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Analytical Study of the Tibia Bone under Static Load using Finite Element Method

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Abstract: In this study, Tibia bone stress analysis using the Finite Element Method under static load has been studied. And also for identification of the stress concentrated regions in the tibia bone. The human body consists of many bones and muscles. In many instances, we see our body mainly bones in the body prone to many damages due to different type of loads applied. So, it is necessary to estimate the effects of the applied loads on the body. In this study, we will deal with static loads only. For a human to walk, one has to carry the whole weight of the body. Sometimes, whole weight of the body may be shifted on to the single leg while running means whole weight of the body will transfer to the tibia bone which is below the knee roll though the thigh bone. So, the tibia bone should have enough strength to carry the body weight. Understanding the biomechanical behaviour of the tibia bone during the static as well as dynamic loading is essential in order to formulate objective treatment solutions in case of ankle trauma and fracture. But, our study limited to static loading only.
Keywords: Tibia bone, Finite Element Method.

I. INTRODUCTION

The human body consists of many bones and muscles. In many instances, we see our body mainly bones in the body prone to many damages due to different type of loads applied. So, it is necessary to estimate the effects of the applied loads on the body. In this study, we will deal with static loads only. For a human to walk, he/she has to carry the whole weight of the body. Sometimes whole weight of the body may be shifted on to the single leg while running means whole weight of the body will transfer to the tibia bone which is below the knee roll though the thigh bone. So, the tibia bone should have enough strength to carry the body weight. For that, there is a need to have a knowledge regarding bone composition and Mechanical behaviour of the tibia bone. Mechanical behaviour of the bone and bone composition have been taken from the previous studies. In this study, we will deal with tibia bone stress analysis using the Finite Element Method under static load only. The subject deals with this type of problems is 'Biomechanics'. Biomechanics is the study of the structure and function of biological systems such humans, animals by means of the methods of mechanics. Understanding the biomechanical behaviour of the tibia bone during the static as well as dynamic loading is essential in order to formulate objective treatment solutions in case of ankle trauma and fracture. But, our study limited to static loading only. In this, we will study stress variation in the tibia bone under static load.

The tibia is a long hollow leg bone, which has an expanded metaphysic and an epiphysis at both ends of a thick-walled tabular diaphysis. The proximal end of the human tibia displays very special characteristics; it is form by the superior base of a truncated cone. The plateau presents two condyles, internal (medial) and external (lateral), which articulated with the medial and lateral condyles of the femur respectively. The external plate is smaller but higher than the internal one, displaying a convex shape. The internal plate is concave. Going down, the tibia narrows into the diaphysis, which is also called the shaft of the tibia, and then expands again towards the distal end of the tibia that articulates the ankle [6]. The Finite Element Method (FEM) has been used widely in biomechanics to predict stress and strain in complicated systems, load transfer in prosthesis, effects of the internal loads and contact condition on the interface between prosthetic socket and residual limb [7, 8]. Many studies have suggested that the compressive strength and elasticity of trabecular bone is related to its density [9, 10].

Objective of this study is to analyse the tibia bone using Finite Element Method under static load (weight of the body). For Finite Element Analysis of the tibia bone material properties, boundary conditions and load applied have to be supplied. Mechanical properties of the tibia bone have been taken from the current literature and research. And also to identify the stress concentrated regions of the tibia bone under static load.

II. METHODOLOGY

To perform the analytical study on tibia bone, model of the tibia bone has to design. Model of the tibia bone was designed using design softwares. Then, the designed tibia bone is shown in Fig.1.1 will be analysed using finite element method, for this

Solidworks® 2016 software was used. Stresses and strains developed in the tibia bone were obtained. To carry out the Finite Element Analysis (FEA), we have to provide material properties of the tibia bone are shown in Fig.1.2. Finite Element Analysis (FEA) gives stresses and strains produced in the tibia bone on each element and at each node.

