"STATIC STRUCTURAL ANALYSIS OF FEMUR & TIBIA"

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ABSTRACT

Knee joint is most complex joint in human body. Whole joint made from four different bones like femur, tibia, patella, fibula and between femur and tibia there is one other jelly type material menisci.Femur is longest bone in our human. Body due to Unhealthy food, the strength of bones is decreases now days. So we may find injury in knee joint five to ten in 100 people in our work. We will collect CT-SCAN data of femur and tibia of knee joint and will prepare 3D-CAD model using MIMICS and analysis will be done ANSYS software.

Keyword:- *Knee joint, femur ,3-D CAD Model, Stress.*

1. TITLE-1

The knee joint is complex structure in the human body which undergoes critical loading simultaneously while performing different physical activities such as walking, running, in rotational motion, sitting, static positions etc. what we used to do in our day to day life. Major parts in a knee joint are femur, tibia, patella and meniscus. It has two articulation components one is in between the tibia and femur and another between the femur and patella. The knee joint is a pivot hinge joint. It permits extension and flexion of leg with that rotation in both internal as well as external part [1]. It's articular bodies are lateral and medial condyle were patella is present in the posterior region in between the lateral and medial condyle surfaces. Articular capsule of knee joints are the fibrous membrane and synovial membranes. Synovial membranes are those which are been attached near the cartilage of both tibia and femur. Cartilage is elastic thin tissue that acts as protection guard for bone and makes the joint surfaces. In knee joint there are two types of cartilages joint one is fibrous cartilage and other as hyaline cartilage. Fibrous cartilage has resistance to high pressure and has high tensile strength [2] . A meniscus is the articular disk present in the knee joint, having two components i.e. medial and lateral meniscus.

1.1 Knee Prosthesis:

In the field of medicine prosthesis is defined as an artificial device which is replaced in the position of any defective body part or when any body part went missing because of trauma, disease or any congenital condition. Mainly two types of prosthesis are being used in i.e. craniofacial and somato (body). Craniofacial prosthesis is of two types i.e. extra oral prosthesis and intra prosthesis where as somato prosthesis are of many types like limb prosthesis, ear prosthesis any defective body parts when being replaced by an artificial organ [3].

1.2 Knee Replacement:

Knee replacement is also termed as knee anthroplasty. A surgical method of replacing the load bearing surfaces present in the knee joint so as to cure the pain bearing regions and disability areas of the joint [5].Knee replacement is the surgical technique which has been carried out mostly during the cases like osteoarthritis. Other causes which may lead to pain in the knee joints are due to ligament tearing, cartilage defects, pain due to meniscus tearing etc. Knee replacement can be done using two methods i.e. by Total Knee Replacement and other is Partial Knee Replacement [6]. The principle of knee replacement technique is to remove those defective and damaged joint parts and surfaces of knee and replacing it with an implant made of metal and plastic.

1.3Knee Replacement Implant Materials:

Implant model designed consists of a flat metal plate and stem implanted inside the tibia and there is a plastic material for the fixation of the metal implant with the bone, i.e. a UHMW polyethylene and with that there is a counter metal plate fit around the end of the femur. Generally, all the components of the knee implant are made up of metal and their alloy. Polyethylene is used for the articulation of tray surface in between the joint with reduced level of wearing to the implant. Materials used for the designing of those knee implants are as follows [25]:

2. LITERATURE SURVEY

Stress analysis is a discipline under engineering, an effective method to determine the strains and stress acting upon any material. Those materials are subjected to any particular load and forces in any direction. Stress analysis is used for keeping any specific structure in a functional state and maintaining its structure, with that investigating the causes which may lead to the failure and damage to that structure[15].

Stress analysis is done in any geometrically described structure with that checking the properties of the material used in that specific structure, where the loads being applied. Stress analysis can be done through computational analysis, mathematical techniques, and analytical, mathematical approach or combination of two three methods. Mechanical behavior of knee joints is a complex system. There are two states of mechanics in which the body behaves: one is the static state where body in a system is acting on a constant motion, it's either at a rest state or moving with a constant velocity[16].

