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# REVIEW ON HIP IMPLANT IN HUMAN BODY

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## Abstract

Hip implants have been designed to restore hip joints when hip joint is out of order, hip replacement carried out by many other causes. Around the world every year about 800,000 total hip replacements (THR) being execute. A group of researchers have evaluate performance of several hip implant models in the path of biomechanical factors such as contact stresses, stress shielding, kinematics and fatigue to substantiate the quality of hip implants under specific loading conditions. Materials used for hip implants are titanium (Ti) alloys, cobalt chrome, Stainless Steel 316 L and Ultra - high molecular weight polyethylene etc. The main objective of this paper is to enlighten the knowledge about structure of hip joint, cause of joint trouble, and list out the effort for hip replacement technique and advance material development chronologically.

**Key words: -** Hip joint, Implant, Biomaterial

## Introduction

**Hip Joint: -** A hip joint is also called as ball and socket joint, because its femoral head act as ball and its acetabulum (part of pelvic bone) behave like socket. [1] Femur is having four main divisions such as femoral head, greater trochanter, lesser trochanter, and the lower extremity shown in Fig.1. There is a smooth glassy substance lies between the joining surfaces of acetabulum and femoral head, know as cartilage. There are two femurs in human body one at right leg and another at left leg each of which carries half weight of human body [2,3].

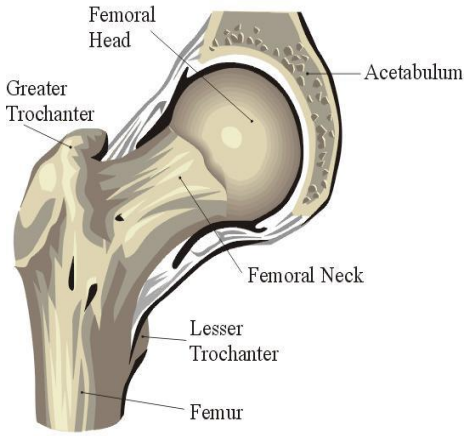



Fig. 1 Anatomy of Hip Joint.

**Cause of Femur Facture-**

The most ordinary causes of femur fractures include accident or fall from height. [4] Further more human suffer from the various hip joint trouble which occur due to development of disease in hip joint which are as follows

**Osteolysis: -** It occurs due to bone resorption. Bone resorption is process in which bone are break down due to loss of calcium and tissue. It may lead to congenital and articular disorder [5].

**Paget's disease: -** It is chronic disease regarded as variation of bone tissue. Bone is steadily renewed as bone is product of tissue (cells). The tissue are accountable for replacing a former bone with new one is become difficult due to Paget disease, because Paget disease causes uneven structure of bone. This normally affects older people [6].

**Osteoarthritis (OA): -** It is the key cause of hip collapse as well as oldest and universal type of arthritis. A Cartilage is the connective tissue that covers up the head of the thigh bone. When the cartilage being collapsed, the femoral head and the acetabulum will erode with each other, shown in Fig.2 this will source of draining of bone and bone gets deformed, even minute movement will create friction among femoral head and acetabulum of hip, compel severe pain [7].

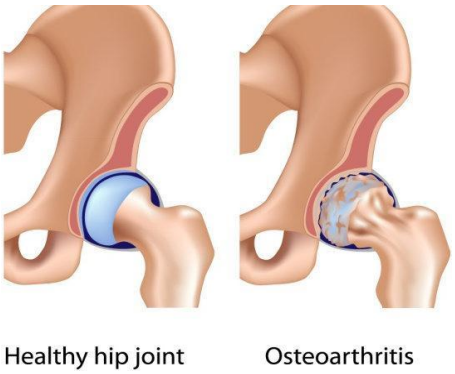



Fig. 2. Osteoarthrtis of Hip Joint

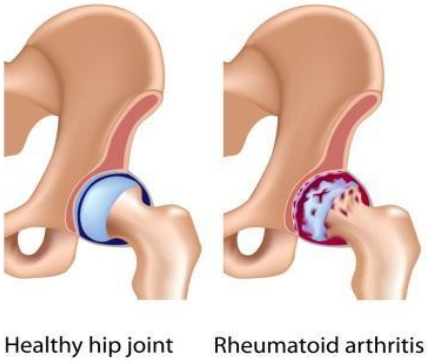



Fig.3. Rheumatoid Arthritis of Hip Joint

**Rheumatoid Arthritis (RA): -** RA is a inflammatory type of arthritis and an autoimmune disease. It may absorb multiple joints and can arise at any age. RA produce chemical changes in synovial membrane (A tissue that outline the joint and seals it into a joint capsule) that causes swells the cartilage, muscles, tendons, ligaments and also misshape (ugly shape) the joints, destroy the cartilage and ultimately lead to destruction of bone [8] shown in Fig.3.

