International Journal of Mechanical Engineering

The Design and Analysis of the Knee Cap Model Using FEA

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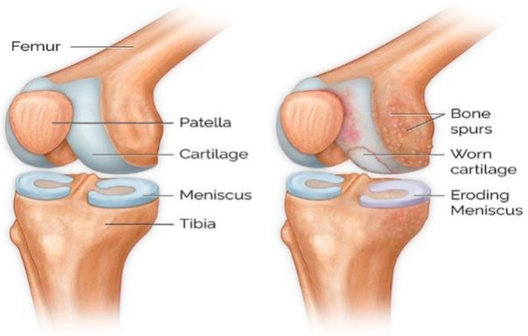
ABSTRACT- The design process of a human knee cap model is presented in this work. Arthritis is the breakdown of the cartilage that lines the ends of the tibia and femur inside the knee joint, often known as the knee cap. This produces discomfort in the knee cap, prompting the replacement of the prosthetic components. In addition to being biocompatible, the prosthetic joints must fulfil and meet specific design standards. Insertion of these joints in humans should not cause too much pain or need too much postoperative care. Furthermore, the longevity and performance of the artificial caps are critical considerations. The severity of the produced stresses at the interface is determined by various parameters, including sagittal radius flexion angles, materials employed for tibia femoral components, and the load operating on the joint and cap bearing surfaces. To guarantee a decrease in stress intensity, it is essential to optimise the design of the prosthetic knee cap while taking the aforementioned parameters into account. In this context, FEM, the most powerful and commonly recognised numerical method for predicting stress state, is increasingly gaining relevance in the optimization of knee cap model design. In view of the above, this work examines the modelling and finite element analysis of a prosthetic knee cap model.

Keywords: Knee cap, Ansys, FEM, knee replacements, and Deformation.

INTRODUCTION

A joint, also known as an articulation, is a connection established between bones in the body that connects the skeletal system into a functioning whole. They are designed to allow for varying degrees and kinds of movement. Some joints, such as the knee, elbow, and shoulder, are self-lubricating and practically frictionless, allowing them to resist compression and large loads while still performing smooth and accurate motions. Joints may also be classed biomechanically based on their anatomy or biomechanical qualities. The major goal is to operate on a complicated joint with two or more articular meniscus, such as a knee joint. The joint is the most strained portion of most human joints' knees because the whole weight of the body is placed on it. Many individuals nowadays suffer from knee joint difficulties, and they want an effective solution to this condition. Knee replacement is the greatest feasible option for this ailment.

A joint or articulation is the connection made between bones in the body which link the skeletal system into a functional whole. They are constructed to allow for different degrees and types of movement. Some joints, such as the knee, elbow, and shoulder, are self-lubricating, almost frictionless, and can withstand compression and maintain heavy loads while still executing smooth and precise movements. Biomechanical classification of Joints can also be classified based on their anatomy or their biomechanical properties. The main aim is to work on the complex joint, which has two or more articular meniscus like a knee joint. In most of the human joints knee, the joint is the stressed part due to the whole weight of the body is subjected on it. Nowadays many people are suffering from knee joint pains, and they need an efficient solution to this problem. The best possible solution for this problem is knee replacement. Knee replacement, also known as knee arthroplasty, is a surgical procedure to replace the weight-bearing surfaces of the knee joint to relieve pain and disability. It is most commonly performed for osteoarthritis, and also for other knee diseases such as rheumatoid arthritis and psoriatic arthritis. In patients with severe deformity from advanced rheumatoid arthritis, trauma, or long-standing osteoarthritis, the surgery may be more complicated and carry higher risk. Osteoporosis does not typically cause knee pain, deformity, or inflammation and is not a reason to perform knee replacement. Other major causes of debilitating pain include meniscus tears, cartilage defects, and ligament tears. Debilitating pain from osteoarthritis is much more common in the elderly. Knee replacement surgery can be performed as a partial or a total knee replacement. In general, the surgery consists of replacing the diseased or damaged joint surfaces of the knee with metal and plastic components shaped to allow continued motion of the knee. Knee replacement surgery is most commonly performed in people with advanced osteoarthritis and should be considered when conservative treatments have been exhausted.



FIGUREURE.1. KNEE JOINT ELEMENTS

- **Knee Cap**

The knee cap has a functional purpose by increasing leverage at the knee joint. With extension movements like kicking, this builds knee strength by around 30%. Front knee discomfort is often caused by patellar problems. In this section, we will look at the most prevalent reasons of kneecap discomfort.

- **Knee Cap Pain**

Knee cap discomfort may be caused by a variety of factors. It's possible that the issue is with the kneecap bone itself, the cartilage that lines it, or stiffness or weakness in the surrounding muscles that causes it to move wrongly.

- **Causes Of Knee Cap Pain**

1. Patellar Chondromalacia
2. Runner's Knee
3. Patellar Tendonitis
4. Tendonitis of the quadriceps
5. Patellar Dislocation.

