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Review on structural, contact and modal analysis on femur bone using different plate material under varying fracture condition

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Abstract — *In human anatomy the femur may be the largest and longest bone however most powerful in compression only. The femur is responsible to put up with the most significant percentage of weight during ordinary weight bearing activities. Femur bone fracture is just one of the usual traumas. When designing bone stripes design, fabric selection, and biocompatibility are the three important considerations. The bone plate must be strong enough to support the load normally put on the bone while the bone heals. The principal goal of the present work is to analyze the cracked femur bone that's cracked in midst of the shaft and supported by prosthetic plate and the relative analysis with different material for single fracture position. In the current work a 3-dimensional CAD version of Femur bone with locking and plate screw is made up of the help of CATIA software then erased in ANSYS work-bench for further investigation. From the current work passing structural, touch and modal analysis on femur bone together with plate gathering for different structure and different substances are performed.*

Keywords- *FEA, Femur Bone, Bone Plate,Cad, Structural Analysis Contact Analysis.*

I. INTRODUCTION

The femur has become easily the most left-wing in vertebrates which may operate and leap. In the body, the femur could be the greatest and biggest muscle, however the most powerful at compression. Even the femur conveys the largest proportion of human body weight during ordinary exercise. Its span is 26 percent of their entire measurement of the individual. The human anatomy of this femur is extended, skinny and virtually pliable. Probably one among the absolute most frequently made harms is that a busted femur. Femoral fractures are an equally essential topic of search for bodily injury since they're the most powerful, longest and lightest bones from the body.

1.1 Types of Femoral Shaft Fractures:

Femoral fractures change widely based on the power which results in the fracture. Bone bits might be properly coordinated (steady fracture) or mis-aligned (homeless fracture). Your skin round the fracture might be undamaged (closed fracture) or also the bone could liquefy skin (open fracture).

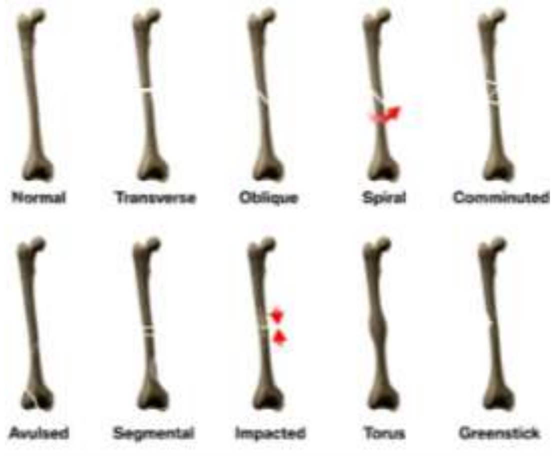

Fig.1. Femoral Shaft Fractures

Doctors clarify cracks utilizing purification methods. Femoral fractures Are Grouped in line with: The place of the fracture (the stem of the uterus is broken up into thirds) the main reason for the fracture (by way of example, the bone may break in different directions, such as by way of instance transversely, longitudinally or in the center). In the event skin and muscles over the bone have been ripped by the accident.

1.2 The most common types of femoral shaft fractures include:

1.Transverse fracture: In Such a fracture, the fracture is a straight Horizontal line which crosses the axis of the thigh.
2. Oblique fracture: This type of fracture has an inclined line onto the rotating shaft.
3. Fracture line encircles the shrub like bits of a candy cane. A spin onto the thigh induces such a fracture.
4. Comminuted fracture: In Such a fracture, the bone is broken up into three Or more parts. In the majority of instances, the quantity of bone fragments corresponds to the pressure required to split bone.

Cause: Femoral shaft fractures in young people are often due to a sort of high-energy collision. Being struck by a car when walking is still just another frequent cause, as well as drops in the height and gunshot wounds. An accident with less force, such as a fall from a standing position, for example, could bring about the femoral shaft to rupture in an older person with poorer bones.

Symptoms: An fracture of the femoral shaft usually causes severe pain Immediately. You cannot induce the leg and it may appear distorted: Briefer than the other leg, not directly.

1.3 Introduction of Bone Plates:

Unlike most body cells, bone tissue has the extraordinary ability to regenerate. If your broken bone is stored together, then it might regenerate the veins and regain most of its unique strength. In severe cracks, the bone plates are surgically implanted to keep the bone in place. The bone plate must be strong enough to support the load on the bone since the bone heals. The plate must also provide a stiffness similar to that of this bone to which it's attached. The implant should not be toxic and should not lead to an inflammatory reaction within the body. The endurance of the bone is significant because the stress protect rises with the stiffness difference. Tension shielding is the occurrence where the implant takes the majority of the strain normally set on the bone. While that is of use when the bone remains weak as the bone heals and regains strength, there's a reduction in bone density and recovery of final advantage if the bone does not permit bone to keep raising strain. By the beginning, the choice of stuff has been the limiting factor to their success. Since technology has evolved, substances have also been developed.

