IJREAT International Journal of Research in Engineering & Advanced Technology, Volume 2, Issue 4, Aug-Sept, 2014
ISSN: 2320 – 8791 (Impact Factor: 1.479)
www.ijreat.org

Analysis Of Stresses On Human Femur Bone

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Abstract

Biomechanics is the theory of how tissues, cells, muscles, bones, organs and the motion of them and how their form and function are regulated by basic mechanical properties. A finite element model of bones with accurate geometry and material properties retrieved from LASER scan data are being widely used to make realistic investigations on the mechanical behavior of bone structures. The aim of this study is to create a model of real proximal human femur bone for evaluating the finite element analysis (FEA). Here, behavior of femur bone is analyzed in ANSYS under physiological load conditions. Hence the mechanical analysis with heterogeneous material property of bone is varying with individual patient. The results of this analysis are helpful for orthopedic surgeons for clinical interest.
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Keywords: *Human Femur Bone, Analysis, Stress, Solid Modeling ,Evaluation of stress.*

1. Introduction

Bone is a multiphase material made up of a tough collage nous matrix intermingled with rigid mineral crystals. Its importance in body is related to distribution of load. Every bone in human body is structured to efficiently take the load where it is situated. Its structure is made such that it is so rigid that it can sustain the static or dynamic load it is subjected to and is made internally with a different structure to keep the blood flowing into and out of it to keep it alive.

The femur bone is the longest bone in a human body and is of utmost importance as most loaded bone. It is always under stress. And the stress is axial. It is interiorly connected with hip bone or the pelvis where the ball of femur fits in the socket of pelvis bone with the help of cartilages and muscles. Secondly it is exteriorly connected to the shank bones or the tibia and fibula and the patellar ligament or the Kneebone it present in the front to protect the joint.
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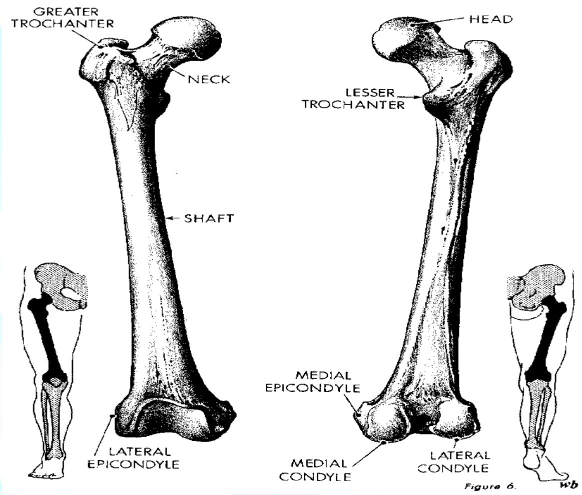

Fig. 1 The image given under shows the femur bone and its actual position in human leg

The cortical and trabecular bone together make up the entire structure of the bone. The cortical bone is considered to be the outer part of the bones in the body. It is a stiff bone and has a porosity of about 5 to 10%.The porosity of the bone is measured. The porosity is defined as the measure of the void (i.e. empty) spaces in a material, is a fraction of the volume, between 0-1, or as a percentage between 0-100 %. The term is used in multiple fields including pharmaceutics, materials, manufacturing, earth, sciences, soil mechanics and engineering. T he cortical bone is much denser, stiffer and stronger than the trabecular bones. On the other hand, the trabecular bone has a higher surface area and is known to be extremely porous. While the cortical bone forms the outer area of the bone, the trabecular bone makes up the inner part of the bone. The spongy bone, as it is frequently called, is highly vascular and is responsible for blood cell production. Cancellous bone, synonymous with trabecular bone or spongy bone, is one of two types of osseous tissue that form bones. Compared to compact bone (cortical bone), which is the other type of osseous tissue, it has a higher surface area but is less dense, softer, weaker, and less stiff. It typically occurs at the ends of long bones, proximal to joints and within the interior of vertebrae. Cancellous bone is highly vascular and frequently contains red bone marrow where hematopoietic, the production of blood cells, occurs. The primary anatomical and functional unit of cancellous bone is the trabecular.

