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# A review of hip joint design and its sustainability

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**ABSTRACT**: In order to analyzed the Hip joint it is very important to analyses the different Stress, Strain and deformation on the joint. Here in this work the following previous work can be studied and summarized. Various analysis was done on the hip joint at different frequency during the normal load condition and calculating the Stress on the joint. Three-Dimensional ball and socket hip Joint under normal contact pressure and different frequencies are observed and results are seen through various previous research.
**KEYWORDS:**

## I. INTRODUCTION

A joint or articulation (or articular surface) is a connection made between the bones in the body that connects the skeletal system into a whole. They are designed to allow for varying degrees and types of movement. Some joints, such as the knee, elbow, and shoulder, flex themselves, almost do not trip, and are able to withstand pressure and keep heavy loads while performing smooth and precise movements. Some joints such as stitches between the skull bones allow small movements (only at birth) to protect the brain and nerve organs. The contact between the tooth and the jaw is also called the joint, and is defined as a fibrous joint known as gomphosis. Members are divided into structural and operational.

### 1.1 Hip Joint

- Diarthrodial joint with its inherent stability dictated primarily by its osseous components/articulations.
- Primary function of the hip joint is to provide dynamic support the weight of the body/trunk while facilitating force and load transmission from the axial skeleton to the lower extremities, allowing mobility.
- Typically works in a closed kinematic chain.

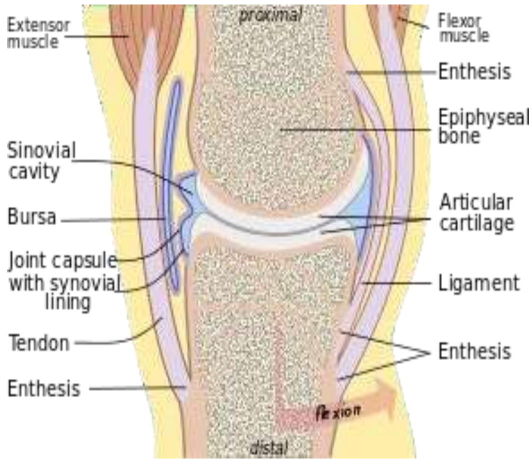


Diagram of Typical Synovial Joint (Anatomical Terminology)

### 1.2 Motion Available

The hip joint connects the lower extremities with the axial skeleton. The hip joint allows for movement in three major axes, all of which are perpendicular to one another.

- The location of the center of the entire axis is at the femoral head.
- The transverse axis permits flexion and extension movement.
- The longitudinal axis, or vertically along the thigh, allows for internal and external rotation.
- The sagittal axis, or forward to backward, allows for abduction and adduction.

In addition to movement, the hip joint facilitates weight-bearing. Hip stability arises from several factors.

1. Shape of the acetabulum - Due to the depth of the acetabulum, it can encompass almost the entire head of the femur.
2. Acetabular labrum (fiibrocartilaginous collar surrounding the acetabulum) which provides the following functions:

- Load transmission

- Negative pressure maintenance (i.e., the "vacuum seal") to enhance hip joint stability
- Regulation of synovial fluid hydrodynamic properties

**1.3 Ligaments and Joint Capsule**

In general, the hip joint capsule is tight in extension and more relaxed in flexion.
The capsular ligaments include

- Iliofemoral ligament (also known as the Y ligament of Bigelow) is the strongest ligament in the body; it lies on the anterior aspect of the hip joint - it prevents hyperextension,
- Pubofemoral lies anteroinferiorly - it prevents excess abduction and extension
- Ischiofemoral ligaments - is the weakest of the three ligaments and consists of a triangular band of fibres that form the posterior hip joint capsule. It attaches to the ischium to behind the acetabulum and it attaches to the base of the greater trochanter - it prevents excess extension

**1.4 The ligamentum teres**

Located intracapsular and attaches the apex of the cotyloid notch to the fovea of the femoral head.

