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A FEM APPROACH TO STUDY AND ANALYSE OF VIBRATION IN PROSTHETIC KNEES IMPLANTATION

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Abstract : FEM has been extensively utilized in engineering and quantitative modeling to numerically resolve differential equations. This research has examined the impact of swinging phases, mandibular and other variables and overweight of total knee substitutions using a finite element technique. Finite element has been utilized to investigate and assess complete joint replacements for mechanical behavior. Total joint substitutions are increasingly being used in the concept, research, and pre-clinical examinations.

***IndexTerms* - knee replacements, prosthetic knees implant, FEM approach.**

I. INTRODUCTION

The prosthetic knee joint has been a topic of great interest in the past. Over time, various researchers have worked on the prosthetic knee joint trying to address the issues like geometric modeling, stress analysis between the articular surfaces, reliability, and fatigue life, wear, dynamic analysis, etc. A large amount of literature is available in this regard. Artificial knee joints can be divided into mechanical and computer types. Mechanical knees can be divided into uniaxial knees and multiaxial / multicentral knees. All knee replacements require some form of a stabilization mechanism. This is a manual or weight- actuated locking system. We also need a way to control flexion and extension movements. Knee replacement is the surgical replacement of the knee joint, where the femur and tibia meet, with an artificial joint or implant. This process may seem modern but dates back to the mid-19th century. Medical technology companies have advanced all types of artificial joints over the last three decades as doctors have discovered a growing demand for artificial joints. Younger (and more active) potential recipients are tired and injured in their joints, demanding permanent or semi-permanent medical solutions. Doctors recommend knee **replacement if the** patient is suffering from constant pain or if daily activities are affected by limited mobility. According to the American Academy of Orthopaedic Surgeons, more than 90% of knee replacement patients experience a significant reduction in knee pain. Recipients may undergo partial or complete knee arthroplasty. The difference depends on the recipient's condition and the level of pain. To verify the artificial knee's functionality following a transplant, a comprehensive investigation of load, dynamic behavior, and wear prediction is necessary. There was no avoiding the fact that finite element analysis will serve as a computational approach for biomedical as well as other technical hurdles. Researchers have looked into both non-contact and contact analysis to better comprehend the prosthetic knee joint's behavior. It was necessary to investigate the impact of bone deformations on contact behavior, so the convergence of finite element solutions was analyzed. Precise solutions for femorotibial contact behavior are obtained by treating the bones as rigid. The articular surfaces of the femoral condyles were measured along their sagittal axis with a laser rangefinder, and the average of these measurements was then used to conduct a femorotibial contact analysis. The stress predictions are sensitive to the mesh resolution. Reproducing the kinematics, contact pressure distribution, and contact area of a deformable system is the goal of the rigid body analysis.

II. METHODS AND MATERIAL

2.1 Dynamic Analysis: The three-dimensional dynamic response of the human knee joint has been studied and reported that most isolated posterior cruciate ligament injuries and combined posterior cruciate and medial collateral ligament injuries are due to posterior impact on the flexed knee. The dynamic multibody musculoskeletal model can predict muscle strength and joint contact pressure at the same time.

2.2 Thermal Analysis: Polymers, which are used as biomaterials for tibial components, change their properties significantly as a function of temperature. Friction creates surface heat during the range of motion throughout the knee, leading to damage and breakage of the ultra- high molecular weight polyethylene tibial insert. The performance of the prosthesis should minimize the effect of heat on the surface of the joint component.

Following are the objectives of work

1) Acceleration and maximal pressure differences are evaluated between set and telephone knee implants during each step in

the gait cycle.

2) Determining the cost-effectiveness of lifelong knee pain.

3) Indication of efficiency in a range of situations with static and wireless arrangement inserts.

