# Design And Analysis Of Hip Implant

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***Abstract***

**During a complete hip replacement, the patient's diseased bone and cartilage are both removed and then replaced with an artificial component (prosthesis). Even though there have been several advancements made in implant sterilization, designing, and fixing, as well as robotic surgery, the long-term challenge is to locate an optimal patient-specific hip implant that fulfills the criteria of the patient. To design a highly accurate patient-specific hip implant by standardizing the existing design, which was the proposed study's primary objective, and to demonstrate that a customized design is superior to a conventional design, which was the secondary objective, were the study's secondary aims and goals. Utilizing the MIMICS 20.0 software, geometric measures of the hip were extracted from CT scans of the hip and shown. The design of the implant was created with the help of Solidworks. FEA is used to do meshing and analysis on the planned implant. It was shown via the comparative research of the FEA analysis that a tailored implant made from SSL 13 material was the best match for the patients in comparison to the standard implant.**

## I. INTRODUCTION

The hip joint is able to support the whole body's weight while also providing stability, primarily during the movement of the trunk on the femur, which occurs when a person walks or runs. The fact that the head of the femur articulates into the pelvis provides the joint with varying degrees of freedom, which in turn assists the movement of the joint. Hip arthroplasty was shown to be a successful medical operation in the early years of the 20th century, and it was used to treat a wide variety of hip joint conditions. The total hip arthroplasty is widely recognised as being among the most effective and innovative surgical procedures now available in the medical field.

It was widely believed that Sir Charnley was the primary designer behind complete hip joint arthroplasty. A bearing surface is inserted between the acetabulum and the femoral head as part of a total hip arthroplasty procedure. After an arthroplasty, the stems are the key components that contribute to the joint's stability. At this time, hip joint arthroplasty has a survival rate of 95% for patients older than seventy years and a success rate of 10 years for those individuals.

Osteolysis is the outcome of biological and biomechanical interactions between the wear debris created by total hip arthroplasty and the environment. Hip arthroplasty, often known as hip replacement surgery, is a surgical operation in which the doctors remove the diseased hip and replace it with an implant that is available for purchase in the medical supply industry. Since 1840, there has been a significant increase in the sophistication of hip replacement surgery. When other treatments, including oral medicine, topical creams, and physical and occupational therapy, are unsuccessful in treating a patient's condition, a difficult surgical procedure may be recommended.

The main reason why a patient-specific implant is required is so that the risks and issues that are often connected with imported implants from other countries may be reduced as much as possible. Conventional implants are not as precise as patient-specific implants. The pre-operative planning that is done as part of patient-specific hip replacement surgery is an important step that may be helpful in reducing or avoiding the post-operative complications that may arise after surgery. A reduction in the likelihood of problems after surgery is one of the primary benefits of careful pre-operative preparation.

In order to perform the hip implant surgery, the patient's physiological conditions such as height, weight, age, blood pressure, temperature and oxygenation level were evaluated. This was done to ensure that the patient was in a state where they could safely undergo the surgical procedure required to replace their hip. To design a highly accurate patient-specific hip implant by standardizing the existing design, which was the proposed study's primary objective, and to demonstrate that a customized design is superior to a conventional design, which was the secondary objective, were the study's secondary aims and goals.

## 2. METHODOLOGY

### Design

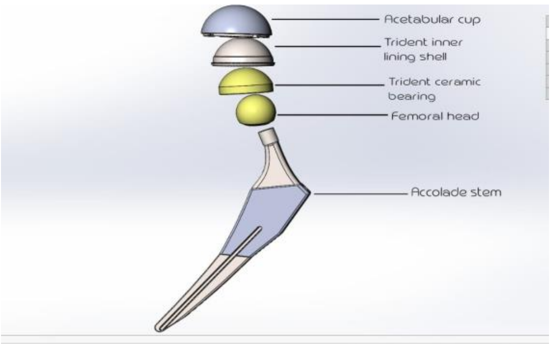



**Fig.1**

Figure.1 represents the design of Hip Implant, which had designed in Solidworks Software, Hip Implant consists of,

Accolade-stem
Femoral-Head
Trident-ceramic-bearing
Trident-inner-lining-shell
Acetabular-cup

### Topology Optimization

Hip implants are designed to replace a damaged or deteriorating hip joint with an artificial implant that can restore mobility and alleviate pain. The design and optimization of hip implants are crucial to ensure a successful outcome of the surgery and long-term functionality for the patient.

Mesh, full body, and shape modify are three techniques that can be used to optimize the design of hip implants.

**Mesh optimization:** This technique involves creating a mesh of the hip implant design and using simulation software to analyze the stresses and strains on the implant during movement. This allows for the identification of potential weak points in the design and optimization of the implant's geometry to improve its strength and durability.

Full body optimization: This technique involves simulating the entire body's movements to ensure that the implant's design is optimized for a range of activities and movements. This includes analyzing the stresses and strains on the implant during walking, running, and other physical activities to ensure that it can withstand the forces placed on it.

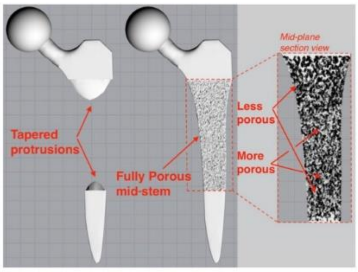



**Fig.2**

Figure.2 shows Tapered protrusions (left) enabled a gradual transition between the porous and solid regions of the porous implant (right).

Shape modification: This technique involves modifying the shape of the hip implant to better fit the patient's anatomy. This can improve the implant's stability and reduce the risk of dislocation, which is a common complication of hip replacement surgery.

