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A Review on CFD Analysis of Femur Bone Plates

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Abstract- - ***The structural contact and modal analysis of the femur bone is done with a single crack in middle of the shaft; this fractured bone is coupled with the prosthetic plate and screw of same materials. Assembled structured is analyzed by finite element method using transient structural analysis. This paper reviews the work done on CAD analysis of femur bone plates model of Femur bone with plate. Finite element analysis has been widely used to describe the mechanical behavior of the long bones, which have been created from CT (Computer Tomography) images. In this work, a three dimensional model of the human femur bone has been modeled by using Bio-CAD software and analysis is done by using COMSOL Multiphysics software.***

Keywords=- ***Finite Element Analysis, Computerized Tomography, Functionally Graded Material, Selective Laser Melting.***

I. INTRODUCTION

In vertebrates that can walk and leap, the femur bone is the most distal bone of the leg. The femur is the longest and biggest bone in the human body, however it is only the strongest under compression. During typical weight-bearing exercises, the femur bears the majority of the body's weight. Its length is equal to 26% of the individual's height. The femur's body is long, thin, and almost cylindrical in shape. One of the frequent injuries is a femur bone fracture. Because femurs are the strongest, longest, and heaviest bones in the human body, they are a crucial area of research in orthopaedic trauma.

Unlike the majority of the body's tissues, bone tissue has the amazing capacity to regenerate. A shattered bone can renew tissue and restore much of its previous strength if it can be kept together. To retain the bone in place for serious fractures, bone plates are surgically placed. Design, material choice, and biocompatibility are the three key factors to take into account while creating bone plates. The bone plate needs to be sturdy enough to withstand the weight that would ordinarily be placed on the bone while it heals. Additionally, the plate needs to be as rigid as the bone to which it is connected. The implant must not be harmful to the body and cannot set off an inflammatory reaction.

The stiffness of the bone plate is important because the stress shielding will increase with the difference in stiffness. Stress shielding is the phenomenon in which the implant bears most of the load normally placed on the bone. Although this is favorable while the bone is weak, as the bone heals and regains strength, if the bone plate does not allow the bone to carry an increasing load, there will be a reduction of bone mass and final regained strength. From the beginning of their use, material selection was the limiting factor to their success. As technology advanced so did the materials.

Because a difference in stiffness will result in increased stress shielding, the bone plate's stiffness is crucial. The phenomenon known as "stress shielding" occurs when the implant carries the majority of the force typically applied to the bone. Although this is advantageous while the bone is weak, if the bone plate does not let the bone to take an increasing load as the bone heals and regains strength, there will be a loss in bone mass and eventual restored strength. The choice of material has been the key to their failure since they were first used. Materials evolved together with technology.