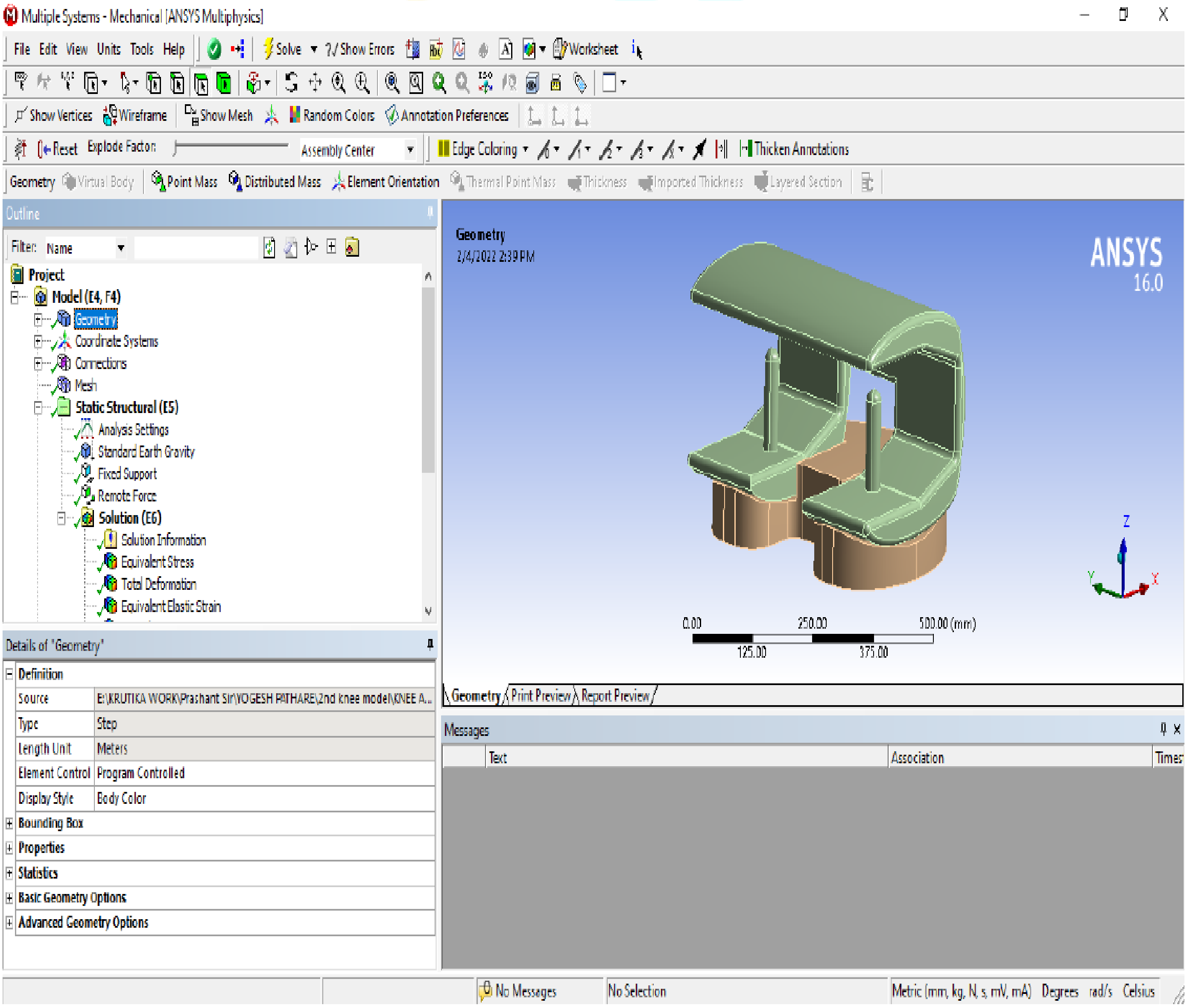
4) To measure the deepness and effect of the tibial part on the pressure of the tibial bearing.

Details of material used are as the materials used are Cobalt Chromium Alloy, Nitinol, Ti-6Al-4V

2.3 Numerical Modelling: Composite beams gleaned from experiments and numerical applications, in particular the "A3" model, are put to use in this endeavour. The finite element model was created with the same geometries, parameters, material properties, and lingo as the composite beams.

2.4 Material Modelling: The finite elements in the ANSYS code standard library were used to define the proposed numerical model. SOLID186, a 20-node high-order 3D solid element was used. Non-linear spring elements (ANSYS COMBIN39) and (Beam 189) are used to represent the behaviour of chemical anchors. COMBIN39 is used to resist the normal force between the concrete and the steel beam. COMBIN39 is a non-linear generalized force-deflection unidirectional element (or non-linear spring) that is used in the analysis. Concrete compressive strains of 0.2% and 0.35% are used to define the lower and upper bounds, respectively.

2.5 Geometry: Geometry used is shown in Figure.1



Details of "Geometry"

Definition

Source	E:\KRUTIKA WORK\Prashant Sir\YOGESH PATHARE\2nd knee model\KNEE A...
Type	Step
Length Unit	Meters
Element Control	Program Controlled
Display Style	Body Color