- Serves as a carrier for the foveal artery (posterior division of the obturator artery), which supplies the femoral head in the infant/pediatric population (vascular contribution to the femoral head blood supply is negligible in adults).
- Injuries to the ligamentum teres can occur in dislocations, which can cause lesions of the foveal artery, resulting in osteonecrosis of the femoral head.

**1.5 Joint Capsules**

- The hip joint is extremely strong, due to its reinforcement by strong ligaments and musculature, providing a relatively stable joint. Unlike the weak articular capsule of the shoulder, the hip joint capsule is a substantial contributor to joint stability. The capsule is thicker anterosuperiorly where the predominant stresses of weight bearing occur, and is thinner posteroinferiorly.

The general score of road drainage system is dependent on its “weakest link”. This means that if any of its elements is out of order, the whole system will not operate as planned and the road willbe damaged. On the other hand a well built and maintained road drainage system is a very sustainable investment policy. The main advantages of a good drainage system are: effective removal of rainwater out of the road surface and its surroundings, road structures that stay dry, good bearing capacity, and a road that is nice and safe to drive.

## II. LITERATURE SURVEY

In 2020 Study of Contact Pressures in Total Hip Replacement; Myron Czerniec et al. Author develop method of hip joint endoprosthesis contact parameters, the impact on maximum contact pressure and the angle of contact of the joint load was estimated depending on the diameter of the endoprosthesis and radial clearance. The correctness of changing the values of maximum contact pressure from the mentioned parameters was determined. Correspondingly: an increase in joint load causes a linear increase in the maximum contact pressure; increasing the diameter of the endoprosthesis head - their non-linear decrease, and increasing radial clearance - their increase.

In 2019 Motion Capture based Dynamic Assessment of Hip Joint Cartilage Contact Pressure during Daily Activities; Xianqiang Liu et al. The objective of this paper is to assess the contact pressure changes during series of dynamic postures such as slow walking, normal walking, fast walking, descending stairs and ascending stairs. A standard anatomical model is built from CT images and twenty kinematical models are constructed using a motion capture system.

In 2018 Stress Analysis of Hip and Knee Prostheses Using a Novel Biomaterial PTFE Glass Composite; Shankar Das et al. In this paper author investigates the stress analysis and contact behavior of MoP hip and knee prostheses using a novel biomaterial called Poly-tetra Fluoroethylene with 25 % glass composite coded as PTFE-25 for the acetabular and tibial liners by using ANSYS.16 software under various loads. The analysis revealed that the von-mises equivalent stress, and contact pressures for both the prostheses are highest in case of PTFE-25 as compared to that of the Ultra-high Molecular Weight Polyethylene (UHMWPE) articulating againest the Co-Cr components.

In 2017 Three-dimensional finite analysis of acetabular contact pressure and contact area during normal walking; GuangyeWang et al. Computed tomography (CT) scanning technology and a computer image processing system were used to establish the 3D-FEM. The acetabular mortar model was used to simulate the pressures during 32 consecutive normal walking phases and the contact areas at different phases were calculated.

In 2016 advance in science and technology research journal Robert Karpinski et al. proposed that the results of a preliminary study on the structural analysis of the hip joint, taking into account changes in the mechanical properties of the articular cartilage of the joint. Studies have been made due to the need to determine the tension distribution occurring in the cartilage of the human hip. These distribution are the starting point for designing custom made human hip prosthesis. Basic anatomy, biomechanical analysis of the hip joint and articular cartilage are introduced. The mechanical analysis of the hip joint model is conducted. Final results of analysis are presented. Main conclusions of the studyare: the capability of absorbing loads by articular cartilage of the hip joint is preliminary determined as decreasing with increasing degenerations of the cartilage and with age of a patient. Without further information on changes of cartilage's mechanical parameters in time it is hard to determine the nature of relation between mentioned capability and these parameters.