**Avascular necrosis: -** This is happen if supply of blood to the bone is disturbed; this condition may lead to collapse or bone death. Advancement in avascular necrosis resulting increase in pain, also bone and the circumfertial joint surface may fall down. [9]

**Femoral head fracture: -** It consists of fracturing the femoral head. This facture often convey due to sudden energy impact and disarticulation of the hip joint.

**Femoral neck fracture: -** It consists of fracturing the femoral neck, which is in between femoral head and greater trochanter. It is a result of high energy impact shock.

**Subtrochanteric fracture: -** This facture occurred when body of the femur (shaft) which is shortly lower the lesser trochanter is break down.

**Intertrochanteric fracture: -** This fracture takes place on the intertrochanteric line which is in between the greater and lesser trochanter. It is the universal type of hip fragmentation. If the patient is healthy then it may heal [10].

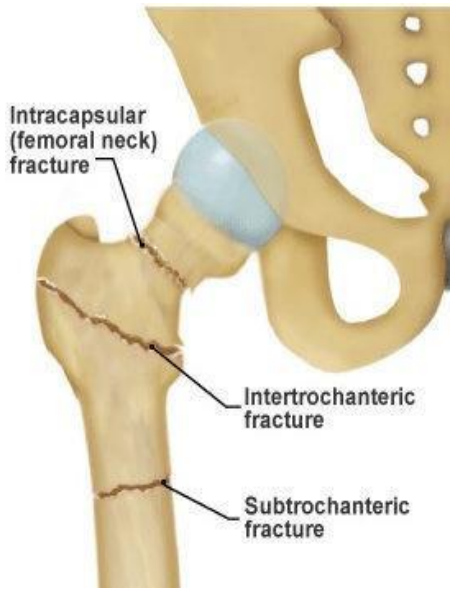



Fig.4. Different Facture of Femur

Above described diseases lead to severe disability. So that people are forced to look for surgical bone replacement in order to get relief from suffering and keep their joints movable.

In New York 1840 Carnochan was the first surgeon who replaces hip joint, by wooden block, but it didn't work. Then in 1890 Gluck introduced femoral stem with the ivory joint, as this strange material produce harmful effect in human body, the experiment done by Gluck was failed. Later a surgeon Dr. Smith-Petersen from Boston present mould arthroplasty in 1925. Which consist of piece of glass having a hemisphere hallow shape, shown in Fig.5 but this material failed quickly as it didn't bear stresses of human body movement [12]

Fig.5. Mould Aarthroplasty with Shape of
Hallow Hemisphere

During 1938-1946 Dr. Robert Judet changes acute femur surface with acrylic material to provide mollify surface. Later they evolve first short stemmed hip implant (see Fig. 6) and failed due to acrylic wear debris [13].

Fig.6. Judet Brother's First Short Stemmed Prosthesis

In 1950s F.R. Thompson and Austin T. Moore introduced the mainly accepted prosthesis which has long steam (see Fig. 7). But this implant does not replaced diseased acetabulum, still this technique is highly successful and it is primarily used in India [17].

Fig.7. Austin T. Moore Long Stemmed Prosthesis

In the 1960s McKee-Farrar prosthesis (see Fig. 8) employed screw fixation but in ancient time, there was deficiency in securing technology. Thus pain was developed because of loosening of the implants [14].

Fig.8. McKee-Farrar prosthesis

In early 1970 a surgeon John Charnley used poly-methyl-methacrylate (PMMA) as bone cement to tightly lock the hip implant to the bone. Truly this was the birth of THR (Total Hip Replacement). In late 1990s major problems was emerged in orthopaedics as aseptic loosening and osteolysis which limit the life span of joint replacements, had developed new Ceramic on Ceramic (alumina and zirconia ceramics) design for hip arthoplastry [15] and still experimentation is departing.

In 21st century Hanumantharaju G, et. Al prepare solid model of bi-polar hip implant (see Fig.9) of Ti-6Al-4V in solid work bench. Afterwards finite element analysis (FEA) was done using ANSYS software by apply different loading condition (250N, 500N, 1000N, 2000N) and predict the behavior of implant. After FEA it was observed that maximum value of stress is negligible, and Ti-6Al-4V alloy has high strength, superior physical and outstanding bio-compatible properties.

