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The Effect of Human Body Weight on Stress Induced in Human Femur Bone

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ABSTRACT
This work represents a static analysisfor intact finite element (FE) femur bonemodel. Where stress distribution in intact femur bone under different activity and for excessive load that was stumbling case(critical and dangerous load case). ANSYS workbench version .14 was used in this numerical analysis. The results represent the effect of body weight on both stresses values and distributions. Results show that body weight effect on stress with different behavior but in general even though results are obtained using a load case obtained from literature as well as average material properties, it is considered that they give an indication of critical places considering equivalent stress in a femur using this modeling approach, a next course of action, considering medical treatment of the patient or surgery planning, may be undertaken. , present work can be utilized to predict stress in femur bone at specific positions that helped the designer of hip prosthesis to imagine critical stresses values.

Keywords: Static analysis, intact femur, Stumbling case, ANSYS workbench. Hip prosthesis

1. INTRODUCTION

Of all human long bones, femurs are the heaviest, longest, and strongest. In younger people with good bone quality, normal bone properties, femur fractures usually require highenergy events such as the 6.5 million automobile accidents that occur annually in the U.S. alone, U.S. Department of Transportation, 2007. In elderly people with poor bone quality, osteoporosis or osteopenia, lowenergy impact from falls is the most frequent cause of femoral neck fracture Pankovich et.al.[1], the finite element method has become a particularly useful tool in analyzing the stresses in structures of complex shapes, loading and material behavior. Anoverview of its application in orthopedics during the last ten years has beenpresented by Prendergast [2]. For a complete and accurate indication of thestresses in the bone, the model must be modeled in threedimensionalsystems.

2. FINITE ELEMENT MODEL

Model of femur bone had been used in this study where it is imported as (CAD Model [IGES], Sawbones, Vashon, WA, USA) which was consist from cortical bone, lower and upper cancellous bone. It is available in public domainderived from a CT-scan dataset of a synthetic human femur. It is imported to (ANSYS workbench software program version .14) where modeling process femur geometry was accrued by introducing the meshing properties and material properties and then by generating mesh to whole model. The femur in this stage consisted of 30176 key points and 1350.0 lines.In several cases, there were non-continuous and non-smooth curves in the model that induced errorsin the output model; hence, a curve smoothing approach was implemented to avoid such incidenceand to allow meshgenerators more flexibility.

Static analysis for jogging, up and down stairs climbing, and stumbling load case had been studies**.** Based on common geometry, it is practical to compare results from different FEM studies worldwideand besides, FE model could be calibrated withdata from experimental tests availablein the literature. The latter one is of great importance as it is not always possible in biomechanicsto do experimental tests for validating and verifying the numerical tests.More information about the physical object from which the standardized femur model has beenderived is available from M. Viceconti, [4].

4. MATERIAL PROPERTIES

The material properties of FE intact femur bonethat analyzed in present work are illustrated in Table.1.Where bone model was modeled as an isotropic material A. Completoa, et. al., [5]

5. LOADING AND BOUNDARY CONDITION

Static analysis for the most important and dangerous load case on femur bone (stumbling load) where the load reached to 8.7 times the body weight, and for jogging , down , up – stairs climbing load cases, the ratios of these loads times body weight were represented in Table.2. In this work the body weight assumed to be equal to 70, 80, 90 and100 kg.Distal end of intact femur modelwas fixed.For each reconstruction, the force was applied vertically on the upper cortical part S.Shaha, et. al., [6].

6. RESULTS

The FE Von Mises stresses(static analysis) distributions fordifferent types of loading had been representedfor different body weights, some resultsare shownin Fig.2. Where comparison between 70kg, 100kg body weight had been represented, it is clear from Fig.2a, Fig.2b that the maximum difference in von misses stress reaches to67Mpa for stumbling load case, due to excessive load that produced in in case of 100 kg under stumbling case, results for stumbling load case and for other activities are shown in **Fig.3** for body weight of (70, 80, 90, and 100kg) respectively.

Generally it is clear from whole results for each case that the equivalent stresses were higher in compression for the concave side than intension on the convex side and were greater in the coronal plane, Posterior part of the neck was under effect of tension at distal portion of the femur with this loading conditions, as expected from the normalconcavity of the posterior aspect of the femur. While in the anterior side there issmall fluctuation in the nick but it could be considered as predominately subjected toa compressive axial stress.