The capability of absorbing loads by articular cartilage of the hip joint is preliminary determined as decreasing with increasing degenerations of the cartilage and with age of a patient. Without further information on changes of cartilage's mechanical parameters in time it is hard to determine the nature of relation between mentioned capability and these parameters. Given the way of obtaining results, method presented in the paper may provide additional information's about a condition of the hip joint, especiallywhether the progress of chondromalacia, without performing surgical procedures, which can be crucial for elder patients.

In 2016 Tribology International Ehsan Askari et al. proposed that the occurrenceof audible squeaking in some patients with ceramic-on-ceramic (COC) hip prostheses is a cause for concern. Great effort has been dedicated to understand the mechanics of the hip squeaking to gain a deeper insight into factors contributing to sound emission from COC hip articulation. Disruption of fluid-film lubrication and friction were reported as the main potential cause, while patient and surgical factors, and design and material of hip implants, were also identified as leading factors.

This article summarizes the recent available literature on this subject to provide a platform for future research and development. Moreover, high wear rates and ceramic liner fractureas viable consequences of hip squeaking are discussed.

As already discussed, hip crying does not occur when there is a liquid film coating due to non-contact between the speaking areas. However, the liquid film is disturbed by an increase in local stiffness, metallic debris between exposed areas, alterations of synovial fluid material and / or abnormal behavior in artificial hip joints such as edge loading and minimal separation. The fluid-film lubrication regime is converted into mixed lubrication or border lubrication. Therefore, the friction coefficient is usually increased, which can lead to hip flexion. Slight separation, rim-neck insertion and loading edge abnormal movement behavior in THA that prevents the bearing from producing liquid film coating. In these cases, there are adverse conditions for lubrication and severe contact stress due to the low alignment of the bearing surfaces. In the absence of liquid film coating, the bearing areas are smoother and more resistant to friction, which acts as resistance to related movements. Friction can cause vibration in hip expression due to structural instability such as negative-sloping friction, stick-slip, contact power changes, mode-coupling, and material inaccuracies. In addition, vibration-induced vibrations can significantly increase wear rates in THA. Therefore, hip squeaking may be associated with higher levels of wearable hips compared to quiet hips. High levels of aging may lead to a reduction in ceramic liner fractures, but it requires further investigation to evaluate the possible effect of hip flexion. There is no further information about the effects of hip strain.

In 2015 Mohammad Rabbani et al. proposed that the stress distribution of the entire assembly of the femur and hip prosthesis be investigated for boundary conditions under nine system functions using limited material analysis. For each task, different strengths of different sizes and directions were applied to the prosthesis during the period of testing the key points developed throughout the 3D model. This includes the full definition of geometry, material structures and boundary conditions. Contemplated activities include slow walking, regular walking, fast walking, climbing, descending stairs, standing, sitting, and standing on legs 2-1-2 and bending knees. The findings of this study can be used to improve hip joint a prosthesis by changing the artificial geometry to achieve a balanced stress distribution.

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The purpose of this study was to investigate the biomechanical influence of a different type of load on the distribution of stress through hip implants. Sensitive areas were identified and discussed. The effect of speed and the contribution of torsional load on various life activities is explained. These loading conditions have more influence than artificial geometry or type of top cover. In this study FEA was chosen, as it is the most approved method. Research data can be linked to the application of Frost's law on bone resorption to predict bone growth in different areas.