Variations in manufacturing Variations in the manufacture and surgical preparation for knee replacement occur between cemented and uncemented components, between resurfacing the patella or not, and between denervating the patella using electrocautery or not. Cemented fixation may be more vulnerable to future aseptic loosening than the cement-less technique. Retaining the posterior cruciate ligament (PCL) has been shown to be beneficial for patients. Removal of the PCL has been shown to reduce the maximal force that the individual can place on that knee. Typically individuals who have the PCL removed will lean forward while climbing in order to maximize the force of the quadriceps. A variation in the total knee replacement procedure is to permit movement in the prostheses using a polyethene insert, and an approach called mobile-bearing total knee arthroplasty. There is no strong evidence that this approach improves knee function, mortality, number of adverse effects, or amount of pain compared to a fixed bearing approach for total knee replacement that retains the PCL. Minimally invasive procedures have been developed in total knee replacement that does not cut the quadriceps tendon. There are different definitions of minimally invasive knee surgery, which may include a shorter incision length, retraction of the patella without eversion (rotating out), and specialized instruments. There are few randomized trials, but studies have found less postoperative pain, shorter hospital stays, and shorter recovery. However, no studies have shown long-term benefits. Softwares generally used for analysis on total knee replacement: Medical simulation, or more broadly, healthcare simulation, is a branch of simulation related to education and training in medical fields of various industries. Simulations can be held in the classroom, in situational environments, or spaces built specifically for simulation practice. It can involve simulated human patients - artificial, human or a combination of the two, educational documents with detailed simulated animations, casualty assessment in homeland security and military situations, emergency response, and support virtual health functions with holographic simulation. In the past, its primary purpose was to train medical professionals to reduce error during surgery prescription, crisis interventions, and general practice. Combined with methods in debriefing, it is now also used to train students in anatomy, physiology, and communication during their schooling. These are some of the screen-based simulation software for analysis of bones

- ✓ ACLS Simulator
- ✓ Anatomy Module
- ✓ Anaesthesia Simulator
- ✓ AnaesthesiaSims TAT - ASA/CAE
- ✓ Healthcare
- ✓ Curiosum
- ✓ MicroEKG

Neonatal Simulator These are high fidelity simulators which can enable us to examine the minute change in bone moments.

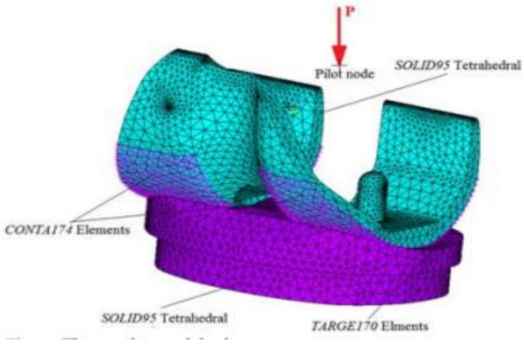


FIGURE. 2 THE MESHING OF THE KNEE CAP.

Source: http://mdpub.net/fulltext/172-1584967152.pdf

These are high fidelity simulators which can enable us to examine the minute change in bone moments.

By using ANSYS software

The finite element method (FEM) is a widely used numerical technique to analyse stress-strain states in various biomedical devices and prosthetic bone joints, in particular. Accurate geometric models of the tibial and femoral components of artificial knee joint were constructed using ANSYS software. Two-dimensional diagrams of the femoral and tibia components. The finite element model was generated by meshing the solid model brick elements. The tibial component was constrained in all degrees of freedom at its lower surface. The femoral component was rigidly fixed. the compressive load was applied to the femoral component at the bearing points at different flexion angles. Modelling of all the components of the knee joint, i.e., Femur(thigh) bone, the knee cap(patella) and the Shinbone or otherwise called Tibia along with Fibula which stabilizes the human leg are modelled and designed in Solidworks software. All the designed bones and the knee cap are further assembled in the same software

Modelling & Assembly

All the parts (Tibia, Kneecap, Femur and Patella) are initially modelled in the Solidworks software and then assembled in the same.

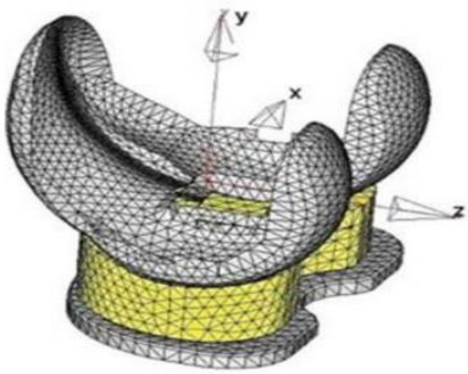


FIGURE.3 THE ACTION OF FORCES ON THE KNEE CAP.

Source: http://mdpub.net/fulltext/172-1584967152.pdf

Design of the knee cap

For the design of kneecap, we selected the front plane and drew the front view of the cap with the help of line and spline commands. Later the drawn sketch is selected, and the revolved it through 180°. We get the solid object. However, we require a surface model. So, in order to get it, we use the shell feature which removes the material from the object and leaves the kneecap.