II. LITERATURE REVIEW

Ahirwar et al.[1] To assess the interface deformation, stress, and strain created at the bone-bioimplant contact, finite element analysis was used. The FEA results showed that when the naturally anisotropic condition of the human femur was well taken into account, the interface deformation and stress for a bone-bioimplant assembly were dramatically reduced. Fu et al. [2] proposed Computational fluid dynamics to examine fluid flow in the scaffold. The simulation findings demonstrated that when the scaffold's pore size increases, its permeability rises and its FSS falls. Additionally, the FSS was dispersed in stages across the cell surface. Li et al.[3] Investigate a modelling technique for biomimetic porous bone scaffolds for biological three-dimensional printing that is practical and efficient and is based on a replication of the histomorphological features of human vertebral cancellous bone. The bionic modelling design approach put forward in this study takes into account the biological properties of the cancellous tissue in the vertebrae and performs imitation and design of images of two-dimensional slices that resemble vertebrae. The method of computational fluid simulation was used to characterise the flow through porous materials. Numerous authors [4]–[9] aims to conduct a comprehensive analysis into the stiffness, strength, permeability, and stress concentration of six scaffold topologies with a porosity range of 68.46–90.98%. The FE model was verified and further developed to investigate the impact of stress concentration on the scaffolds' stiffness and strength. The findings shown that the pore shape can affect the Ti6Al4V bone scaffolds' permeability, stiffness, strength, and stress concentration factor. **Wang et al.[10]** The study's findings on the performance of four groups of various honeycomb designs demonstrate the viability and potential of using honeycomb structures in the creation of biomimetic bone scaffolds. The yield strength (88-146 MPa) was much higher than that of the femoral neck, and the elastic modulus (1.6-3 GPa) of the four scaffolds matched the elastic modulus of human cancellous bone (0.1-4.5 GPa) in terms of static characteristics (0.56–3.71 MPa). With the exception of the SU scaffold's high permeability, the permeability of the other three sets of scaffolds (1.5*108-4.8*108 m2) is comparable to that of cancellous bone (0.5*108-5.0*108 m2). The four groups of scaffolds' wall shear stresses, which ranged from 2.8 to 42.8 MPa, might encourage cell deposition of mineralized extracellular matrix (0.55–30 MPa) in the 3D scaffold, which was helpful for bone tissue regeneration. **Pravat Kumar Satapathy et. al. [11]** This research examines a fragmented Femur bone with a functionally graded bone plate. The fracture fixation plate in this case is made of Functionally Graded Material . The functionally graded bone plate is thought to be made up of many layers of homogenous elements. **Koris J. et. al. [12]** Scenario 1 had a gap between the end of the femur and the implant collar, scenario 2 had no gap but no bone attachment into the collar, and scenario 3 had no gap but no bone attachment into the collar. Scenario 1 had a gap between the end of the femur and the implant collar, scenario 2 involved no gap but no bone attachment into the collar, and scenario 3 involved bone development down the length of the collar with attachment. In scenario 1, the greatest stress observed in the implant was 3104.2Mpa, compared to 1054.4Mpa in scenario 2 and 321.2Mpa . S. Karuppudaiyan et. al. [13] The biomechanical structural behaviour of tibia bone was investigated using a 3D model created utilising a reverse engineering method. The primary goal of this research is to create a subject-specific finite element model of the tibia bone using the Reverse Engineering approach, as well as to investigate the biomechanical structural behaviour and fracture risk of the tibia bone under physiological loading circumstances. These mechanical characteristics are employed as an input for finite element analysis since the properties of bone vary depending on the mix of mineral content and protein content. The findings of finite element analysis were compared to the literature on FEM models built using CT scans. Authors [14]–[19] in response to knee loading, FEA indicated that the maxima of von Mises stress, a predictor of fracture yielding, and the third major compressive stress would be greater in the placebo-treated femur than the drug-treated femur. This FE investigation lends credence to the hypothesis that mechanical weakening of the femur was detected in tumor-invaded trabecular bone, and chemical compounds such as PD407824 may possibly aid in avoiding bone loss and bone fracture. **Evandro Pereira Palacio et. al. [15]** Synthetic adhesives are employed in a variety of medical specialities, including surgery; however, data on their application in orthopaedic treatment are limited. Biomechanical and histomorphometric assessments were done at three separate times , as well as a clinical examination conducted weekly by measuring the animals' body mass. The bone callus area on the humerus in both groups was similar . There were no significant differences in inflammatory cells , osteoblasts , or osteoclasts in either group.

Femur Bone The femur bone is a thigh bone, this connects the hip joint to knee joint of a human body. The femur bone is the second largest and strongest bone in our body. Thus, it requires maximum amount of forces to break the bone. Fracture occurs in femur bone only when the bone is affected with great force due to bending and twisting forces. The common fractures of a femur bone are due to accidents and tumor. It connects the hip joint to the knee joint. Femur bone contains three parts namely: ·Upper Extremity, ·Body or Femoral Shaft and ·Lower Extremity. Figure 1 shows the structure of Femur Bone. 1.1 Upper Extremity The head of femur, which articulates with the acetabulum of the pelvic bone, composes two-thirds of a sphere. It has a small grove, connected through the round ligament to the sides of the acetabular notch. The head of the femur is connected to the shaft through the neck. 1.2 Body (Shaft) The body of the femur (or shaft) is long, slender and almost cylindrical in form. It is a little broader above than in the centre, broadest and somewhat flattened from before backward below. It is slightly arched, so as to be convex in front, and concave behind.

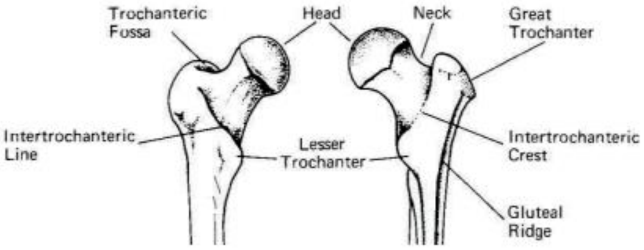

Figure 1. Structure of Femur Bone

Lower Extremity The lower extremity of the femur (or distal extremity) is larger than the upper extremity. It is somewhat cuboid in form, but its transverse diameter is greater than its anteroposterior (front to back). It consists of two oblong eminences known as the condyles. Anteriorly, the condyles are slightly prominent and are separated by a smooth shallow articular depression called the patellar surface.

III. CONCLUSION

The structural contact and modal analysis of the femur bone is done with a single crack in middle of the shaft; this fractured bone is coupled with the prosthetic plate and screw of same materials. Assembled structured is analyzed by finite element method using transient structural analysis. s. With this approach, it is also possible to find out the very complicated fractured regions easily, and helps in smooth running of surgeries. Hence, this method paves way for better modeling and analyzing the anatomical structures like bones and other parts of body organs.

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