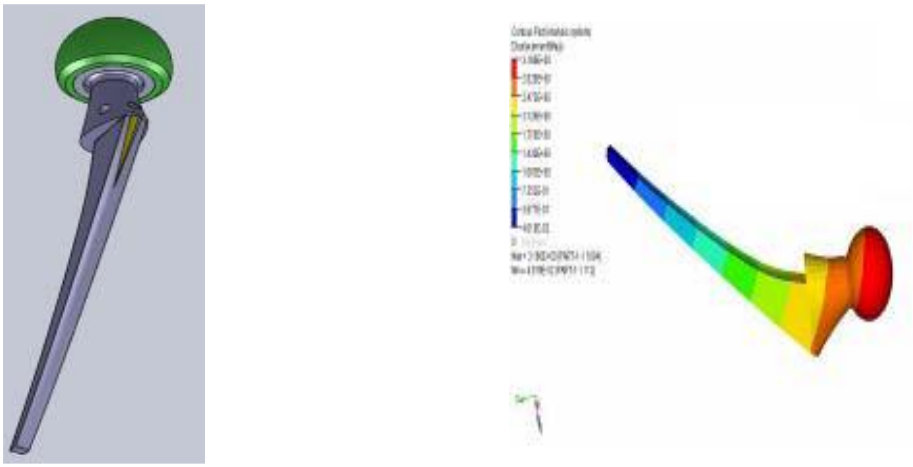


Fig.9. CAD Model & FEA Model of Bi-polar Implant

V. Burele et. Al deliberate Two CAD models of femoral stems of SS316L - one is made from standard hip implant available in the market while other (i.e customized implant) was designed from parameter of specific patient anatomy which was taken from the radiograph of patient. A

dynamic Finite element analysis was done for different activities like slow walk, normal walk, fast walk, up stair, down stair, standing up, standing down, standing on 2-1-2 legs, knee bend, and, jogging by considering average person weight was a 100 kg. The virtual study marked minor stresses in head and neck section of the customized hip prosthesis stems than the standard implant. [16] As shown in Fig.10

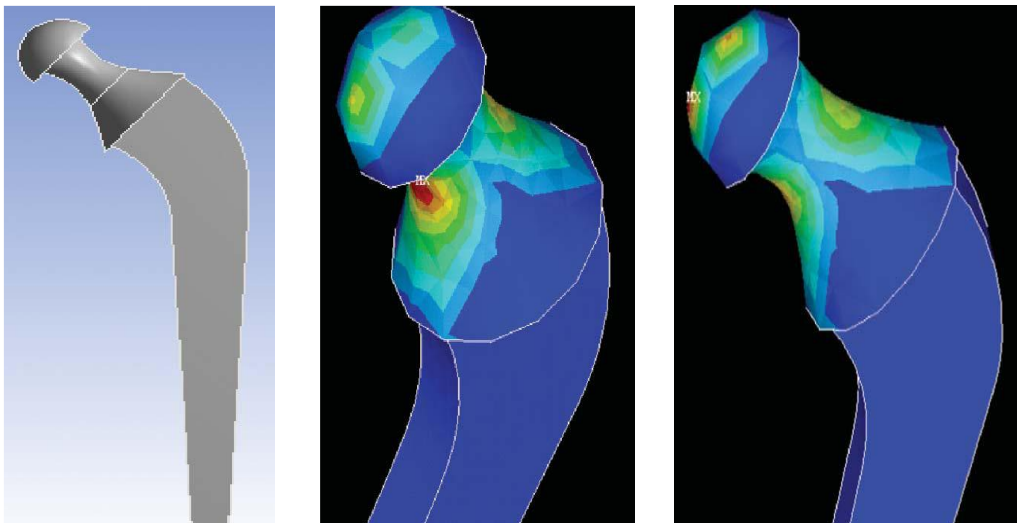
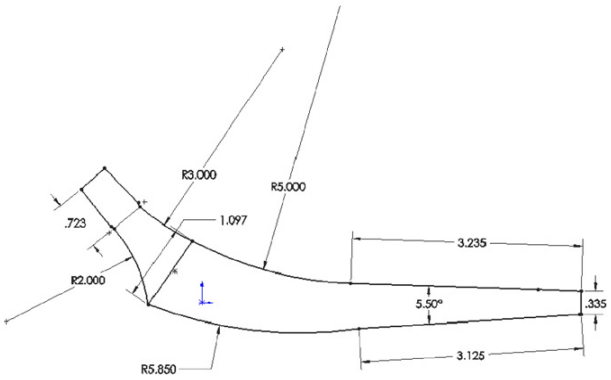
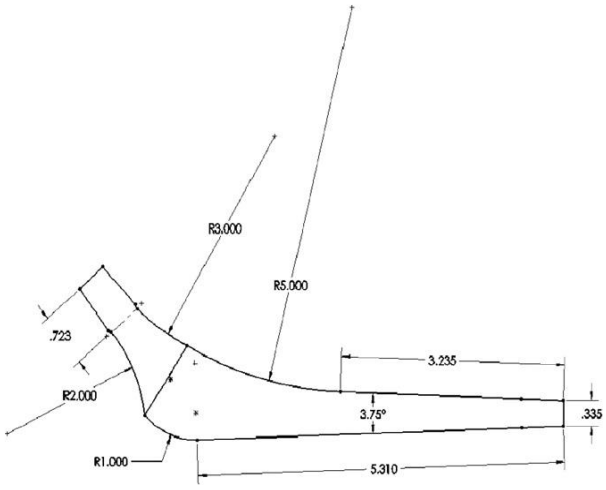


