A Review of Different Designed Hip Joint under Normal Contact Pressure

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Abstract– *The hip joint is unique anatomically and physiologically, so a lot of problems may appear through its structure lead to damage. In order to analyze the Hip joint it is very important to analyses the different Stress, Strain and deformation on the joint. In this paper reconsider, a 2D/3D model of the hip joint and its implementation of software platform, various different designed hip joints like Hip Joint Angular Acceleration, Hip Joint Prostheses Using Finite Element Method, Non-Spherical Hip Joint and Hip Prosthesis Based on Different Common Materials under normal contact pressure are mainly reviewed.*

Keywords— *Hip joints, Contact normal Pressure, Hip prosthesis, FEM.*

I. INTRODUCTION

In 2000, the market for medical devices including implantable prostheses worldwide was over 300 billion dollars, which take approximately 8% of the global health care Outgoing, which serves to reach more than 20 million patients [21].

Hip Replacement (THR) is a procedure that is performed surgically, and these procedures can be performed as a total replacement or a Hemi Replacement (replacing half of the hip joint) (THR). The hip joint compared to other joints in the body is the most stable joint, but bodyweight may also lead to developing arthritis because of the extra pressure [13]. All medical components such as orthopedic implants and fractures which has no exception against failure, also the most design problems to prevent failures in these cases are complicated because it expected to operate for a long time, so the responsibility lies on the designer, because of relative values of pressures and high strains, that may occur from the components, also from the complex responses of the human body.

The hip joint is one of the human important components that support the body which connects the femur with the pelvis. The hip joint frequently is subjected to high daily pressure from upper body weight. It is known that the hip joint can withstands up to 4 times of human body weight [1]. With increasing age, these pressures can reduce and endanger its function. Osteoarthritis is one of the most common deteriorations in hip function where a condition may cause severe pain due to joint stiffness. For treating this pain, the hip prosthesis has been proposed for an artificial component designed to perform the same function as a natural pelvic joint and which could be implanted surgically. This surgical operation is referred to as Total Hip Arthroplasty. Materials that have been widely used for hip joint prosthesis can be divided into several coupling materials, namely metal to metal, ceramic to ceramic, polymer to ceramic, and metal to polymer on artificial femoral heads and ace tabular inserts. Here the main limitation of the life of artificial hip joints is influenced by tribological aspects.

The ball and socket joint (or spheroidal joint) is a type of synovial joint in which the ball-shaped surface of one rounded bone fits into the cup-like depression of another bone. The distal bone is capable of motion around an indefinite number of axes, which have one common center.

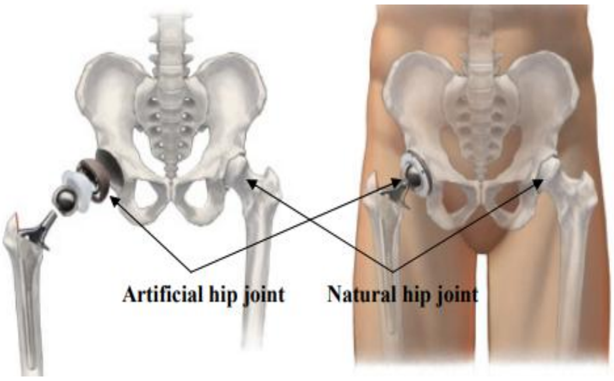

Figure 1.1 Artificial and Natural hip joint

The numerical study using finite element analysis can be used to analyze the hip joint prosthesis stress. ASTM F2996-13 is one of the references to do the analysis. The ASTM F2996-13 is refer to ISO 7206-4 for the hip joint geometry limitation [16]. This analysis can be solved using ANSYS Static Structural software which is already done by the previous studies for the different cross-sectional areas of the hip prosthesis [16]. In this study, the designs of the hip joint prosthesis from different manufacturers were compared for their mass, stress, and safety factor. There are three different designed products from different manufacturers used for static structural approach in ANSYS, which are UNDIP, A, and V hip joint prosthesis. The ASTM F2996-13 is selected for the reference to this study with Stainless steel AISI 316L and Titanium alloy Ti6Al4V materials variation.

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The rest of paper is organized as follows: In section II we review the work related Hip joint design. In section III we describe the finding of the study. IV conclude this paper.

II. LITERATURE SURVEY

In recent years, due to unhealthy habit, life styles and other reasons there has been a need for devices/medical support equipments that assist the elderly with and encourage independent walking.The hip joint is a ball and socket synovial joint, formed by an articulation between the pelvic acetabulum and the head of the femur. It forms a connection from the lower limb to the pelvic girdle, and thus is designed for stability and weight-bearing – rather than a large range of movement. Many researchers have work on different design of hip joint. here reviewed the different design of hip joint.