Fig.1.1 Model of the Tibia bone

	Elastic Modulus (MPa)	**Density (kg/m³)**	**Poisson's Ratio**	**Shear Modulus (MPa)**	**Tensile Strength (MPa)**	**Yield Strength (MPa)**
Cortical bone	**17500**	**2000**	**0.300**	**318.9**	**135**	**125**

Fig.1.2 Properties of the Tibia bone

In this study, only static condition is considered for study of stress analysis in the tibia bone. In Static condition, weight of the human body is the only load will act on the tibia bone. Average weight of the adults is considered to be 70 kg. And the loading surface area of the tibia bone superior face approximately considered to be 120 cm^2.

$$pressure = \frac{load}{area}$$
$$= \frac{70}{120}\frac{kg}{cm^2}$$
$$= 0.5833\frac{kg}{cm^2}$$

In static condition, whole weight of the body will transfer to the lower parts of the body. Total load will be distributed equally to both the lower legs like simply supported beam. As we have taken total weight of the body is 70 kg. So, half of the load will be transfer to the each of the tibia bone. Now, weight applied on each tibia in static condition is 35 kg. So, Pressure applied on each tibia bone is **0.29167 kg/cm²**. For the stress analysis in the tibia bone, boundary conditions have to be provided. Lower part of the tibia bone (Talus) is fixed (all degrees of freedom arrested) and on the upper part of the tibia bone is supplied with load.

III. RESULTS

Results obtained for Analytical study of the tibia bone under static load using Finite Element Method are presented. Finite Element Analysis gives the Stress distribution within the tibia bone, it is very necessary to the transplants of the bone, and prosthesis of the bone. It helps to identify the stress concentrated regions in the tibia bone.

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A. Von-Mises Stress Analysis

After loads applied, the von-mises stress result gives the stress concentrated regions in the tibia bone. Below Figures shows the stress concentrated regions of the tibia bone in different views. From the stress analysis of the tibia bone, it can be observed that stress concentration is more in the region of small area. It can be concluded that stress concentration is more in the outer surface of the tibia bone just above the talus bone. Stress analysis results are shown in Fig.1.3, 1.4, and 1.5.