Bounding Box

Properties

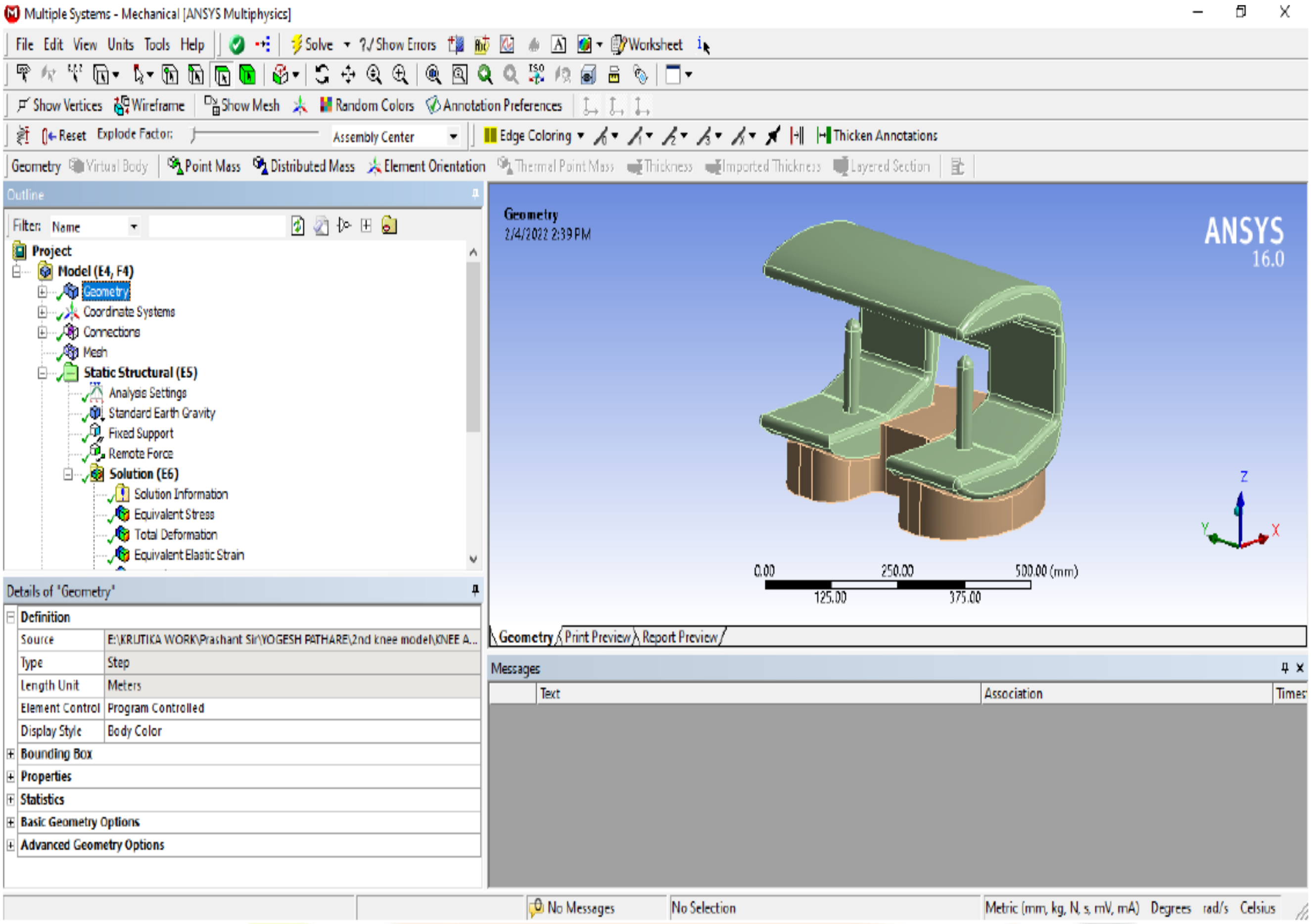
Statistics

Basic Geometry Options

Advanced Geometry Options

Fig. 1:Geometry

2.6 Meshing: Meshing carried out is shown Figure.2

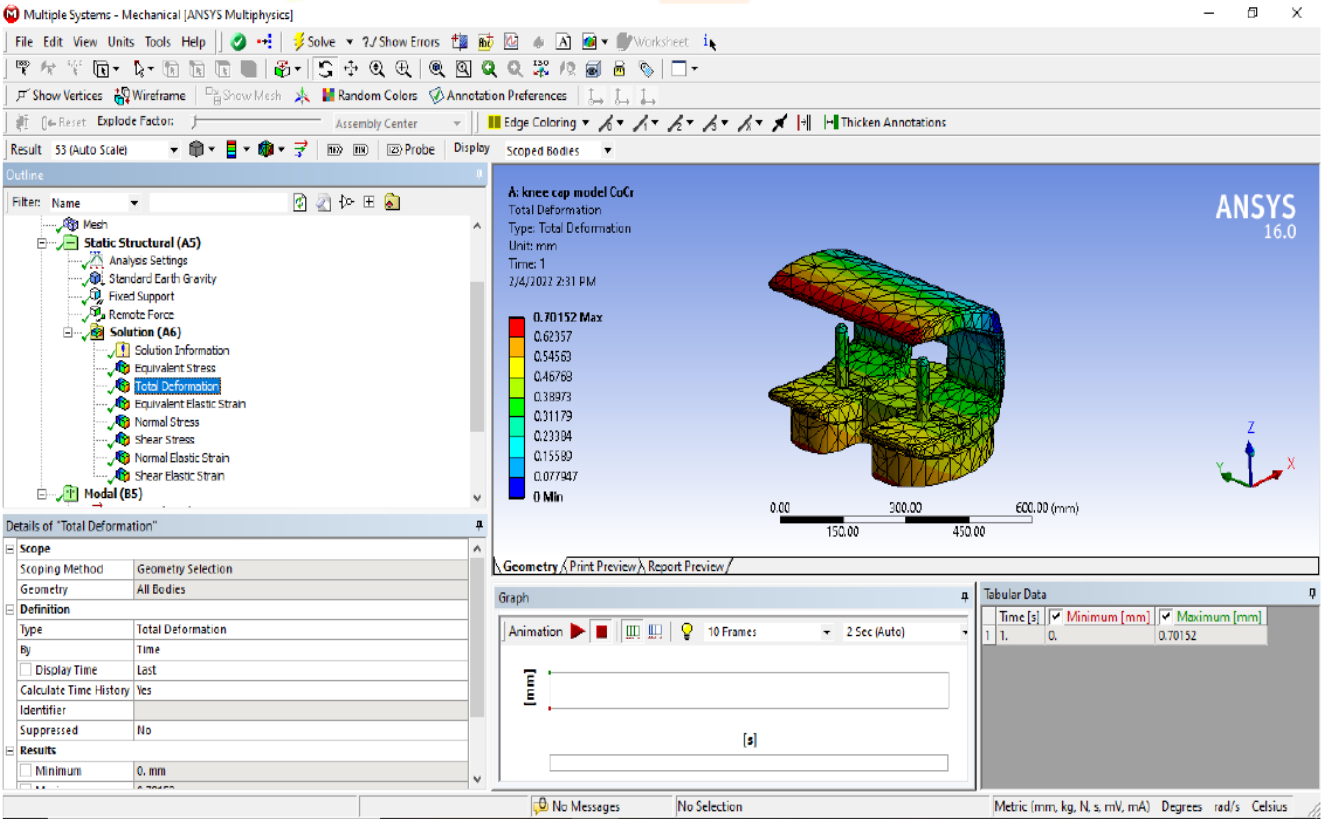


Details of 'Geometry'

Definition	
Source	E:\KRUTIKA WORK\Prashant Sir\YOGESH PATHARE\2nd knee model\KNEE A...
Type	Step
Length Unit	Meters
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	
Properties	
Statistics	
Basic Geometry Options	
Advanced Geometry Options	

Fig. 2: Meshing

2.7 Total Deformation: Total deformation obtained for CoCr is shown in Figure.3



A: knee cap model CoCr
Total Deformation
Type: Total Deformation
Unit: mm
Time: 1
2/4/2022 2:31 PM