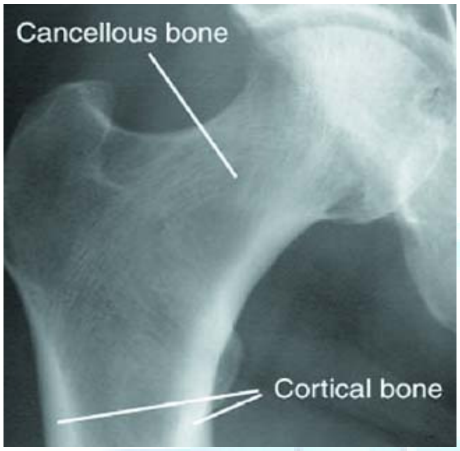

Fig. 2 Cancellous and Cortical Layers in Bone

Illustration of the different types of loading that can be imposed on bone. Bones can be subjected to axial compression, axial tension, torsion, shear, bending, or any combination of these.

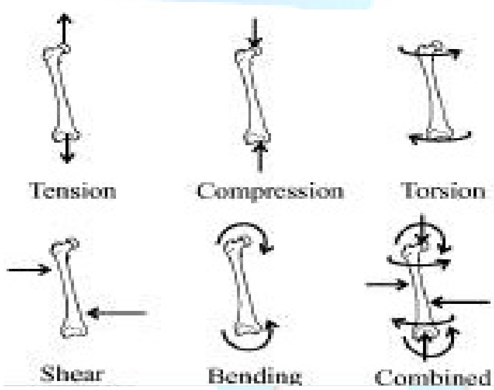

Fig. 3. the different stresses acting on a Femur bone

Because bones can resist more compression than tension, they typically fail in tension. For this reason, we theorize that osteoporotic fractures of the femoral neck happen by virtue failure at the superior aspect of the femoral neck (where tension develops as a result of weight-bearing during locomotion).

2. Theory

Bone is the actual solid component of the body. For its virtual analysis is a software we need to get the imaging of the part under experiment. The first step in getting the model of the part is to get it scanned in the form of cloud point data. Cloud point data technique is used to get greatest accuracy and its other advantage are given below

2.1 Cloud Point

Over the last few years, formal ontologies has been suggested as a solution for several engineer problems, since it can efficiently replace standard data bases and relational one with more flexibility and reliability. In fact, well designed ontologies own lots of positive aspects, like those related to defining a controlled vocabulary of terms, inheriting and extending existing terms, declaring a relationship between terms, and inferring relationships by reasoning on existent ones. Ontologies are used to represent formally the knowledge of a domain where the basic idea was to present knowledge using graphs and logical structure to make computers able to understand and process it. As most recent works, the tendency related to the use of semantic has been explored, where the automatic data extraction from 3D point clouds presents one of the new challenges, especially for map updating, passenger safety and security improvements. However such domain is characterized by a specific vocabulary containing different type of object. In fact, the assumption that knowledge will help the improvement of the automation, the accuracy and the result quality is shared by specialists of the point cloud processing.

A point cloud is a set of data points in some coordinate system.In a three-dimensional coordinate system, these points are usually defined by X, Y, and Z coordinates, and often are intended to represent the external surface of an object.Point clouds may be created by 3D scanners. These devices measure in an automatic way a large number of points on the surface of an object, and often output a point cloud as a data file. The point cloud represents the set of points that the device has measured.As the result of a 3D scanning process point clouds are used for many purposes, including to create 3D CAD models for manufactured parts, metrology/quality inspection, and a multitude of visualization, animation, rendering and mass customization applications. While point clouds can be directly rendered and inspected, usually point clouds themselves are generally not directly usable in most 3D applications, and therefore are usually converted to polygon mesh or triangle mesh models, NURBS surface models, or CAD models through a process commonly referred to as surface reconstruction. There are many techniques for converting a point cloud to a 3D surface. Some approaches, like Delaunay triangulation, alpha shapes, and ball pivoting, build a network of triangles over the existing vertices of the point cloud, while other approaches convert the point cloud into a volumetric distance field and reconstruct the implicit surface so defined through a marching cubes algorithm. Point clouds can also be used to represent volumetric data used for example in medical imaging. Using point clouds multi-sampling and data compression are achieved.