Design of Bones (Femur & Tibia)

The design of a bone is a very complicated job and requires surface modelling techniques. Because the surface of the bone contains very intricate contours.

Assembly

It involves bringing in all the individual parts together and then assembling by giving suitable mates. The lower portion of the upper bone(femur) is in contact with the inner surface of the kneecap. The outer portion of the knee cap is an inmate with the upper portion of the spacer, which acts as a shock absorber. The lower portion of the plate is in fixed contact with the Tibia bone or otherwise called as the shin bone.

Concept of ANSYS software and FEM

The finite element method (FEM) is a popular computational methodology for analysing stress-strain states in different biomedical devices, particularly prosthetic bone joints. ANSYS software was used to create accurate geometric models of the tibial and femoral components of a prosthetic knee joint. The solid model brick components were meshed to create the finite element model. At its lower surface, the tibial component was limited in all degrees of freedom. The femoral component was firmly fastened. At varying flexion degrees, a compressive load was applied to the femoral component at the bearing points. Catia software is used to model and develop all components of the knee joint or the knee cap (patella). In the same programme, all of the planned bones and the knee cap are constructed. Now, the knee cap is analysed by assigning a material such as Titanium alloy.

Scope of the study

ACL damage, fractures, torn meniscus, knee bursitis, and patellar tendinitis are all possibilities. Loose body syndrome, iliotibial band syndrome, dislocated kneecap, and hip or foot discomfort are all mechanical issues that may cause knee pain. Teaching and learning are the most important activities in the educational system. The study's goal was to determine which of them was the best. The study may be expanded by include other areas of education, such as primary education and other professional education courses. The research was carried out in a single city. It has the potential to spread to other cities. The first portion of this research is based on the notion that the patterns of contact stress on a knee prosthesis's tibial implant. The second section of this research looks at the long-term structural integrity of metal tibial components in terms of fatigue life. The experimental and computational findings both demonstrated that there was a positive match.

Objectives of the study

1. To study the design and modelling of knee cap in Catia.
2. To study the deformation display in knee cap model in Ansys.
3. To study the causes of knee cap pain.

KNEE CAP MODEL IN CATIA

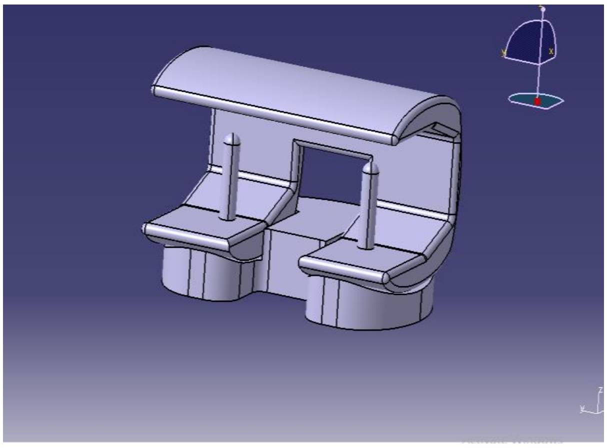


FIGURE.4 KNEE CAP MODEL IN CATIA

KNEE CAP MODEL IN ANSYS

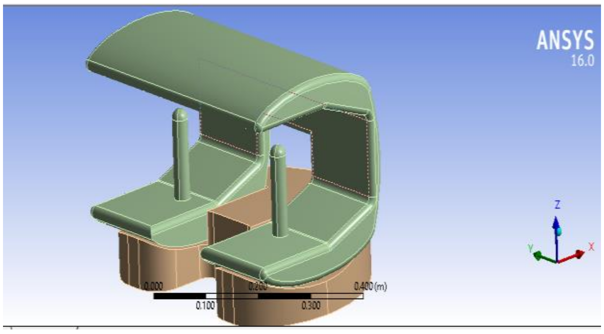


FIGURE.5KNEE CAP MODEL IN ANSYS

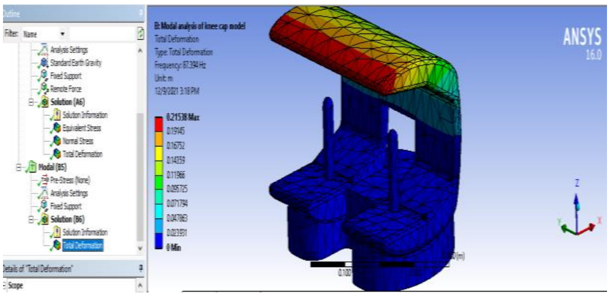


FIGURE 6. KNEE CAP MODEL IN ANSYS (TOTAL DEFORMATION)

LITERATURE REVIEW

Peng Li (2015) This study describes a method for registering a large number of adult 3D surface whole body scans and segmenting the knee area to create a knee-specific dataset. We next used shape analysis techniques on the segmented surfaces to determine the population's significant knee shape variance. We evaluated 2069 male images and provide the first five important knee shape modes in standing and bending positions. The knee models were utilised to create a knee pad for the United States Army. The knee geometry from actual people was supplied through our investigation of knee form and selection of representative models. There was no use of traditional anthropometry in the analysis or creation of knee forms; the knee pad was built entirely from geometry. Although conventional anthropometry has a role in product design, it is more frequently than not employed to produce geometry. Our method starts with statistically meaningful geometry, which we feel is better to deriving body forms from anthropometry.