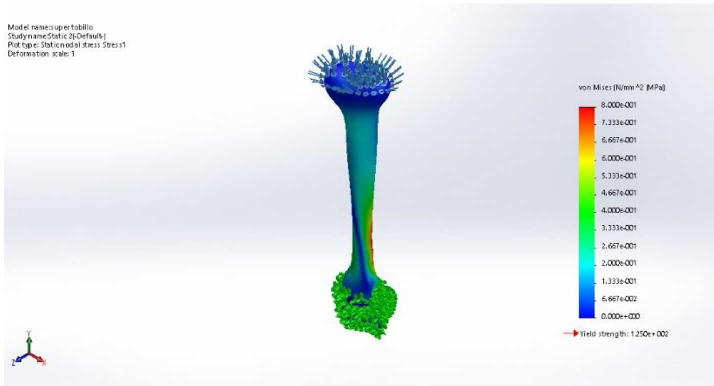

Fig.1.3 Isometric View of the Tibia Bone after Stress analysis

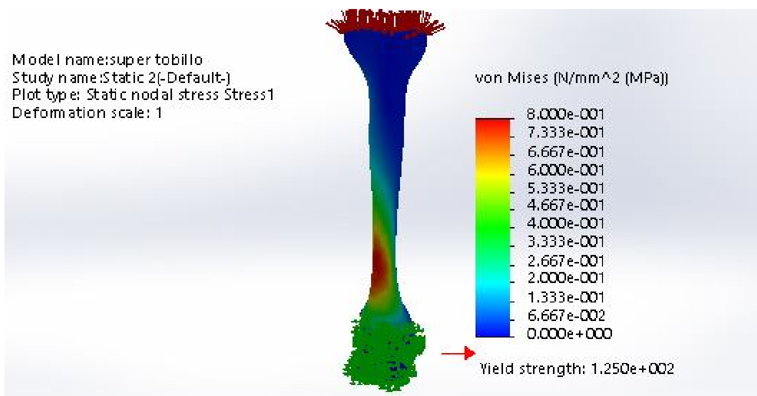

Fig.1.4 Right side View of the Tibia Bone after Stress analysis

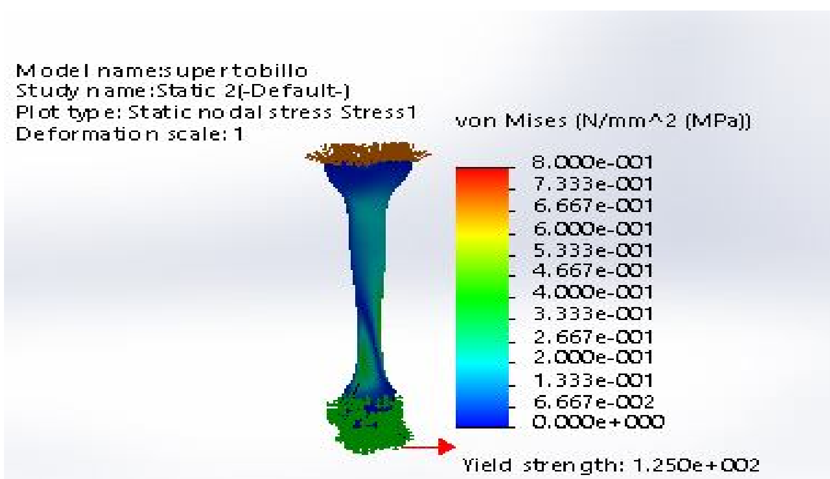

Fig.1.5 Front side View of the Tibia Bone after Stress analysis

B. Strain Analysis

Strain analysis under the given boundary conditions gives the critical compression region in the tibia bone. Strain analysis results are shown in Fig.1.6, 1.7, and 1.8.