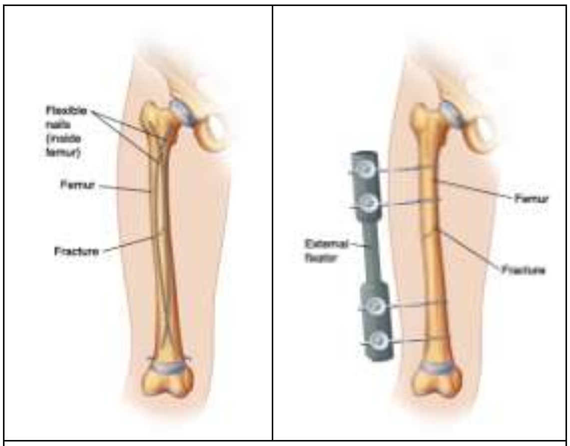

Figure 2: Surgery to place fixation devices

1.4 Metals

Iron and steel were the materials most commonly utilised in the 1920s. It had been their tensile strength which made iron and steel attractive. They disintegrated quickly and led to the erosion of bones. But, metal is poor to additional superb alloys in terms of erosion, biocompatibility and durability. However, there might still be applications in older patients where physical requirements and life expectancy are limited, particularly if price is a determining factor. Stainless steels are only suitable for use in temporary implant devices. Discolored copper and nickel bones in which they were all incorporated. Gold, silver and pure aluminum do not result in discoloration, but are too feeble and tender for this particular application. Chrome-nickel metal was resistant to body fluid corrosion compared to other alloys.

Titanium was utilized in the 1930s. Its lightness and good chemical and mechanical properties are essential characteristics for this application. Aluminum is just one of the binding elements. The strength of titanium alloys is significantly lower than that of stainless steel, but their particular strength is much higher than that of other alloys. But, titanium has a very low cut immunity, which makes it less desired for bone fractures, plates and similar uses (www.corrosion-doctors.org). A disadvantage of alloy implants would be that the demand for another operation to remove the augmentation. This additional surgery can damage the bone and is a obvious disadvantage. Therefore, it could be desired to transform an implant into degraded or reabsorbed material. Some ceramic and polymeric substances are bioabsorbable plus some actually help promote bone growth. The main challenge for this particular type of substances is to build up the required mechanical components, since they will be often less resistant than alloys.

II. LITERATURE

Pravat Kumar Satapathy et. al. [2018] [1] this work focuses on the analysis of the broken femur with a functional classification bone plate. The femoral bone is modeled using scanner data (computed tomography) and the material properties are assigned using Mimics software. The fracture fixation plate used here is made of graduated functional material (MGF). The functional classification bone plate is thought to be composed of several layers of homogeneous material. The finite element method is used for analysis. A static analysis was performed for the bone plate system, taking into account both the axial load and the torsional load. The investigation shows that by introducing an FG bone plate instead of titanium, fracture stress increases by 63% and deformation decreases by 15%, especially if torsional load is taken into account.

Koris J. et. al. [2018] [2] this article focuses on children with primary bone cancer and who need growth plate resection. They may have a progressive deviation in the length of the legs which can be reduced with extensible prostheses. A serious complication is the catastrophic failure of the implant. Over time, the bone will reshape and the tension pattern in the implant will change. Using finite element analysis, we can model various conditions for bone turnover to determine what effect this has on stress distribution and amplitude. The load is distributed over the entire length of the bone. This can help prevent catastrophic plant failure in stressful conditions. Further investigation of patient outcomes is needed to ensure that model results are verified.

S. Karuppudaiyan et. al. [2018] [3] this work focuses on the biomechanical structural behavior of the tibia bones and has been examined using a 3D model of the tibia bones generated using a reverse engineering approach. Developing a precise and reliable bio-CAD bone model of internal and external bone geometry is always a difficult task for orthopedics. Most researchers have used computed tomography (CT) images to develop the finite element model of the bone, but still need a better algorithm to get an accurate model. The main objective of this study is to create the subject-specific tibia finite element model using the reverse engineering (RE) technology and to study the biomechanical structural behavior and the risk of fracture of the tibia under physiological stress conditions. Although we suggest that a reverse engineering approach could be used to develop this type of complex geometric model, this study can provide an excellent basis for the development of 3D bone models for finite element analysis and implant development. Offer the use of the additive manufacturing method.