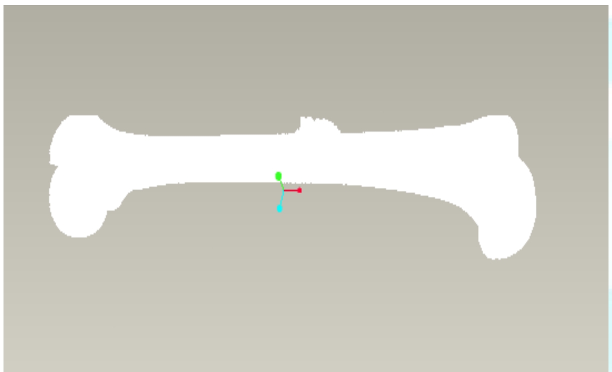

Fig. 4 Cloud point data image of femur

2.2 Surface and Solid Modeling

Surface Modeling:

Once we get the data in the form of cloud points, the next step is to make a surface model out of it. The surfacing is done with the help of CATIA software. We used the CATIA V5 R17 version of software to get the surfacing done. We open the cloud point data in IMAGEWARE software to create the surface modeling in image ware, we are took multi section's for generating the smooth multi curves.By using these curves we generate the (NURBS-Non Uniform Rational B-Splines) surfaces that are surface modeling. After that surfaces are exported in IGES format from image ware.

This surfaced model is the connecting link between the steps of scanning and the solid modeling. The data we get by scanning cannot directly be used for analysis. For that sec we need to generate the surfaced model of the part in the appropriate software.

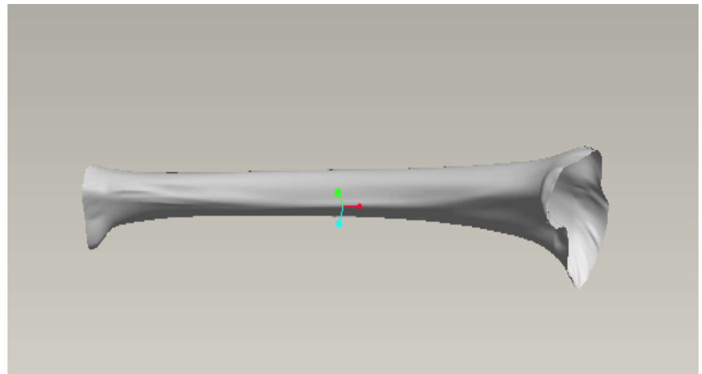

Fig. 5. Surfaced Image of Femur bone.

Solid modeling:

Femur is scanned by Romer Absolute Arm with integrated scanner. Scanning is done in polyworks scanning software. Points cloud capturing in polyworks software. Polyworks/modeler is a comprehensive modeling solution that enables a total interoperability between point cloud digitizing equipment and polygonal modeling (STL).First we spray the developer on the object surface to avoid the reflection when scanning by laser scanner.Laser rays are spread on the object surface, points cloud data captured in polyworks software slowly all around the surface of the component.

Now data is completely captured in the software, now edit the points cloud to polygonal mesh, after meshing export the data in STL format. After that, we will open the data in IMAGEWARE software to create the surface modeling in image ware, we are taking multi section's for generating the smooth multi curves. By using these curves we generate the (NURBS-Non Uniform Rational B-Splines) surfaces that are surface modeling.
After that surfaces are exported in IGES format from image ware.

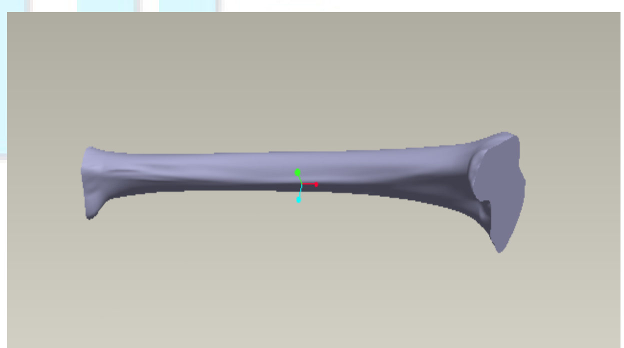

Fig. 6. Solid model Image of Femur bone

3. ANSYS Result

Meshing:

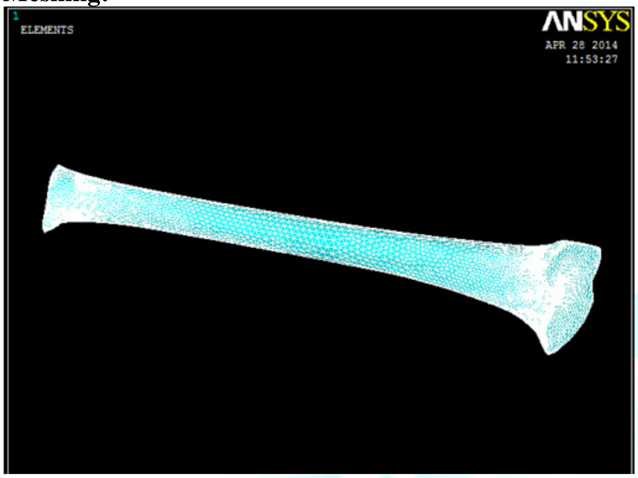

Fig. 7. Image of femur bone after meshing

Von mises stress:

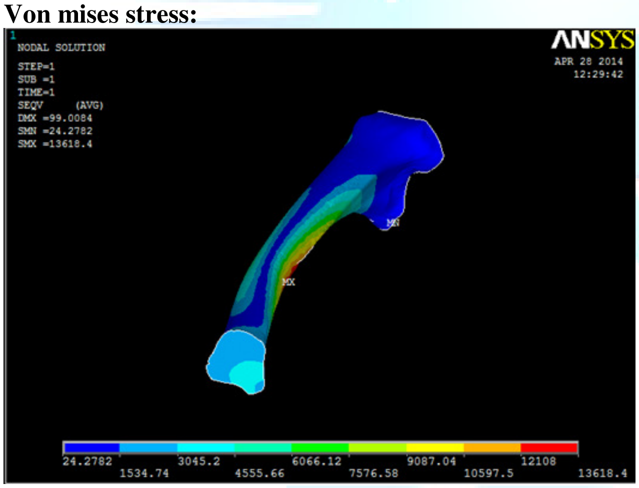

Fig. 8. Image of Nodal Solution of Von mises stress

Deformed shape:

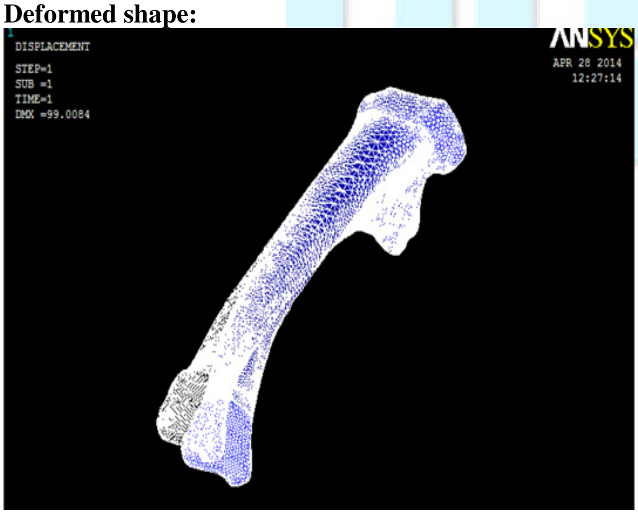

Fig. 9. Image of Nodal Solution of Von mises stress

Tabulated Result:

Table 1: Analysis Result

Element	*Max.*	**Min.**
Stress (N/mm^2)	13618.4	24.2782
Displacement (mm)	99.0084	-

4. Conclusions

- From the above analysis, it can be clearly stated that the stresses or strains on a bone can be evaluated virtually with great accuracy.
- The above analysis does not need practical testing of bone but the results thus obtained are comparable.
- This saves time, money as well as efforts.
- This is a helpful device in the field of health sciences, especially for orthopedics

Acknowledgments

It is a matter of great satisfaction and pleasure to present the paper on "Analysis of Stresses on Human Femur Bone".With great pleasure we express our deep sense of gratitude to our paper guide Prof. S. N. Khan for his valuable guidance, discussion and constant encouragement for successful completion of this paper work. He gave us suggestions and constructive inputs from time to time in friendly manner, which is perhaps a unique characteristic nature of his mind.

We are highly obliged to our respected Head of the Department Prof. Dr. A.A.Pawar and All staff members for their kind co-operation and help.

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