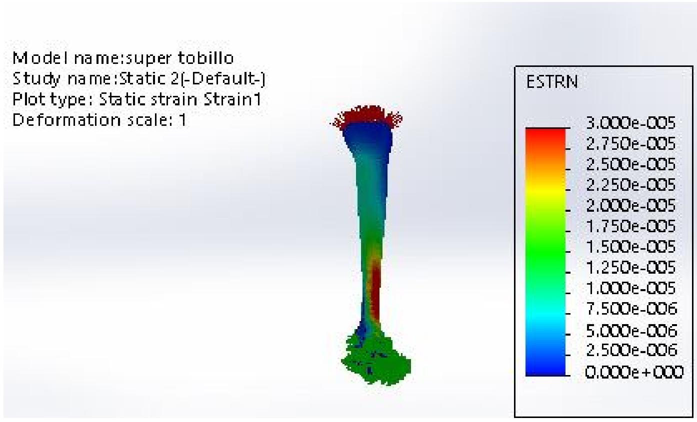

Fig.1.6 Isometric View of the Tibia Bone after Strain analysis

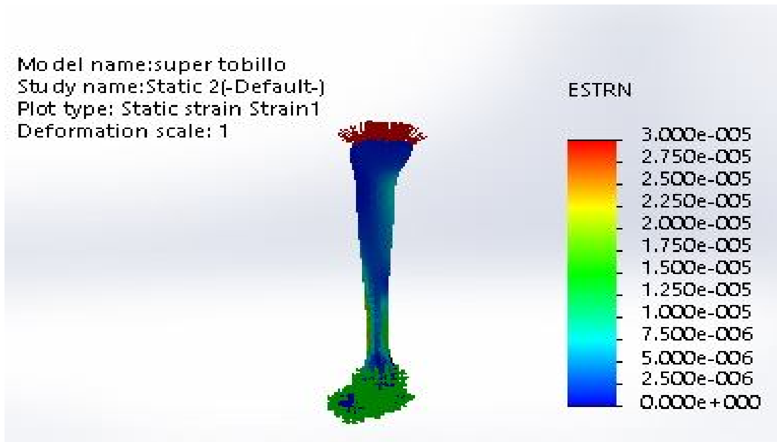

Fig.1.7 Front Side View of the Tibia Bone after Strain analysis

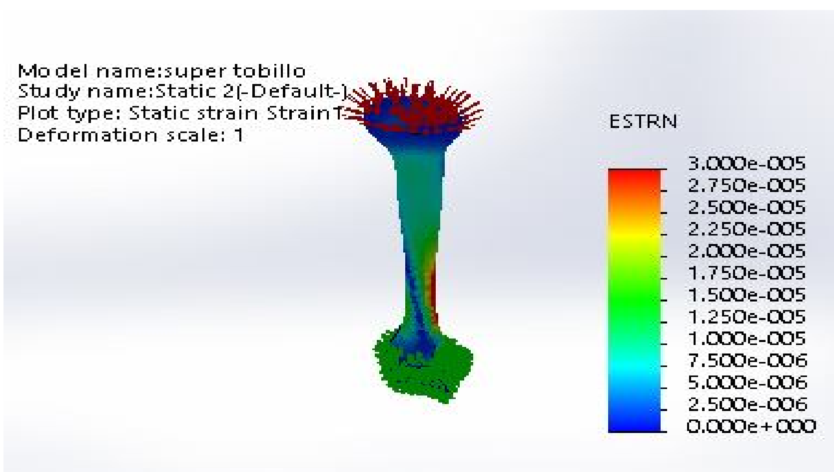

Fig.1.8 Right Side View of the Tibia Bone after Strain analysis

IV. CONCLUSIONS

Finite Element Analysis is a good method in finding the main causes of long- term bone fracture, bone resorption for clinical practice. FEA can be used to study the developed stresses and contact conditions at the bone physiological loading in order to determine the biological response of the bone. And also, FEA provides the optimized implant design and proper material selection in load bearing implants. From the results shown in the results and discussion section, it can be concluded that stress concentration occurs more in the region of least cross sectional area of the tibia bone.

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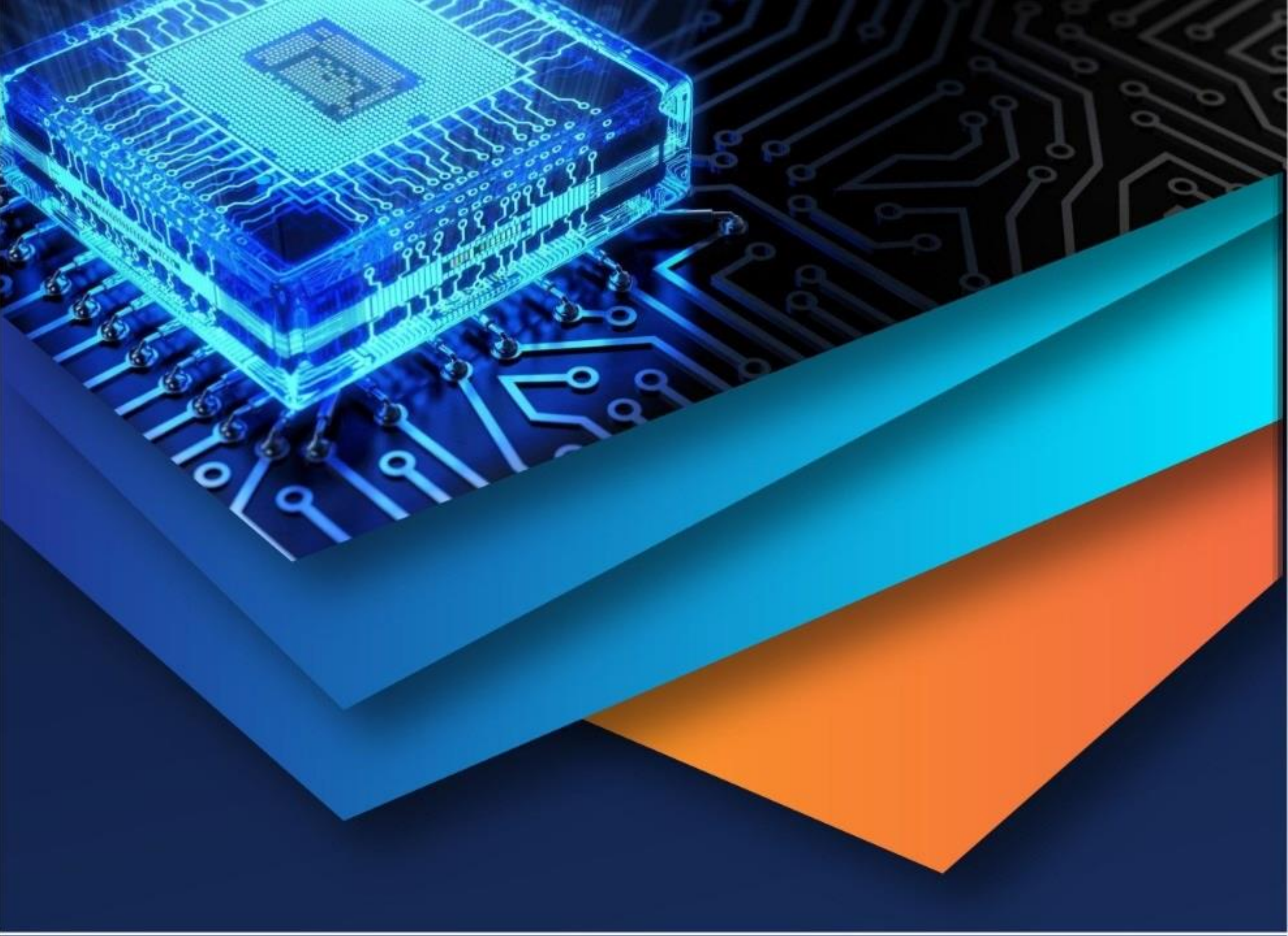
REFERENCES