2016 IJRASET Tushar V Kavatkar et al. has proposed that Total hip replacement (THR) is one of the most effective programs for using biomaterials in the medical industry. In THR, a round head attached to a woman's trunk speaks against a round cup / line attached to the pelvic bone. The tribological function of the hip joints performed is a critical issue for their success, because improper tissue reactions to the wear of the hip causes loosening and failure. Wearing of the joints of the hip joint prostheses is a major problem causing their primary failure. More research on the wearing of hip prostheses has been published over the past 10 years. Theater / price models were suggested to investigate geometric and material parameters. This detailed study of hip joint wear analysis was performed to highlight the anatomy of the hip joint, aging and implantation such as the stiffness and stiffness of the soft hip joint. It aims to gain a deeper understanding of the aging of couples carrying the hip joint due to various contact pressures under the load of body movement. Tribal behavior of hip implants is a major issue for improving the integrity of these elements, wearing them as one of the main causes of their limited service life. Weapons analysis of the hip joint prosthesis has been analyzed in this study using three dimensional movements, gait loads and a moderate feature model and the impact of various contact stress and pressure distribution on the bearing area of the hip joints. The Wear model is used to investigate the impact of geometric parameters and material on wear trends in physical conditions. Due to the gait movement, the thickness and location of the high contact pressure on the bearing parts also change the travel conditions. With the loading of geometry and gait movement, line wear and volume in the cup area increases with the flow cycle rate.

In 2105 In this study a detailed study of the analysis of the fully defined factor of contact and tight wear on the hard hip joint prosthesis under the load of 3D physiological gait in walking cycles has been performed. Compared to ceramic-on-ceramic and metal-on-metal, the couple carrying PCD-on-PCD has significantly lower aging depending on the accumulated aging of the line and volume. As the wear on the contact between the cup and the head changes continuously. To date the amount of coefficient of regular wear is used by pregnant couples to match. Therefore different amounts of wear coefficients can be used to mimic future work. The current wear model was based on abrasion-adhesion wear. To accurately measure the aging of solid stamps, other dress codes, such as those caused by local fatigue and tribo rust, need to be integrated into the future. Acceptable hip loading is based on circulatory cycles, but abnormal in-vivo loading from multiple functions may intensify the pressures that may result in increasing aging. Current wear simulations are limited to 2 × 106 cycles (equivalent to 2 years of insertion) which may not be sufficient to show the flexibility of the actual wear. As widely reported, THRs in the human body are generally expected to live 15-20 years or more. It is therefore important to study and evaluate the long-term progression of aging, which will enable us to predict the actual behaviors associated with THR aging.

In 2014 C. Desai et al. has suggested that the hip joint is one of the largest structures that carry weight in the human body. In the event of a failure of the natural hip joint, it is replaced by a hip joint prosthesis, known as the hip joint prosthesis. The design of the hip joint prosthesis should be as resistant to fatigue of the hip joint and bone cement, and reduce the aging caused by the slide that exists between its head and socket. In the present paper an attempt is made to consider both fatigue and the effects of simultaneous wear on moderate performance- the health of the hip joint prosthesis. A specific feature of hip joint prosthesis modeling using Hyper MeshTM (version 9) has been reported. Static analysis (load due to dead body weight) and dynamic analysis (load due to walking cycle) are defined. Fatigue health is measured using the S-N curve for individual objects. The narrative of continuous wear of the hip joint prosthesis, Archard dress code, socket geometry modification and flexible analysis were used in sequence. Such use subsequent reductions in systemic stress have been observed with an increase in wear. Ultimately life is measured on the basis of wearing a socket.

In the present study, fatigue and dysfunction of the hip joint prosthesis were considered. The hip joint prosthesis has been found to be safe in the case of a fixed human weight load.

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When a flexible analysis was performed, chronic fatigue health of the hip joint prosthesis was observed. In the analysis, stress on the bone marrow is ignored. The highest pressures are observed at a point where the thickness is less than 1 mm. Using Archad law, a wear depth of 0.138 mm / year has been estimated. The analysis of joint fatigue and wear showed a reduction in stress in the hip joint prosthesis. The pressure is reduced due to the increase in the contact area on the socket, and the load is evenly distributed throughout the contact area. But reliable modeling is needed to ensure these results. In this current study a 2 mm socket is considered essential and based on this limited hip joint prosthesis will be 14.5 years. This analysis can be extended, taking into account changes in the shape of the hip stem in the femur. The occurrence of creep is ignored in all analyzes that may be important in the early stages.