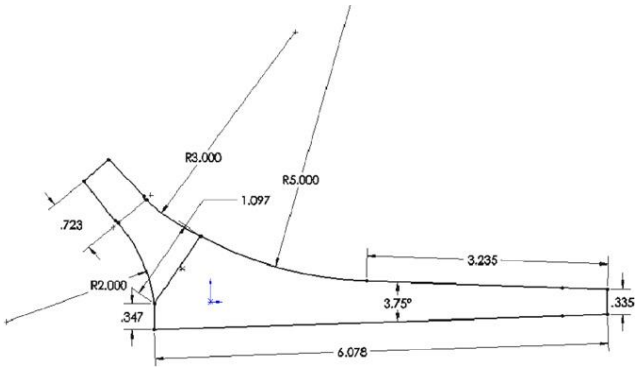
Fig.10. (A) CAD Model, (B) FEA of Standard Implant (C) FEA of Customized Implant




Hip profile 1




Hip profile 2




Hip profile 3
Fig.11. Different Hip Profiles

Three hip profiles shown in Fig.11 were disclosed by Anthony L. Sabatini et. Al, Hip profile 1 having radius on proximal end at lateral side along with having straight stem. In hip profile 2 medio-lateral angle of stem extend also radius and arc length of profile amplify. Lastly, in profile 3 corner shoulder provide against radius on lateral side.

To developed twelve hip stem design these three hip profiles combined with the four cross-sections namely circular, elliptical, oval, and trapezoidal along with analyzed in COSMOS Works for CoCrMo, Ti6Al4V, and SS 316L material, by applying 3000N load perpendicular to the neck of hip implant (see Fig12). After analysis it was observed that in case of trapezoidal cross section of stem profile distribute stress evenly on the medial side, but not evenly allocate from the medial to lateral side. But design having circular and elliptical cross section didn't emerge low stress value. The Ti6Al4V show inferior stresses than the CoCrMo and SS316L [27]

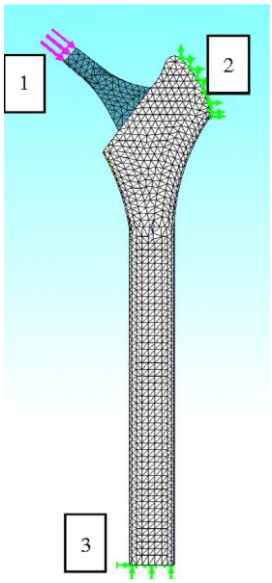



Fig.12. Mesh of femur, pt. 1 show 3000N applied load, pt. 2 & 3 show fixed portion of femur

Every year numbers of hip joint replacement surgeries increasing in India. A number of manufacturers like BIOMET, Johnson and Johnson Depuy, Stryker, etc. provide a range of artificial hip prosthesis with variety of biomaterial.

## Biomaterials

A biomaterial is a substance (not drug) which is used to build up, treat, or change any tissue, organ of human body to carry out peculiar function for particular period of time. [18, 19] A wide range of material used as biomaterial such as Metal, Ceramic, Polymer, Composite material, Polyurethane etc. for long-term usage of implant in the body a biomaterial should possess some important properties. A biomaterial should not be toxic, means it should not give off anything from its mass [15]. It should be biocompatible means it does not have any adverse effects in a biological system [16-17]. Its corrosion resistance is high, if corrosion resistance is low implants release undesirable metal ions which are non-biocompatible & reduce the life of implant [18]. Its wear resistances high because low wear resistance results in implant loosening due to Wear debris are found to be biologically active [19]. It also has long fatigue life as it is related with response of the material under repeated cyclic loads [20].

## Conclusion

The present study will assist and enhance facts of hip region for the clinicians, orthopaedicians, and radiologists. Also to take innovative step towards altering suitable artificial prosthesis design which is more purposeful to prevent general complications like prosthetic loosening and dislocation. Same study stipulates development in hip implant design, hip replacement technique and advancement in material chronologically.

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