Hip screw compression fixation for a femoral neck fracture

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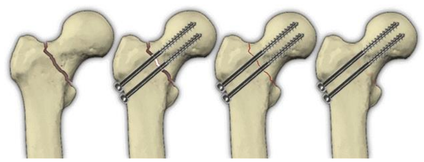
Problem Description

One of the most common problems encountered in femoral neck failure is the fact that patient is not able to walk immediately after the surgery. To resolve the problem, the most common procedure is inserting few screws to connect the femoral head and femur.



Project's Goals

- To investigate the screw pattern impact on the performance of the hip immediately after the surgery
- To analyze the effect of different bolt materials(which is better: stiffer or softer?)
- To study how the number of the bolts affect the stress concentration in the body of the hip

Methodology

- SIMULIA Abaqus software was used for modeling
- Different materials used for screws including Ti, Steel, and some hypothetical materials
- Validating some of the results with Solid Works simulations

Data

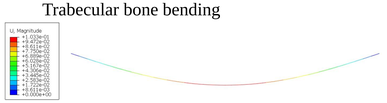
	Trabecular	Cortical
Density ($^{g}/_{cm^3}$)	1	1.2
Young's modulus (MPa)	2671	4055
Numbers of element	50	50
Poison's ratio	0.3	0.3
Radius of cross section(mm)	15	15
Length (mm)	380	380
Load applied ($^{N}/_{m}$)	40	40

$E_{eff} = V_c.E_c + V_t.E_t$ = 3635.505879 Mpa
ν=0.3

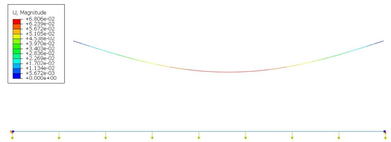
Validation

Abaqus Model

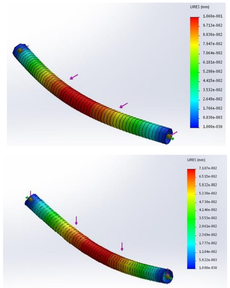
Trabecular bone bending



Cortical bone bending



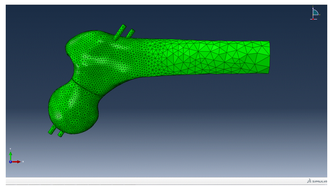
Solid Works Model



Mesh

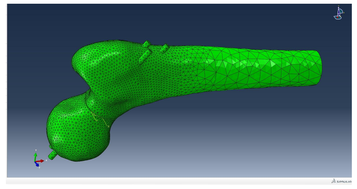
Elements' type:C3D10 (10 node quadratic tetrahedral)

2 screws



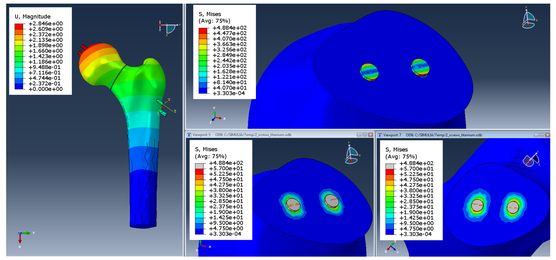
Number of elements:67872

3 screws

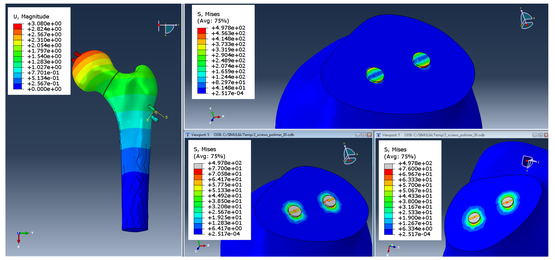


Number of elements:75195

2 Screws

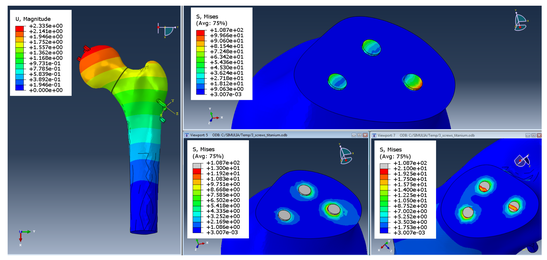


Ti screws

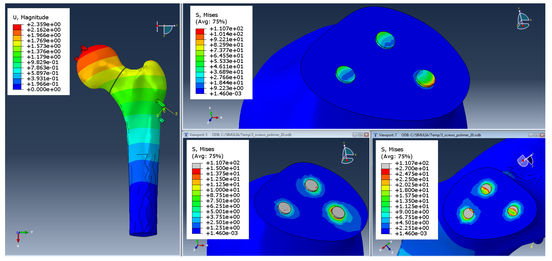


Hypothetical screws(20 times stiffer than the bone)

3 Screws



Ti screws



Hypothetical screws(20 times stiffer than the bone)

Conclusions

1) FEA analysis of the femur bone reinforced by two and three screws is performed
2) Different screw materials were tested
3) Simulation performed with 67872 and 75195 element for the 2-screws and 3-screws cases correspondingly
4) 10 node quadratic tetrahedral elements were used
5) Validation of the results for bone properties obtaining was performed (Abaqus results VS SolidWorks ones)
6) After simulation it appeared that the best way to fixate failed femur neck with 3 screws made of steel.

	2 Screws					3 Screws				
Screw material	Steel	Titanium	E=5Ebone	E=10Ebone	E=20Ebone	Steel	Titanium	E=5Ebone	E=10Ebone	E=20Ebone
Umax, mm	2.704	2.846	4.247	3.57	3.08	2.32	2.335	2.46	2.402	2.359
S VM max, bone, MPa	47.19	57	158.12	117	77	17.1	21	47.94	36.07	27
S VM max, screw, Mpa	487.2	488.4	508.9	512.4	497.8	110.5	108.7	121.5	115	110.7

References

1. Rajapakse, Chamith S. et al. "Micro–MR Imaging–based Computational Biomechanics Demonstrates Reduction in Cortical and Trabecular Bone Strength after Renal Transplantation." *Radiology* 262.3 (2012): 912–920. *PMC*
2. San Antonio, T., Ciaccia, M., Müller-Karger, C., Casanova, E., 2012. Orientation of orthotropic material properties in a femur FE model: a method based on the principal stresses directions. Medical Engineering and Physics 34, 914–919