Dr. Shaker S. Hassan (2013) In this paper, The FEM (ANSYS) was used to calculate the fatigue safety factor and equivalent stress for all kinds of KAFO models (Von-Mises). A piezoelectric sensor was used to measure the interface pressure between the patient's leg and the brace. The gait cycle data (Ground Reaction Force (GRF) and pressure distribution) were gathered from one poliomyelitis patient (wearing KAFO brace) and one normal person. Paraplegic individuals with low degree spinal cord damage and excellent trunk muscular control are given knee ankle foot orthoses (KAFOs). In this study, three kinds of KAFOs were employed (plastic-metal, metal-metal, and composite materials), with the composite materials depending on the amount of perlon layers (13 layers & 9 layers) with one layer of carbon fibre and (6 layers) without carbon fibre. Tensile and fatigue machines were used to examine the mechanical qualities of the majority of the KAFOs' materials. The ANSYS findings provided the profile of fatigue safety factor for metal-metal KAFO (3.69), plastic-metal model (0.88). While the (13) layers for composite material were about (1.4), the (9) layers and (6) layers were (1.07) and (0.41), respectively. For the proposed design, the value of the safety factor grew as the composite material was used.

Ashish Vaswani (2019) Using Finite element analysis, this work simulates the design of a knee brace and analyses its stress shielding ability. This study describes how this knee brace can overcome the challenges that other knee braces on the market encounter. Walking issues worsen as people become older. The usage of a knee brace is one of the therapies for walking issues. This study examines current knee brace designs, weighs their benefits and drawbacks, and offers an efficient, cost-effective, light-weight, and appealing knee brace design for the Indian population. The anatomy of the knee is described in this paper. It gives a quick summary of the knee's anatomical components and their functions. Later, it addresses knee difficulties and offers examples of how such problems might occur. It sheds light on the gait cycle in humans. This research lays the groundwork for future research on knee braces. It offers structural design of a knee brace using the CAD modelling programme "Solid works." It outlines the components and operation of a knee orthosis. Finally, it examines the stress on the knee and the effectiveness of knee braces in mitigating these stresses under peak loads encountered during everyday activities.

ANALYSIS

It is evident that the human knee joint which is affected by the disease arthritis or which is damaged due to impact has to be replaced by the artificial components called prostheses. The two major prostheses used in total knee replacement are femur and tibia. These two prostheses constitute an artificial knee joint called femorotibial or tibiofemoral joint. The femorotibial joint must effectively function at various flexion angles for different loading conditions. To make the prosthetic joint function effectively, to reduce the wear between the femur and tibia and to increase the life, it is required to investigate different biomaterials for both femur and tibia at different flexion angles and sagittal radius for different loading conditions.