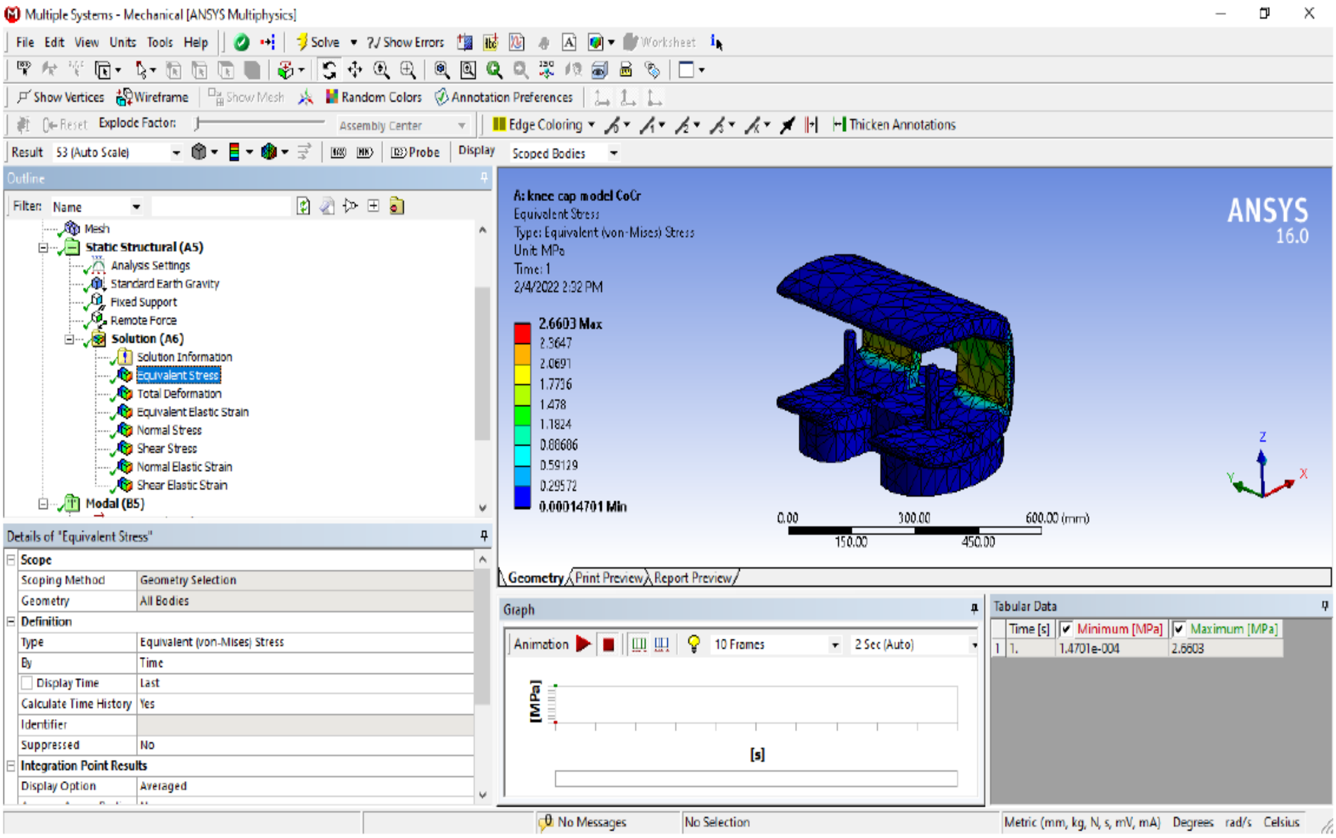
Details of "Total Deformation"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
By	Time
☐ Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Results	
☐ Minimum	0. mm

Tabular Data

	Time [s]	☑ Minimum [mm]	☑ Maximum [mm]
1	1.	0.	0.70152

Fig. 3. CoCr Total Deformation



Result 53 (Auto Scale)

Display: Scoped Bodies

A: knee cap model CoCr
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1
2/4/2022 2:32 PM