In 2013 Eko Saputra et al. proposed a range of arterial hip joint movements during human activities, measured by the total patients of postoperative hip arthroplasty, previously reported. Two human activities were discussed, namely the Western style and the Japanese style. This paper analyzes hip joint movements during human activities, based on a limited range of motion, using the imitation of a limited feature. Western-style activities include picking, standing and sitting, while Japanese-style activities include sitting with the legs fully bent at the knees (seiza), stabbing and

The purpose of this study was to investigate the possibility of prothetic insertion and to calculate von Mises pressure during operations. The 3-dimensional nonlinear finite element (FE) method was used in the simulation. The positions of the acetabular liner cup were different. The results show that in Western-style activities, pick-up work creates implants in a specific area of the acetabular liner, while in Japanese-style operations no visual implants are detected. However, the Japanese work of Zarei has a significant value in the movement list. Von Mises' emphasis on artificial insemination has been shown and the value is higher than the material yield stress. The paper investigated the scope of the Western and Japanese-style human activities movement is used to analyze limited objects in a THA patient. A combined unipolar artificial hip model was used in the simulation. Based on the results, it can be said that many Western-style and Japanese-style activities can be safely performed by THA patients. Installation and relocation is predicted to occur when picking up a Western trend style function and a combination of ante version of a 45-15 degree acetabular liner. Seiza work in Japanese style work is not recommended for THA patients because the internal circulation safety margin is less than 10 degrees. The insertion between woman's neck and cup of acetabular liner during contact can be predicted by imitation of a limited feature. It is shown that von Mises pressure in the input area is higher the yield factor.

## III. CONCLUSION

The above survey gives an idea of recently development in the design of hip joint and its sustainability. Various model and there analysis are proposed and developed at different frequency during the normal load condition and Stress generated on the joint during movement.

## REFERENCES

1. Binglang Xiong, Peng Yang, Tianye Lin, Jinli Xu, Yong Xie; Changes in hip Joint Contact Stress During a Gait Cycle based on the Individualized Modeling Framework of"Gait-Musculoskeletal System-Finite Element"October 28th, 2021
2. Myron Czerniec , Jarosław Zubrzycki; Study of Contact Pressures in Total Hip Replacement. Posted: 14 August 2020
3. Xianqiang Liu, Xiaoyan Zhang, Sheng-hua Zhong; Motion Capture based Dynamic Assessment of Hip Joint Cartilage Contact Pressure during Daily Activities 29 May 2019
4. Prasun Chakraborti, Shankar S Das; Stress Analysis of Hip and Knee Prostheses Using a Novel Biomaterial PTFE Glass Composite 29 December 2018
5. GuangyeWang, WenjunHuang, Qi Song; Three-dimensional finite analysis of acetabular contact pressure and contact area during normal walking Volume 40, Issue 6, November 2017
6. Robert Karpinski, Lukasz Jaworski, Jaroslaw Zubrzycki, “Structural Analysis of Articular Cartilage of The Hip Joint Using Finite Element Method”, Advances in Science and Technology Research Journal 2016.
7. Ehsan Askari, Paulo Flores, “A review of squeaking in ceramic total hip prostheses”, Tribology International 2016.
8. Mohammad Rabbani and Hossein Saidpour, “Stress Analysis of a Total Hip Replacement Subjected to Realistic Loading Conditions”, Verizona Publisher 2015.

9. Tushar V Kavatkar, Milind S Kirkire, Harshal Salvi, Dipak Patil, "Wear Analysis of Hip Joint Prosthesis", IJRASET 2016.
10. C. Desai, H. Hirani, A. Chawla, "Life Estimation of Hip Joint Prosthesis", J. Inst. Eng. India Ser. C 2014.