4.1. Statistical Analysis

1. GEOMETRY OF KNEE CAP MODEL

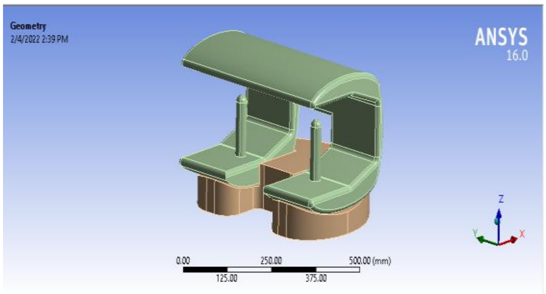


FIGURE.7 GEOMETRY OF KNEE CAP MODEL

2. MESHING OF KNEE CAP MODEL

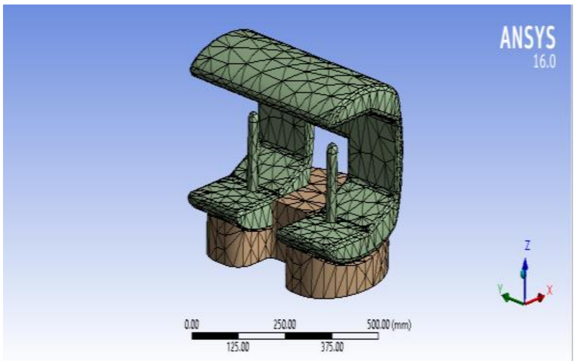


FIGURE.8 MESHING OF KNEE CAP MODEL

3. EQUIVALENT STRESS OF KNEE CAP MODEL

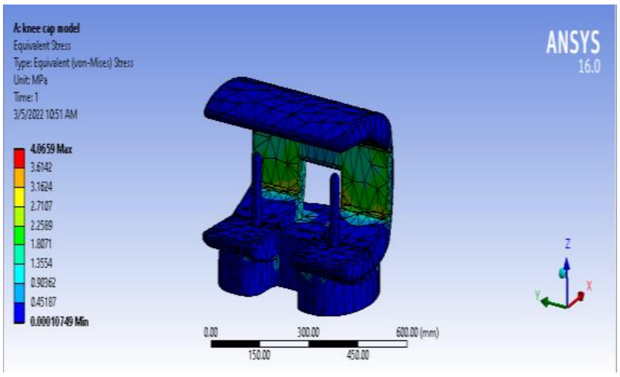


FIGURE.9 EQUIVALENT STRESS OF KNEE CAP MODEL

4. EQUIVALENT ELASTIC STRAIN OF KNEE CAP MODEL

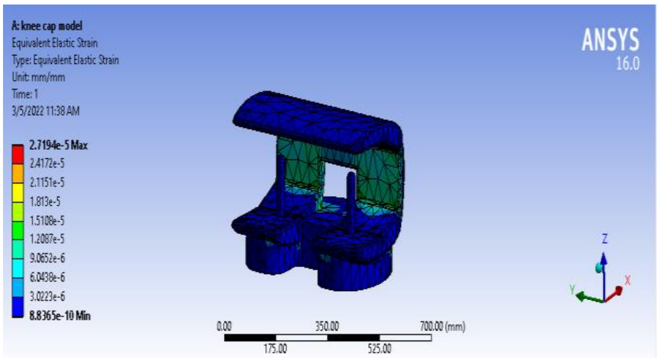


FIGURE.10 EQUIVALENT STRAIN OF KNEE CAP MODEL

5. NORMAL STRESS OF KNEE CAP MODEL

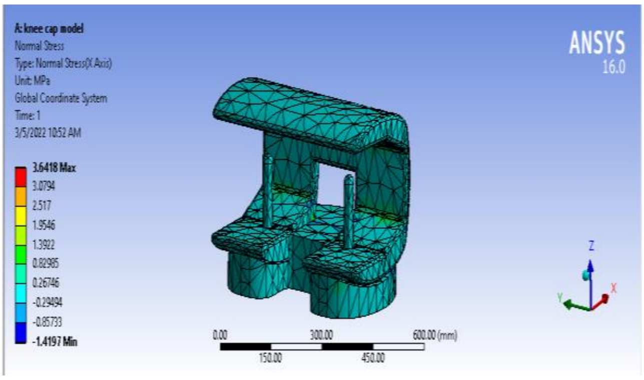


FIGURE.11 NORMAL STRESS OF KNEE CAP MODEL

6. TOTAL DEFORMATION OF KNEE CAP MODEL

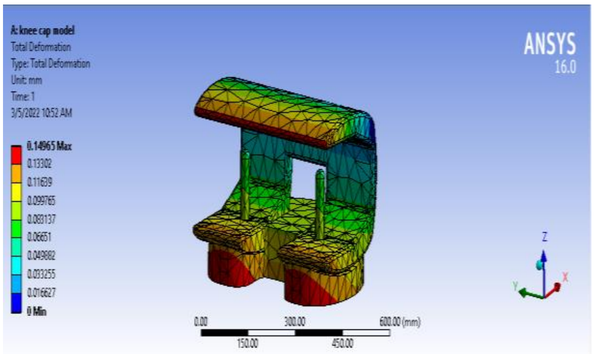


FIGURE.12 TOTAL DEFORMATION OF KNEE CAP MODEL

4.2. MODAL ANALYSIS

1. MATERIAL COCR

TOTAL DEFORMATION OF KNEE CAP MODEL

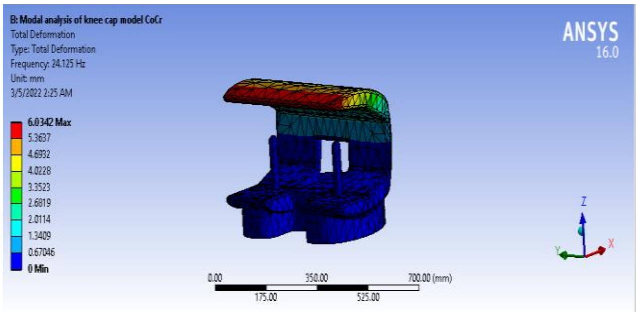


FIGURE.13 TOTAL DEFORMATION OF KNEE CAP MODEL IN MODAL ANALYSIS