In this work [14] software modelling design and analysis of artificial hip joint to highlight and study the characteristics of the biomaterials that commonly used to design a hip joint based on the stress, strain, and displacement distribution. In this work, the behaviour of (Ti-6-Al4V, Al2O3, and Cr-Co-Mo alloys) have been studied based on the stress, strain, and displacement and the results appeared that the use of Al2O3 as a material of femoral head that presents higher stress values compared to use Cr-Co-Mo alloy. However, in the case of strain and displacement Al2O3 appears results to better than Cr-Co-Mo alloy. Overall, the final results that conducted through this study and analysis of the artificial hip joint model were acceptable compared to the known followed standards in the hip joint design process.

This work [15] proposed designs of a 2-DOFs and 3-DOFs hip joint designs for an exoskeleton robot. Together with benchmarking of 1-DOF hip joint designs for exoskeleton robots that are freely downloadable online. These designs were tested based on the human lower-limb motion of hipabduction and adduction, hip flexion and extension,and circumduction. The alpha and beta designsdownloaded online were studied by subjecting them tostress conditions. Both existing designs models with the 1-DOF hip joint showed flaws in terms of fullfunctionality and comfort, as they failed to provide vitaldegrees of freedom vital in simple gait [15]. Thedesigns were not adaptive to human walking patternsand lacked the comfort that all volunteer users hopedfor. Thus, this qualifies these designs as non-eligible.

The main objective of this work [16] is to compare stress analysis results of the previously produced UNDIP hip joint prosthesis with those of the other hip joint prosthesis from the different manufacturers using the computational finite element method (ANSYS Static Structural software). The computational analysis refers to ISO 7206-4 and ASTM F2996-13 to calculate the stress and safety factor from the products. The materials used in the simulation were Stainless Steel AISI 316L and Titanium Alloy Ti6Al4V. The results of this work is showing that the lightest was obtained for the UNDIP prosthesis, followed by A and V prosthesis respectively. For 316L material, the only safe hip joint prosthesis could be A product, which was the only prosthesis with safety factor more than 1. Conversely, for Ti6Al4 material, the UNDIP product might be the best hip prosthesis because of its lightweight with the acceptable safety factor.

In this study [17], author proposed a method to determine the assist timing for wire type assist suit. In this method, since the assist timing is determined based on the hip joint angular acceleration by the IMU sensor, the assist can be performed at the optimal timing for each user. As a result of the experiment that in some trials, the maximum hip extension torque were reduced compared to normal walking can be observed. That is the effectiveness of this method can be expected. [17]

The main purpose of this study [18] was to verify a hypothesis that only the magnitude of sensory noise and stiffness can reproducibly determine trends in the hip or ankle movement strategies. Simulations of postural control of a musculoskeletal model for three noise conditions and three stiffness conditions were performed. Variations in the angles of the hip and ankle suggested that the sensory noise amplitude had no influence on the selection. However, the ankle strategy tended to be selected with the increase of stiffness. Strategy shifts of elderly may be derived from other components; muscle weakness, increase of neurological time delay, or learning based on other evaluation index.

Author [19] found the temporal mean of virtual interference to be significantly different in almost every region between the hip conditions. The significance was most distinct when using the static spherical method of COR. These results are promising to individual clinical assessments of hip pathologies using static radiographs and ultimately work towards preventing premature hip disease.

This work [20] reports the estimation of hip joint visco elasticity during voluntary force control using a novel device that applies leg displacement without constraining the hip joint. The influence of hip angle, applied limb force and perturbation direction on the stiffness and viscosity values was studied in ten subjects. No difference was detected in the hip joint stiffness between the dominant and non-dominant legs, but a small dependency was observed on the perturbation direction. Both hip stiffness and viscosity increased monotonically with the applied force magnitude, with posture being observed to have a slight influence. These results are in line with previous measurements carried out on upper limbs, and can be used as a baseline for lower limb movement simulation and further aeromechanical investigations.

III. FINDINGS OF THE SURVEY

In this study review the various hip joint designs in brief. Also explore the software modeling design and analysis of artificial hip joint to highlight and study the characteristics of the biomaterials that commonly used to design a hip joint based on the stress, strain, and displacement distribution. Hip joint design for exoskeleton robot is also reviewed. In this study reports the estimation of hip joint visco elasticity during voluntary force control using a novel device that applies leg displacement without constraining the hip joint. This study helps the researchers to design the hip joint for the betterment of the user.

IV. CONCLUSION

This paper surveyed the hip jointdesign in brief and various designs its software modeling and techniques used in this design and material used in this design are discussed. In this study find the best hip joint design in various aspects. The finding of the study explores the different hip joint design, material and characteristics of materials. This is useful for the researchers to design and useful hip joint design and other medical equipment which is helpful for the human beings .

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