Feifei Jiang et. al. [2018] [4] this article focuses on bone metastases associated with breast cancer that lead to bone loss, followed by an increased risk of bone fractures. In order to develop a strategy to prevent tumor growth and protect bone, it is essential to understand the mechanical properties of bone under tumor load. Using a mouse model of breast cancer, we performed a finite element analysis (FEA) of two bone samples from the distal femur. One sample came from a mouse treated with placebo and the other from a mouse treated with the experimental drug PD407824, a checkpoint kinase inhibitor. Higher voltage peaks in the trabecular segments have been observed in the lateral condyle, a critical area for the integrity of the knee joint. In summary, this FE study supports the hypothesis that mechanical weakening of the femur has been observed in the trabecular bone that entered the tumor and that chemical agents such as PD407824 may help prevent bone loss and fracture.

Evandro Pereira Palacio et. al. [2018] [5] this article focuses on the synthetic adhesives used by various medical specialties, particularly in surgery; However, studies reporting their use in orthopedic practice are rare. The purpose of this study was to compare the results when ethyl 2-cyanoacrylate or butyl 2-cyanoacrylate was used in the treatment of fractures in rats. METHODS: prospective controlled study of 90 rats with humerus, femur and tibia fractures treated with ethyl 2-cyanoacrylate. Biomechanical and histomorphometric analyzes were performed in three different times (60, 120 and 180 days). Results: No difference in body mass was observed. In the two groups, there was no significant difference regarding the maximum load, the elastic limit and the stiffness coefficient of the femurs. Ethyl 2-cyanoacrylate has been shown to be more effective than butyl 2-cyanoacrylate in the treatment of fractures in rats.

Alberto de Castro Pochini et. al. [2018] [6] in this article focuses on evaluating the tendon reconstruction technique for complete rupture of the pectoralis major muscle using an adjustable cortical button. METHODS: prospective study of 27 male patients with an average age of 29.9 years (SE = 5.3 years) and a follow-up period of 2.3 years. The procedure consisted of autologous grafts consisting of semi-tendons and delicate tendons and an adjustable cortical button. Patients were functionally evaluated according to the Bak criteria. Early or delayed reconstruction of the main broken pectoral muscle tendons with significant muscle retraction using an adjustable cortical button and autologous explants of the knee showed a high rate of good results.

Lucas Lopes da Fonseca et. al. [2018] [7] this article focuses on the study evaluating the reproducibility of the three main classifications of ankle fractures most commonly used in emergency clinical practice: Lauge-Hansen, Danis-Weber and AO-OTA. The secondary objective was to assess whether the level of work experience had influenced the agreement between observers to classify this pathology. The study included 83 preoperative digital radiographs of ankle fractures in the anteroposterior and lateral views of various adults between January and December 2013. The Hansen-Lauge ranking showed the worst observer agreement between the three systems. The AO classification showed moderate agreement and the Danis-Weber classification showed an excellent index for agreements between observers regardless of their professional experience.

Carlos Eduardo Benvindo et. al. [2018] [8] this article focuses on the study, which aims to evaluate the fixation of trabecular metal wedges in patients who have undergone total hip arthroplasty with major hip defects. Radiographs of 19 patients (21 hips) who underwent a complete revision of the hip stent with trabecular metal wedges from September 2010 to December 2014 were evaluated. The implanted trabecular metal wedges showed excellent short and medium term results and could be another option in the reconstruction of large hip defects and sometimes replace bone reconstruction using bone tissue banks or autologous grafts.

Edie Benedito Caetano et. al. [2018] [9] the aim of this study was to analyze the anatomical variations of bicipital aponeurosis (BA) (lacertus fibrosus) and their effects on compression of the median nerve, which extends medially to the brachial artery under the bicipital aponeurosis. These results suggest that a thickened BA may be a potential nerve compression factor by narrowing the space through which the median nerve passes.

Michiaki Miura et. al. [2017] [10] this article focuses on the finite element analysis (FEA) of the proximal femur, previously validated with a wide mesh. However, in recent studies, these were not sufficient to simulate the model with small implants. This study aimed to validate the FEA model with smaller specimen specific meshes based on proximal femoral computed tomography (CT) using recently frozen cadavers. The specimen-specific FEA model based on the proximal femur scanner with small elements was validated using recently frozen bodies. The equations proposed by Keller for the vertebrae have proven to be the most reproducible for the proximal femur in the elderly.

A.V. Javir et. al. [2017] [11] this study builds on advances in biomedical technology. Computer-aided design (CAD) and finite element analysis (FEA) in the design of bone implants are an important application in mechanical engineering. Different materials with different mechanical properties are used; The voltages and stresses for the different load conditions are calculated and finally optimized to obtain the maximum effective life of a system. CAD and FEA have revolutionized the way prostheses are designed and developed. This work takes place in four stages; Bone compression test with Universal Testing Machine (UTM), 3D digitalization of the natural femur with the white light scanning camera, prosthesis modeling with Pro-E, static and dynamic analysis of the prosthesis with the ANSYS instrument.