2. MATERIAL Ti6Al4V

TOTAL DEFORMATION OF KNEE CAP MODEL

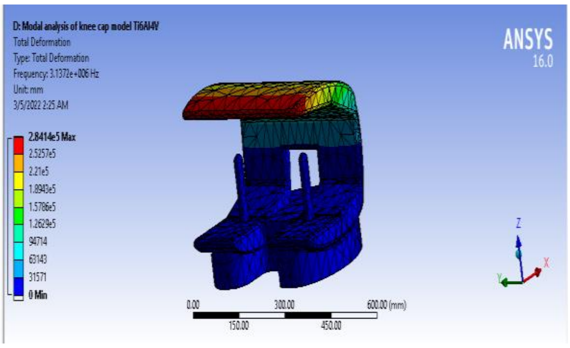


FIGURE.14 TOTAL DEFORMATION OF KNEE CAP MODEL IN MODAL ANALYSIS

3. MATERIAL NiTi

TOTAL DEFORMATION OF KNEE CAP MODEL

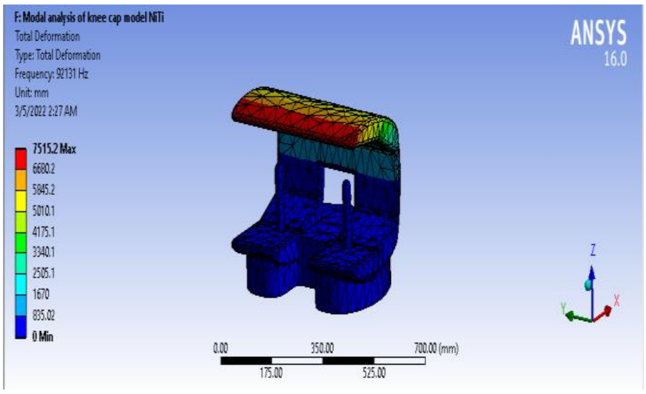


FIGURE.15 TOTAL DEFORMATION OF KNEE CAP MODEL IN MODAL ANALYSIS

4.3. COMPARATIVE ANALYSIS OF KNEE CAP MODEL WITH DIFFERENT MATERIALS

1. MATERIAL CoCr

1. TOTAL DEFORMATION OF KNEE CAP MODEL

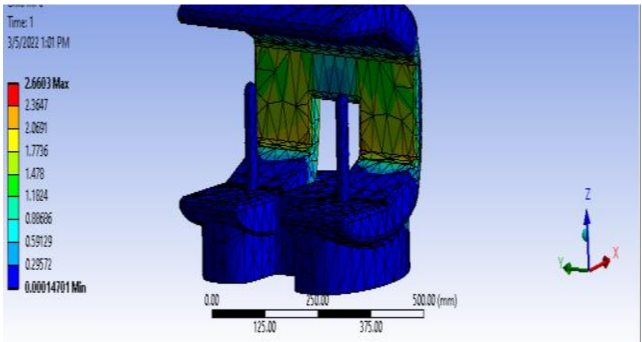


FIGURE.16 TOTAL DEFORMATION OF KNEE CAP MODEL

2. EQUIVALENT STRESS OF KNEE CAP MODEL

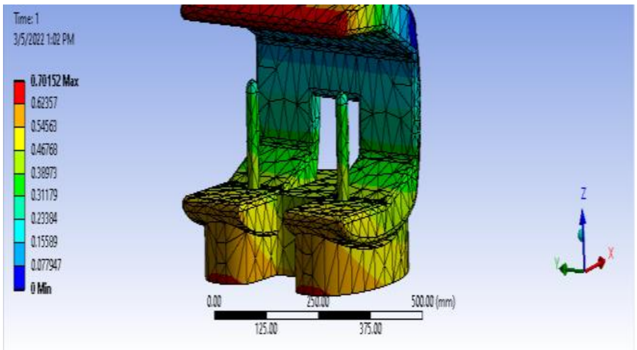


FIGURE.17 EQUIVALENT STRESS OF KNEE CAP MODEL

3. EQUIVALENT ELASTIC STRAIN OF KNEE CAP MODEL

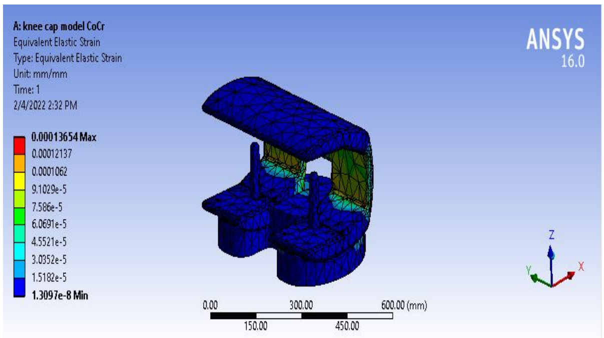


FIGURE.18 EQUIVALENT ELASTIC STRAINOF KNEE CAP MODE

4. NORMAL STRESS OF KNEE CAP MODEL

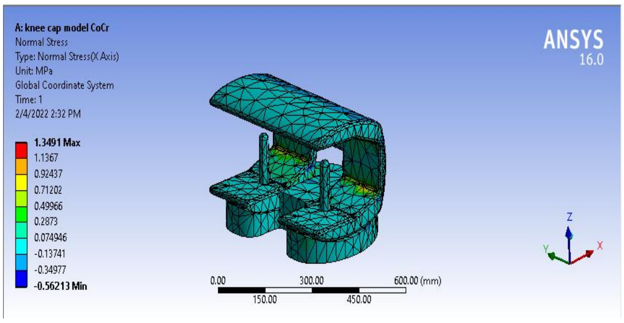


FIGURE.19 NORMAL STRESS OF KNEE CAP MODEL