The other state of the body is dynamic, in which the body in the system is in motion where there is a presence of acceleration and the study of the body in that state is studied according to time, velocity, displacement, speed of the body in a particular linear direction or in any certain direction, with an involvement of forces acting on the body or any applied load. The knee joint is one of the most important joints in the human body. The knee joint is also called as the hinge joint which performs lots of activities like standing, walking, sitting, flexion, extension, with bending of knee etc. with different loads acting upon it with a certain pressure[17].

Knee joint in a human body is made up of mainly 3 components those are tibia, femur and patella with a presence of deformed body. People suffering from knee joint pain and any injury to knee risking everyday and in sports activity leads to occurrence of wearing and tearing on the knee joint. Failure and improper functioning of knee joint due to defect occurrence in the knee may lead to operative solution i.e. removal of components of the knee with an artificial implant termed as knee prosthesis. Examination of defect in knee can be done by X-ray and CT scan as well as with MRI imaging. Mostly knee replacement is done through a small incision, small as 3-4'[18].

According to the defect and failure condition total and partial knee replacement is carried out. In total knee replacement a large implant is inserted in place of the knee joint which favors long term durability and biocompatibility. In spite of excellent working and result it frequently fails in around 4-5 yrs due to chronic inflammation of generated wear particles which results in implant failure giving defective outcomes. Those wear particles interact with the immune system leading to toxicity affects in in- vivo[19].

Due to this hypersensitivity reaction occurred from immunotoxic. Ni, Co, Cr are common sensitizer but when comes in contact with Ti and its alloy they show hypersensitive reaction leading to corrosion and wear of metal implant. The usefulness of material tested according to hypersensitivity of the material as respect to the sensitizers CoCrMo towards the implant material and checking its reliability of the properties of the implant in the target site and its compatibility and durability checking its toxicity rate. Partial knee replacement is done by two methods i.e. unicompartmental partial knee replacement and tri/bicompartmental partial knee replacement. In unicompartmental partial knee prosthesis a Unicondylar fixed bearing knee implant, which is the most commonly used modeled prosthesis or a mobile bearing knee implant. Bi or Tricompartmental partial knee implant consists of one or more component of knee causing less damage to any healthy ligament during the implantation procedure[20].

Dual Articulating Total Knee Prosthesis consist of femoral component, with that a tibia tray and a movable plate. Femoral condyle has lateral and medial condyle and near an automatic mechanical curvature at the articulating surface. This kind of prosthesis provides full flexion and extension without any dislocation of the inserts and with a rear physiological near articulating motion where the stress concentration at the articulating

surface is neglected. Articulation mostly occurred at the femoral and tibia insert surfaces. Thus stress concentration calculated at the knee prosthesis inserted region which gradually reduces leading to less loosening of prosthesis and the durability of the fixed implant will increase. With a large contact area throughout the range of motion of knee leads to reduction of stress concentration and the wearing of the implant components. Cruciate ligament makes a greater range of motion possible than the conventional type of total knee replacement prosthesis which is now a day's modeled only a number grossly 140 implants were designed. Relationship in between the concave and the convex surfaces present at the lower surface are of the joint with the articulating surface and the fixed bearing tibia tray convex surface with the articulating upper convex surface all those interfaces between the convex and concave surfaces makes it difficult for the implant to get loosened and cause wearing effect. It provides stability the knee joint during both flexion and extension of the knee with implant and gives proper rotator motion[24].

3 CONCLUSIONS

The static structural analysis of the knee joint has a great significance, as these analytical results provide us a wider knowledge about the mechanical behavior of the knee. Performing stress analysis as a simulation method instead of intrusive methods is one of the important part of biomechanical study for different 3D models.

The study reveals that the stress analysis work performed by X-ray images which help us to obtain a rough geometry of the knee joint. Analysis work was supported by ANSYS 13.0 which ensured that only desired and specific parts of the knee joint are involved in the designing and simulation of the model. Converting the specific geometry designed in CAD into Solidworks and Meshlab, and importing it in STL format can be used to validate the knee model along with finite element analysis. The material assignment was performed by Solidworks.

For designing 3-D CAD model of the knee joint and knee implant, total CAD software operation was used, to examine the overall geometry of the designed model. It has been established that the angular stability of the knee implant can be improved through this analytical approach. Thus it has been demonstrated that this analysis paves the way for incorporation of different materials based on stress work.

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