Yue Zhang et. al. [2017] [12] this article focuses on the process of removing hard bone, an anisotropic viscoelastic composite that is complicated and difficult during orthopedic surgery. Piezoelectric surgery is used more and more in orthopedic surgery because of its selective cutting properties and its much higher precision than conventional instruments. This article examines the mechanism of piezoelectric surgery and analyzes the advantages and disadvantages of piezoelectric surgery and conventional instruments when cutting hard bone tissue from different angles such as cutting force, cutting temperature, tissue damage, cutting performance, etc. It also provides some suggestions for further research.

M Vijay Kumar Reddy et. al. [2016] [13] this article focuses on the density of minerals in the bone which can be measured by bone densitometry. Bone minerals are used to estimate the risk of fractures due to osteoporosis in people of all ages. Osteoporosis causes a decrease in bone mineral density due to the formation of small holes (bone loss) in the bone. Osteoporotic fractures are a serious public health problem. Early detection of people at high risk of osteoporosis can help them stop causing multiple and sudden fractures in the future. This study is conducted using finite element analysis (FEA) on femoral bones under static conditions. Finite element analysis has been widely used to understand the mechanical behavior of femoral bones of different ages based on images developed by computed tomography (CT). In this work, three-dimensional models of the human femur were developed using the MIMICS software and finite element analysis (FE) was performed using the multi-physics software COMSOL 5.0.

Aversa Raffaella et. al. [2016] [14] this article focuses on the human femur and shows a great ability to resist external stress. This is due to the mass distribution, morphology and orthotropic behavior of the trabecular and cortical bone. A precise modeling of the femur is presented, which takes into account the bone distribution and behavior of the orthotropic material. The use of the Biofidel model aims to develop an "in silico" tool that allows to evaluate the change in biomechanics caused by the change in the structural and morphological properties of the prosthetic bones. In this study, a Biofidel Femoral Finite Element (FEM) model from computed tomography (CT) was developed using a specific combination of software to correctly represent bone physiology and structural behavior. The correct identification of the disposition and distribution of the trabecular bone in the proximal diaphysis allowed the modeling and the definition of the material properties.

Sandeep Kumar Parashar et. al. [2016] [15] this document has focused on the past few decades. Finite element modeling has been developed as an effective tool for modeling and simulating the biomedical system. Finite element modeling (FEM) is a computer technology that can be used to solve biomedical engineering problems based on continuum mechanics theories. This article presents the state of the art for the application of finite element modeling in the four fields of the Chanik bone biome. H. Analysis of stresses and deformations, determination of mechanical properties, design of the failure fixing (implants) and prediction of the breaking load.

Hans Liebl et. al. [2015] [16] this thesis focuses on the experimental validation of a non-linear FEA modeling approach (finite element analysis) to assess the risk of fracture in vitro to the proximal femur and on the transfer of the method to standard data from in vivo multidetector tomodensitometry (MDCT). hip in order to predict an additional risk of hip fracture in patients with and without vertebral fractures associated with osteoporosis using bone mineral density (BMD) measurements as the reference standard. The FEA simulation protocol was transferred to standard MDCT images in vivo with improved contrast in order to calculate the individual risk of hip fracture for 4 subjects tested with or without a history of osteoporotic vertebral body fracture by age and gender. In addition, calculations of FEA-based risk factors were compared with manual measurements of femoral BMD for all subjects. FEA simulations have been successfully validated by elastic and destructive in vitro experiments. In subsequent in vivo analyzes, differences in BMD measurements did not reflect differences in MDA-based FDA-based risk factors for further hip fractures.

III. METHODOLOGY

Finite Element Analysis: Finite element analysis (FEA) is a computerized method for predicting how a merchandise reacts to real-world forces, vibration, heat, fluid flow, along with additional physical results. Finite element analysis shows whether a commodity will break, wear out, or work the way it was designed for the present job ANSYS 18.2 applications used.

Figure 3.1: Flowchart for Finite element analysis

Bone & Prosthetic plate materials	Density Kg/m^3	Young's Modulus E (Gpa)	Poission Ration	Ultimate Tensile Strength (Mpa)	Ultimate Compressive Strength (Mpa)
Femur cortical bone	1750	16.7	0.3	43.44+_ 3.62	115.29+_1 2.94
SS316 L	7750	193	0.31	485	570
Titanium alloy	4500	121	0.37	1250	1100

Material property chart

IV. CONCLUSION

The contact and also modal investigation of this femur bone has been completed using one fracture at centre of this rotating shaft; the bone that is broken has been combined using all the prosthetic plate and also twist of exactly the equal substances. Assembled ordered is examined with finite element procedure utilizing passing structural investigation.

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