5. SHEAR STRESS OF KNEE CAP MODEL

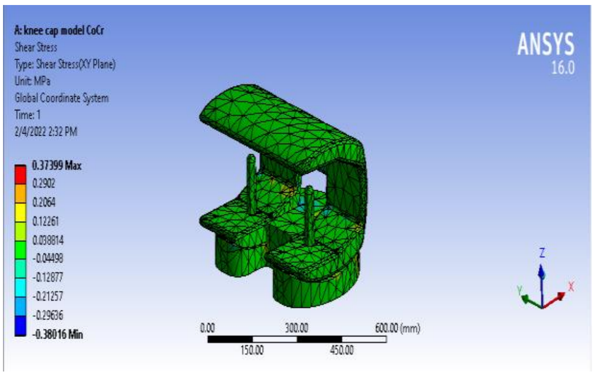


FIGURE.20 SHEARSTRESS OF KNEE CAP MODEL

6. NORMALELASTIC STRAIN OF KNEE CAP MODEL

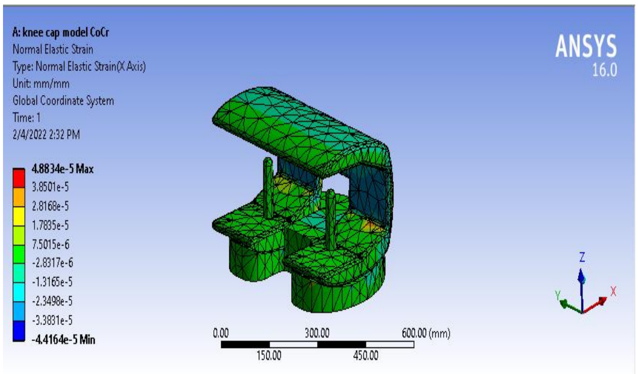


FIGURE.21 NORMALELASTIC STRAIN OF KNEE CAP MODEL

7. SHEARELASTIC STRAIN OF KNEE CAP MODEL

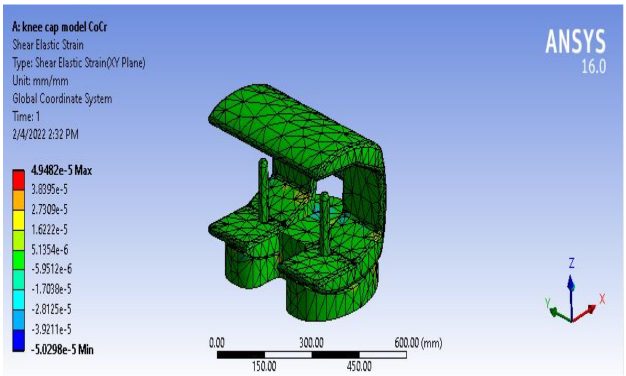


FIGURE.22 SHEARELASTIC STRAIN OF KNEE CAP MODEL

Contact Pressure of various materials

Maximum contact stresses were measured on the polyethylene parts and also on the tibial cartilage when femoral part was chromium cobalt alloy, Ti-6A1-4V and NiTi shape memory alloy. The results were shown in table. It can be seen that there was no major difference in the results for different materials. For more confidence on the results, the menisci were replaced by a flat plate of UHMWPE and the maximum contact pressure was obtained on the plate, but it was found that the magnitude of this parameter was same for all the materials.