[1] Namrata Phate, Raji Nareliya, Veerendra Kumar, Amrita Francis, “Three-Dimensional Finite Element Analysis of Human Tibia Bone”, Volume 3 Issue 1, April 2014.
[2] Tofan Doru-Alexandru, Tomoaia Gheorghe, “Tibio-Tarsal Joint Biomechanics Analisys through Finite Element Modeling”, A Static Loading Model of the Human Tibio-Tarsal Joint.
[3] Prasanna Kumar Lenka and Amit Roy Choudary, “Analysis of trans tibial prosthetic socket materials using finite element method”, J. Biomedical Science and Engineering, 2011, 4, 762-768.
[4] Little RB, Wevers HW, Siu D, Cooke TD, “A three-dimensional finite element analysis of the upper tibia”, J Biomech Eng. 1986 May;108(2):111-9.
[5] M.A. Lafortune, P.R. Cavanagh, H.J. Sommer III, A. Kalanek, “Three-dimensional kinematics of the human knee during walking”, Journal' of Biomechanics, Vol. 25, 1992, pp. 347-357.
[6] Buckwalter, J.A.; Glimcher, M.J.; Cooper, R.R.; Recker, R. “Bone biology, part I: Structure, blood supply, cells, matrix, and mineralization”. Journal of bone and joint surgery (1995), 77A; 1256-1275.
[7] Faustini, M.C., Neptune, R.R. and Crawford, R.H., “The quasisstatic response of compliant prosthetic sockets for transtibial amputees using finite element methods”. Medical Engineering & Physics (2006), 28; 114-121.
[8] Jia, X., Zhang, M. and Lee, W.C.C., “Load transfer mechanics between trans-tibial prosthetic socket and re-sidual limb- dynamic effects”. Journal of Biomechanics (2004), 37; 1371-1377.
[9] Bell, G.H., O. Dunbar, J.S. Beck & A. Gibb., “Variations in strength of vertebrae with age and their relation to osteoporosis”. Calcified Tissue Research (1967), 1; 75-86.
[10] Weaver, J.K. & J. Chalmers., “Cancellous bone: Its strength and changes with aging and an evaluation of some methods for measuring its mineral content. I. Age changes in cancellous bone”. Journal of bone and Joint Surgery (1966), 48A; 289-299.
[11] Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P. Molecular biology of the cell. 4th edition.
[12] Junqueira, L.C.; & Carneiro, J. (1999). Histologia básica. 9 ed, Rio de Janeiro: Guanabara Koogan.
[13] Junqueira, L.C.; & Carneiro, J. (1997). Biologiacelular e molecular. 6 ed. Rio de Janeiro: Guanabara Koogan.
[14] Holtrop, M.E. (1975). The ultra structure of bone. Ann Clin Lab Sci, 5:264.
[15] Sailesh Rajani., 3-D Modelling and Finite Element Analysis of the Tibia.
[16] Antonia Dalla Pria Bankoff, “Biomechanical Characteristics of the Bone” University Of Campinas, Brazil.
[17] M. Franklyn, and B. Oakes, Tibial Stress Injuries: Aetiology, Classification, Biomechanics and the Failure of Bone.



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