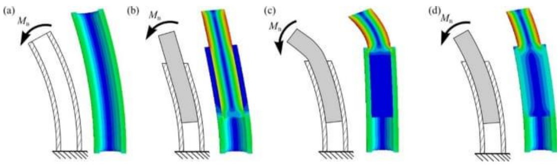
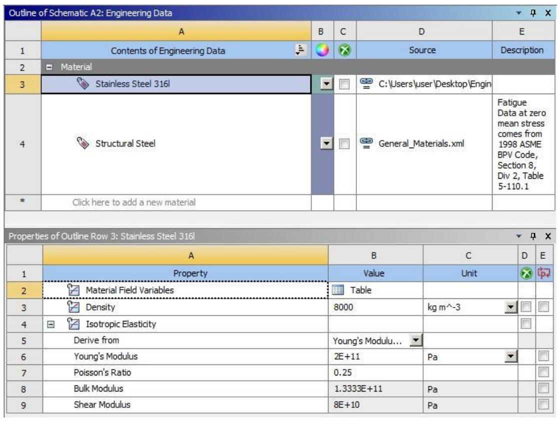



**Fig.3**

Figure.3 shows Qualitative numerical analysis to illustrate the influence of implant stiffness on the stress situation in the bone. (a) Healthy bone without implant. (b) Bone with too stiff implant ("stress shielding"). (c) Bone with implant that is too flexible. (d) Implant with adjusted stiffness

Overall, the use of mesh, full body, and shape modification techniques can help optimize the design of hip implants and improve their long-term functionality for patients. It is important to note that the optimization process may involve a combination of these techniques and should be tailored to each individual patient's needs and anatomy.

## Analysis


Outline of Schematic A2: Engineering Data

| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | Contents of Engineering Data | | | Source | Description |
| 2 | Material | | | | |
| 3 | Stainless Steel 316l | | | C:\Users\user\Desktop\Engin | |
| 4 | Structural Steel | | | General_Materials.xml | Fatigue Data at zero mean stress comes from 1998 ASME BPV Code, Section 8, Div 2, Table 5-110.1 |
| * | Click here to add a new material | | | | |

Properties of Outline Row 3: Stainless Steel 316l

| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | Property | Value | Unit | | |
| 2 | Material Field Variables | Table | | | |
| 3 | Density | 8000 | kg m^-3 | | |
| 4 | Isotropic Elasticity | | | | |
| 5 | Derive from | Young's Modulu... | | | |
| 6 | Young's Modulus | 2E+11 | Pa | | |
| 7 | Poisson's Ratio | 0.25 | | | |
| 8 | Bulk Modulus | 1.3333E+11 | Pa | | |
| 9 | Shear Modulus | 8E+10 | Pa | | |

**Fig.4**

Figure.4 defines the material properties of the implant. This includes the modulus of elasticity, Poisson's ratio, and yield strength of the implant material.

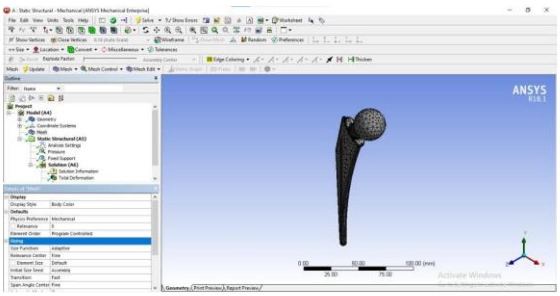



**Fig.5**

Figure.5 shows Mesh the geometry of the implant. This involves dividing the implant into small, finite elements that can be analyzed using ANSYS.

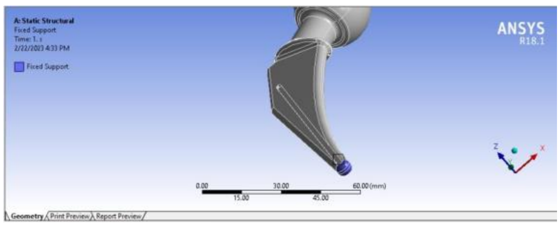



**Fig.6**

Figure.6 defines the fixed support boundary condition on any surfaces or nodes that represent the portions of the implant that are firmly anchored in bone or tissue. This may involve using the Fixed Support constraint in ANSYS.

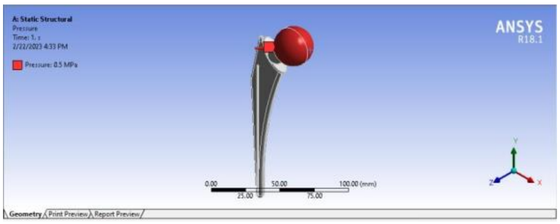



**Fig.7**

Figure.7 defines the loading and boundary conditions of the hip implant. This includes the type and magnitude of the loads applied to the implant and the constraints placed on the implant.

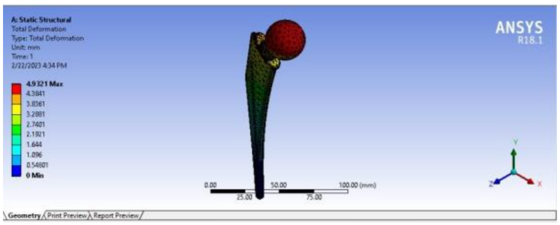



**Fig.8**

Figure.8 shows analyze the results of the simulation. This involves examining the stress and strain distribution in the implant to determine whether the implant is likely to fail under the given loading and boundary conditions.

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