Whole results of current study show that increasing body weight leads to increase the von. Misses stress and also to change the stress distribution along the whole bone geometry. these results can be utilized when we implant prosthesis to afemur in order to comparing the stresses/strains distribution round the femur where the can help the designer to improve the prosthesis design parameters and the effect of each one on general stress distribution and in study the effect ofprosthesis fixation (stress shielding) in attempting to reach to be close to stresses distribution of the intact femur, for example, theremodeling phenomenon due to stress shielding.

7. DISCUSSIONAND CONCLUSIONS

The aim of this study wasto develop a practical FE model and to estimate the risk of bone failureduring gait based on static analysis type especially for excessiveload case that was stumbling in order to simulate this critical load type that any femoral bone can be loaded by it, then totake account of patient activity when designing total hip replacement based on critical positions of stress concentration by working on reducing it as possible. In this regard the stress field in theartificial hip components (prostheses, cement mantle, and bone) isanalyzed statically. Also to investigate; peakstress. Where three dimensional subject specific FE model was used to calculate the stress patterns due to loads derivedfrom daily activities.

REFERENCES

1. Pankovich AM, Elstrom JA. Intracapsular fractures of the proximal femur. In: Elstrom JA, Virkus WW, Pankovich AM, editors. Handbook of fractures. Toronto, ON: McGraw-Hill; 2006. p. 264–92.
2. Prendergast, P. J., "Finite element models in tissue mechanics and orthopaedic implant design," Clinical Biomechanics,12(6): 343-366, 1997.
3. H.F. El'Sheikh, B.J. MacDonald, M.S.J. Hashmi, 2003, Finite Element Simulation of The Hip Joint During Stumbling: a Comparison Between Static and Dynamic Loading, Journal of Materials Processing Technology vol.144, No. 2, pp. 249–255.
4. M. Viceconti,"The ISB finite element repository, Instituti Rizzoli, accessed on August 2001, http://isb.ri.ccf.org/data, 1997.
5. A. Completoa, F. Fonsecab, J.A. Simoesa, Experimental validation of intact and implanted distal femur finite element models,2007,Journal of Biomechanics 40 2467–2476
6. Suraj Shaha, HabibaBougherara, Emil H. Schemitsch, Rad Zdero,Biomechanical stress maps of an artificial femur obtained using a new infrared thermography technique validated by strain gages ,2012, Medical Engineering & Physics.