2.6603 Max
2.3647
2.0691
1.7736
1.478
1.1824
0.88686
0.59129
0.29572
0.00014701 Min

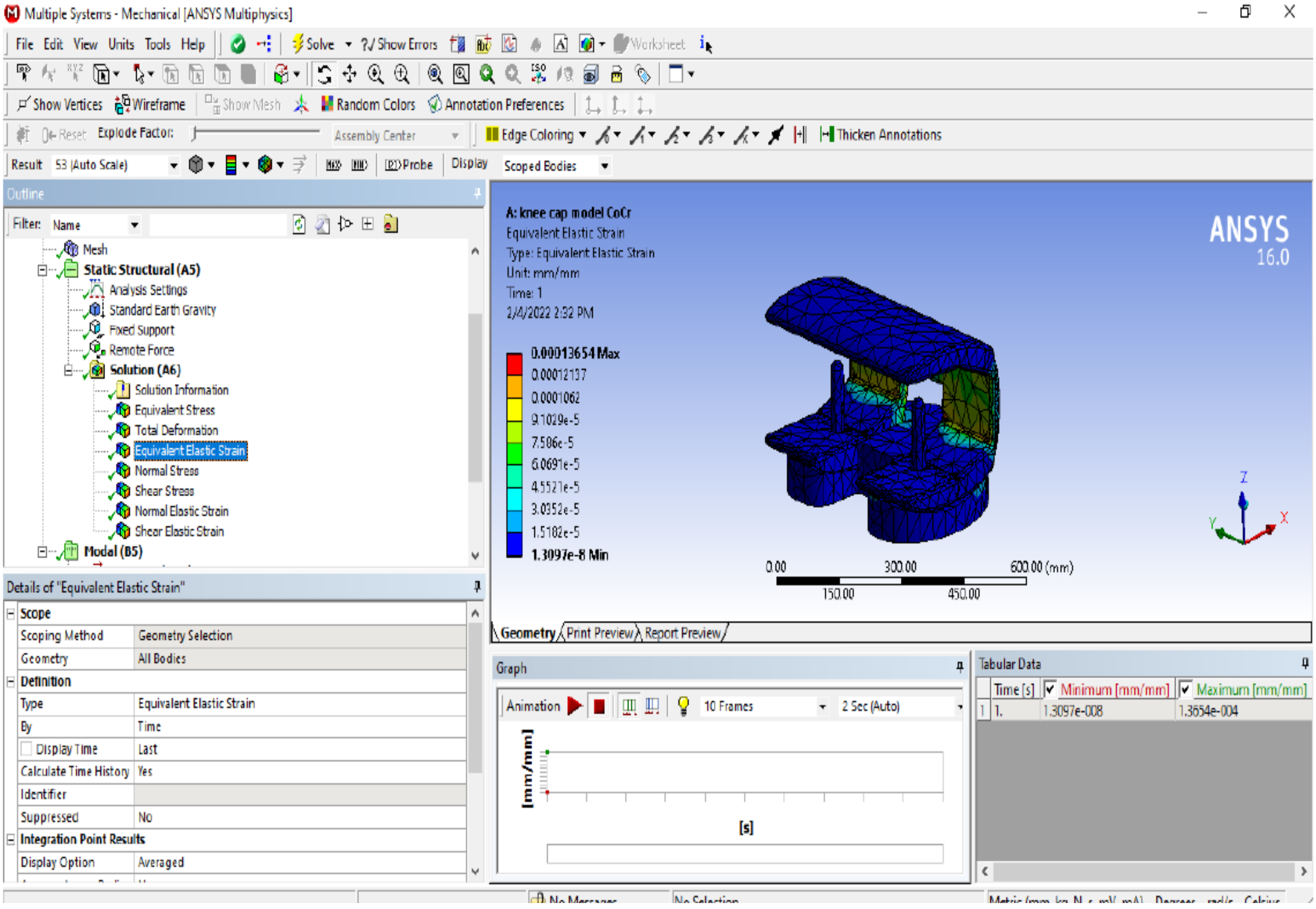
Details of "Equivalent Stress"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Equivalent (von-Mises) Stress
By	Time
☐ Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Integration Point Results	
Display Option	Averaged

Tabular Data

	Time [s]	☑ Minimum [MPa]	☑ Maximum [MPa]
1	1.	1.4701e-004	2.6603

Fig. 4. CoCr Equivalent Stress



Result 53 (Auto Scale)

Display: Scoped Bodies

A: knee cap model CoCr
Equivalent Elastic Strain
Type: Equivalent Elastic Strain
Unit: mm/mm
Time: 1
2/4/2022 2:32 PM

0.00013654 Max
0.00012137
0.0001062
9.1029e-5
7.586e-5
6.0691e-5
4.5521e-5
3.0352e-5
1.5182e-5
1.3097e-8 Min

Details of "Equivalent Elastic Strain"

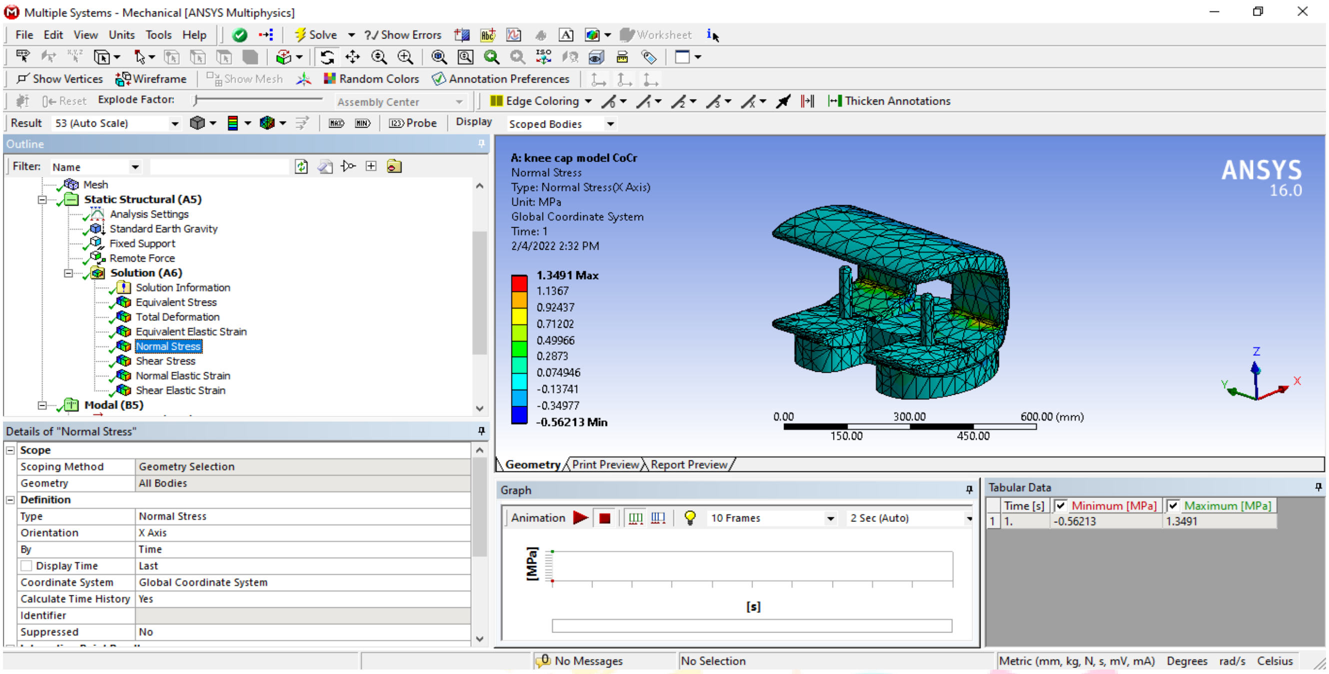
Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Equivalent Elastic Strain
By	Time
☐ Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Integration Point Results	
Display Option	Averaged

