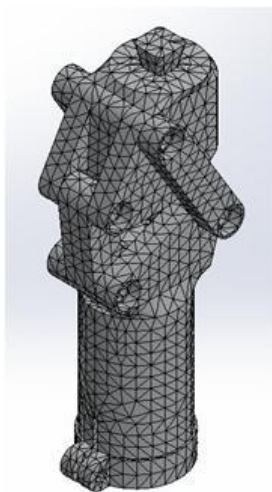


Figure 3: The meshed model of developed AKP

RESULTS AND DISCUSSION

The loading response, which is the first period of the stance phase, begins with

phase initial touch (Figure 4). The formed knee flexion angle is 0° . Figure 5 shows the loading response, which provides twofold support between the first contact period and the mid-stance phase. Face loading occurs when a proportion of time of around 7% of the gait cycle is reached. In form, the knee flexion angle is 150 degrees. During this phase, the weight is transmitted to the foot during stance (right foot dark colour) and landing (left foot, bright colors). As illustrated The loading response, which is the first period of the stance phase, begins with phase initial touch (Figure 4). The formed knee flexion angle is 0° . Figure 5 shows the loading response, which provides twofold support between the first contact period and the mid-stance phase. Face loading occurs when a proportion of time of around 7% of the gait cycle is reached. In form, the knee flexion angle is 150 degrees. During this phase, the weight is transmitted to the foot during stance (right foot dark colour) and landing (left foot, bright colors). As illustrated in Figure 6, the knee flexion angle creates an angle of 0° . For the posture of the right and left foot opposite the initial contact, phase terminal stance (Figure 7) is referred to as the inverse of initial contact. The terminal stance phase occurs during the 60th percentile of the gait cycle. The weight of the body is

transmitted to the rest of the front foot's bottom, as seen in Figure 7. (toe). The von Mises stress arises in the trunk buffer

during a movement from the corner of 0^0 - 15^0 , 15^0 - 0^0 , and 0^0 - 30^0 illustrated in Figure 8, according to the simulation.



Figure 4: Foot movement at the phase of the initial contact



Figure 5: Foot movement at the phase of loading



Figure 6: Foot movement at the phase of mid-stance



Figure 7: Foot movement at the phase of terminal stance

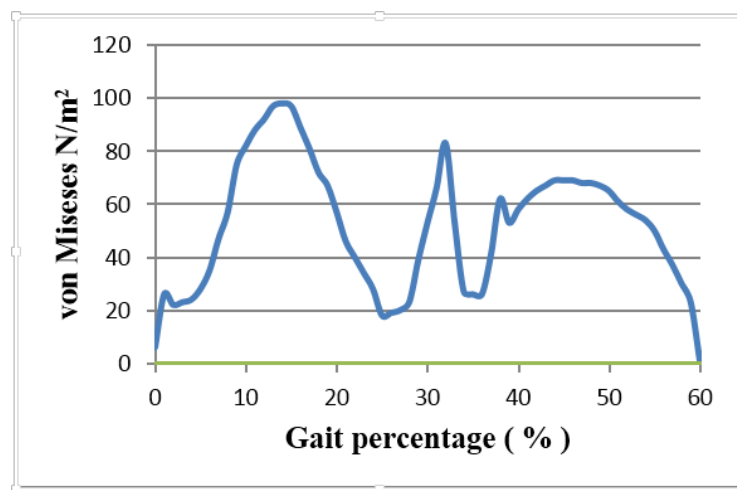


Figure 8: Loading for 0-60% fase gait cycle

CONCLUSION

The artificial knee prosthesis (AKP) produced in this study were evaluated using the finite element method during the first phase of the gait cycle. The developed AKP was proven to be safe based on stress analysis since the maximum stress is lower than the yield stress.

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