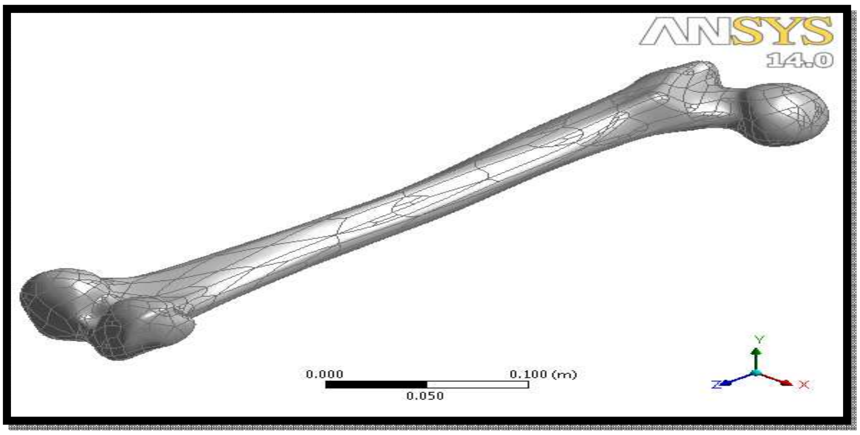

Figure.1 Finite element model of intact femur bone

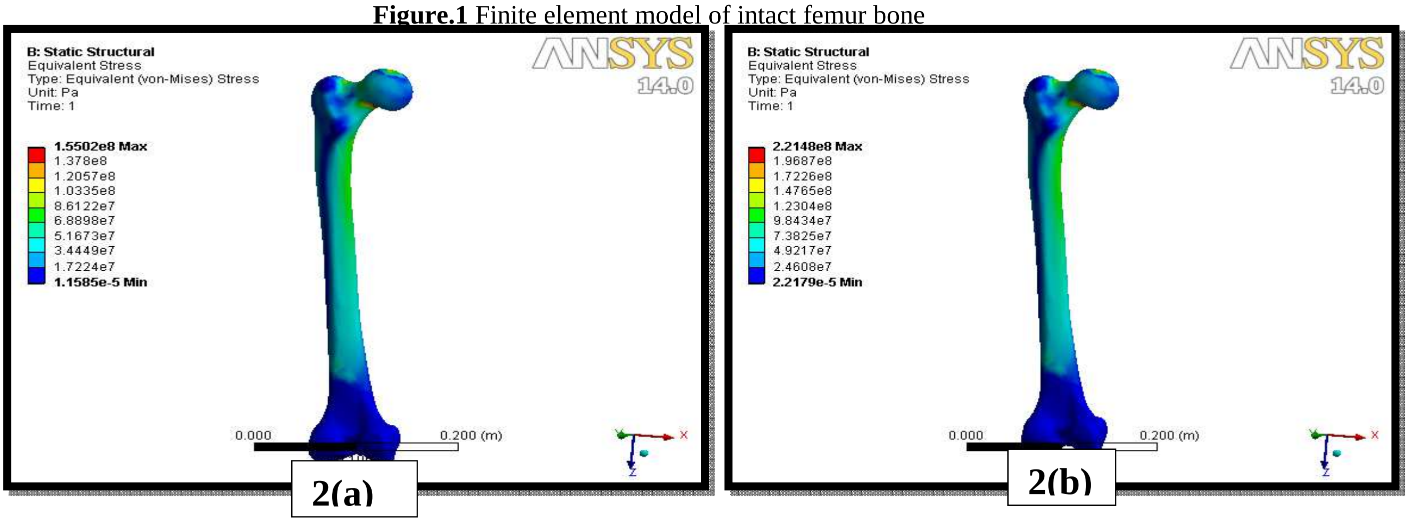

Figure.2 Maximum von misses equivalent stress femur bone (static analysis) Standing case for body weight: 4(a) 70 kg, 4(b) 100kg

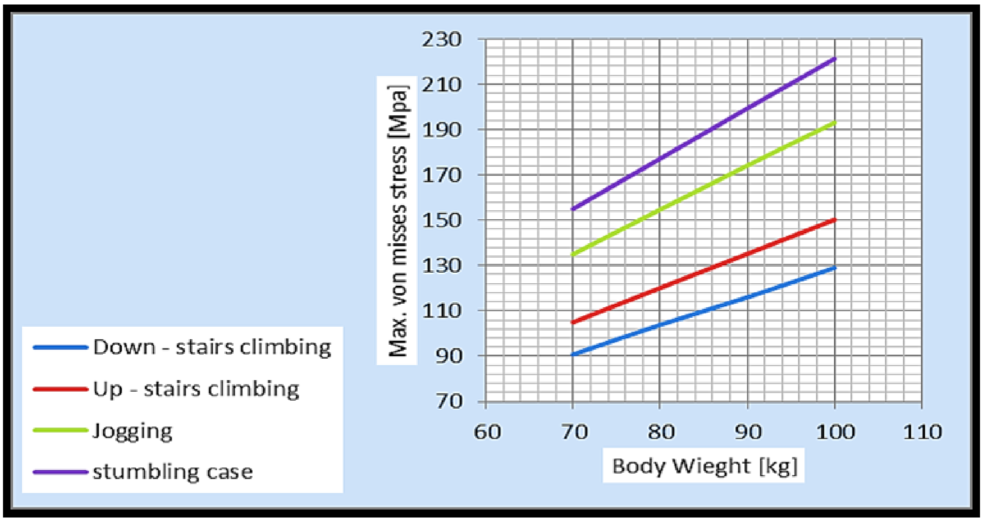

Figure.3 Maximum von misses equivalent stress of intact femur bone (static analysis) for many loadcaseswith body weight (70 – 100) kg.

Type	Young's modulus[Gpa]		Poisson's ratio
isotropic	Cortical Bone	12.4	0.3
	Cancellous Bone	0.104	0.3

Table.1 Material properties

Activity	**Load times body weight (BW)**
Jogging	7.6×BW
Up – stairs climbing	5.9×BW
Down – stair climbing	5.1×BW
Stumbling	8.7×BW

Table .2 Load ratios with respect to body for different activities