Tabular Data

	Time [s]	☑ Minimum [mm/mm]	☑ Maximum [mm/mm]
1	1.	1.3097e-008	1.3654e-004

Fig. 5. CoCr Equivalent Elastic Strain

Figure 4, 5 and 6 are showing Equivalent Stress, Equivalent Elastic Strain, and Normal Stress for CoCr respectively.



A: knee cap model CoCr
Normal Stress
Type: Normal Stress(X Axis)
Unit: MPa
Global Coordinate System
Time: 1
2/4/2022 2:32 PM

1.3491 Max
1.1367
0.92437
0.71202
0.49966
0.2873
0.074946
-0.13741
-0.34977
-0.56213 Min

Details of "Normal Stress"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Normal Stress
Orientation	X Axis
By	Time
☐ Display Time	Last
Coordinate System	Global Coordinate System
Calculate Time History	Yes
Identifier	
Suppressed	No

Tabular Data

	Time [s]	☑ Minimum [MPa]	☑ Maximum [MPa]
1	1.	-0.56213	1.3491

Fig. 6. CoCr Normal Stress

III. RESULTS , DISCUSSION

Total Deformation: Total deformation obtained is shown in Table1.Total deformation Comparison is shown in Figure 7

Table1: Total Deformation (mm)		
Kneecap model materials		
Co-Cr	Ti6Al4V	Ni-Ti
0	0	0
0.077947	0.070244	0.056976
0.15589	0.140490	0.11395
0.233833	0.210736	0.170924
0.311776	0.280982	0.227898
0.389719	0.351228	0.284872
0.467662	0.421474	0.341846
0.545605	0.49172	0.39882
0.623548	0.561966	0.455794
0.701491	0.632212	0.512768

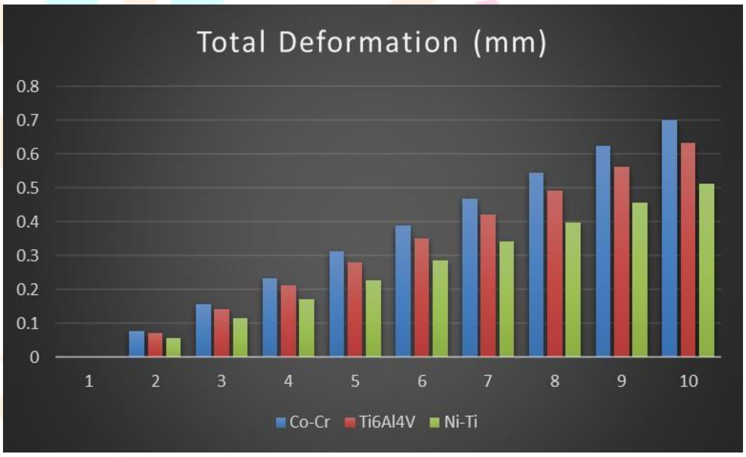


Fig. 7. Total Deformation Comparison Bar Diagram

Equivalent Stress: Equivalent Stress obtained is shown in Table 2.Equivalent Stress comparison is shown in Figure 8

Table 2: Equivalent Stress (mm)		
Kneecap model materials		
Co-Cr	Ti6Al4V	Ni-Ti
0	0	0
1.09E-05	1.00E-05	0.000147
1.4477	1.23	0.29572
2.90E+00	2.65E+00	0.591293
4.343078	4.19	0.886866
5.79E+00	5.65	1.182439
7.238457	7.13E+00	1.478012
8.69E+00	8.61	1.773585
10.13383	10.09	2.069158
1.16E+01	1.13E+01	2.364731

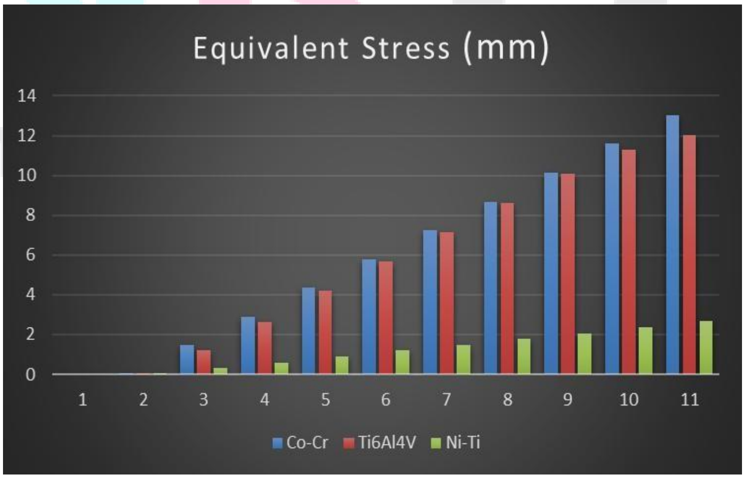


Fig. 8: Equivalent Stress Comparison Bar Diagram

Similarly Normal Stress, Normal Elastic Strain, Shear Stress, Shear Elastic Strain, Equivalent Elastic Strain are obtained.

IV. CONCLUSION

The conclusions can be drawn are as joint can simply sustain a weight of 65 to 70 kg when the weight varies in stable conditions. It can be said during the walking processes i.e., from three coplanar forces that joint wear rises when the stresses are compared to the constant state. The stresses are highly varying in dynamic conditions for the patellar tendon and response force because of running or joint operation in comparison to walking conditions which produce joint injury.

REFERENCES

[1] Sun, Y., Tang, H., Tang, Y., Zheng, J., Dong, D., Chen, X., Liu, F., Bai, L., Ge, W., Xin, L., Pu, H., Peng, Y., & Luo, J. 2021 Review of Recent Progress in Robotic Knee Prosthesis Related Techniques: Structure, Actuation and Control. Journal of Bionic Engineering, 18(4), 764–785. https://doi.org/10.1007/s42235-021-0065-4

[2] Mechi, S., IJEE, M. A.-W.-J. homepage: www., 2021, undefined. (n.d.). Manufacturing and mechanical behavior investigation of prosthetic below knee socket by using natural kenaf fiber. Academia.Edu.

[3] Cairns, N. 2010 The feasibility of vibration analysis as a technique to detect osseointegration of transfemoral implants.

[4] Jweeg, M. J., Hamzah, H. A., Al-Waily, M., & Al-Shammari, M. A. 2021. A Finite Element Simulation of Nano Effects on Stress Distribution in a Below Knee Prosthetic. IOP Conference Series: Materials Science and Engineering, 1067(1), 012141. https://doi.org/10.1088/1757-899x/1067/1/012141

[5] Jweeg, M. J., Hammoudi, Z. S., & Alwan, B. A. 2018 Optimised Analysis, Design, and Fabrication of Trans-Tibial Prosthetic Sockets. IOP Conference Series: Materials Science and Engineering, 433(1). https://doi.org/10.1088/1757-899X/433/1/012058

[6] Yaseen, N. D., Chiad, J. S., & Ghani, F. M. A. 2018 The study and analysis of stress distribution subjected on the replacement knee joint components using photo-elasticity and numerical methods. International Journal of Mechanical and Production Engineering Research and Development, 8(6), 449–464. https://doi.org/10.24247/ijmperddec201849

[7] Kadhim, F. M., Chiad, J. S., & Enad, M. A. S.2020 Evaluation and analysis of different types of prosthetic knee joint used by above knee amputee. Defect and Diffusion Forum, 398 DDF, 34–40. https://doi.org/10.4028/www.scientific.net/DDF.398.34

[8] Abbas, S. M., Sadiq, G. S. H., & Abdul Sattar, M. 2020 Improving the composite materials for Bi lateral prosthesis with below knee amputation. Materials Science Forum, 379–388. https://doi.org/10.4028/www.scientific.net/MSF.1002.379

[9] Pathare, Y. S., & Billore, M. Vibration Analysis of Prosthetic Knees Implant. 34(8), 156–162.