1. Material CoCr

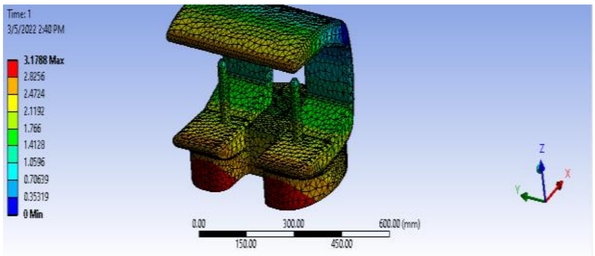


FIGURE.23 CONTACT PRESSURE FOR MATERIAL COCR

2. MATERIAL Ti6Al4V

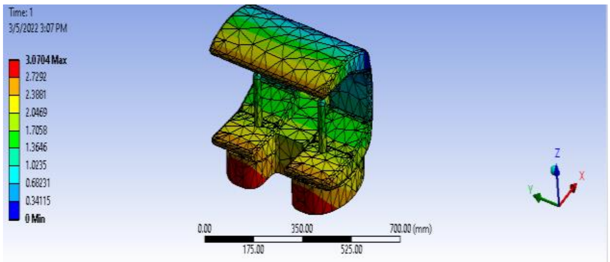


FIGURE.24 CONTACT PRESSURE FOR MATERIAL TI6AL4V

3. MATERIAL NiTi

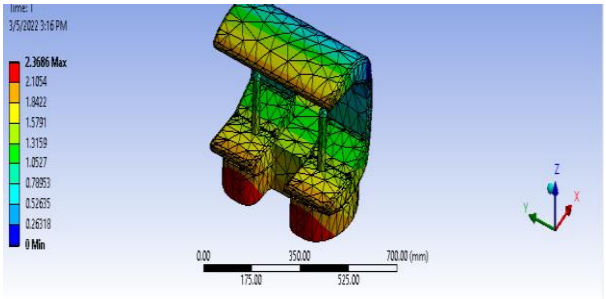


FIGURE.25 CONTACT PRESSURE FOR MATERIAL NITI

Table. Contact pressure for various materials

Materials	Contact Pressure on knee cap model (Mpa)
CoCr	3.17
Ti-6A1-4V	3.07
NiTi	2.36

4.5. Cost-effectiveness of knee discomfort throughout a lifetime

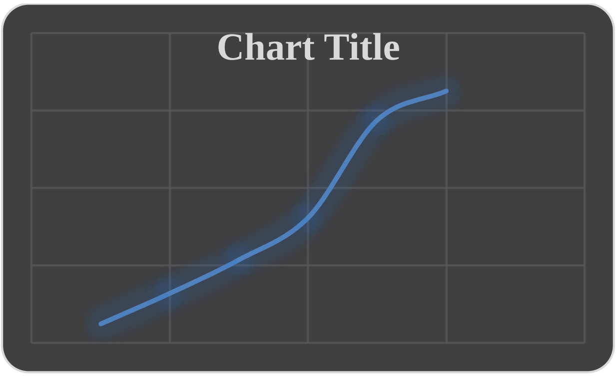
Simulation of the MOST population with knee osteoarthritis provided much higher lifetime likelihoods of total knee replacement, but similar ICERs, although restriction of surgery to those with SF-12 PCS <40now became the optimal scenario at a cost effectiveness threshold of $200 000/QALY.Use of EQ-5D utility values improved ICERs, with the ICER of restriction of surgery to those with SF-12 PCS<40 now amply falling below $200000/QALY. Increasing rates of primary total knee replacement or background mortality only minimally affected incremental cost effectiveness outcomes, and restriction of surgery to those with SF-12 PCS<35 remained the optimal scenario at a cost effectiveness threshold of $200 000/QALY.

If patients who would receive total knee replacement in current practice, but not in the more restrictive scenarios, experienced an additional decline of 50% in quality of life over the long term, all scenarios of performing total knee replacement including current practice became economically attractive given a cost effectiveness threshold of $200 000/QALY and with an additional decline of 80% given a cost effectiveness threshold of $100000/QALY.

Modal Analysis results

1. MATERIAL COCR

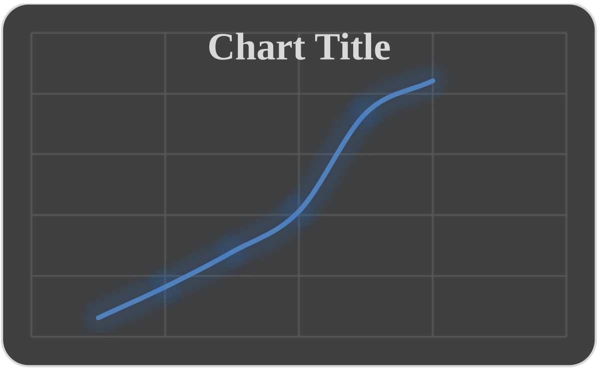
TOTAL DEFORMATION OF KNEE CAP MODEL



GRAPH.1 TOTAL DEFORMATION OF KNEE CAP MODEL IN MODAL ANALYSIS

2. MATERIAL Ti6Al4V

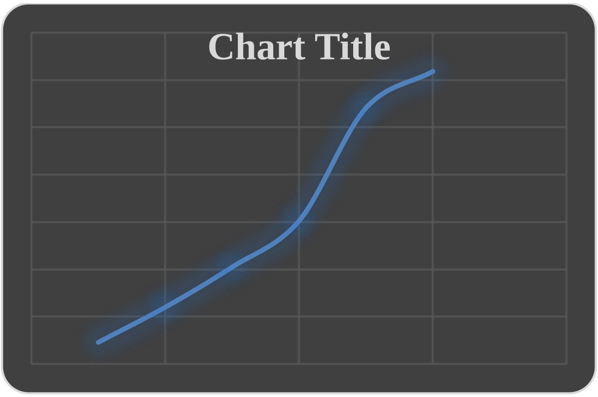
TOTAL DEFORMATION OF KNEE CAP MODEL



GRAPH.2 TOTAL DEFORMATION OF KNEE CAP MODEL IN MODAL ANALYSIS

3. MATERIAL NiTi

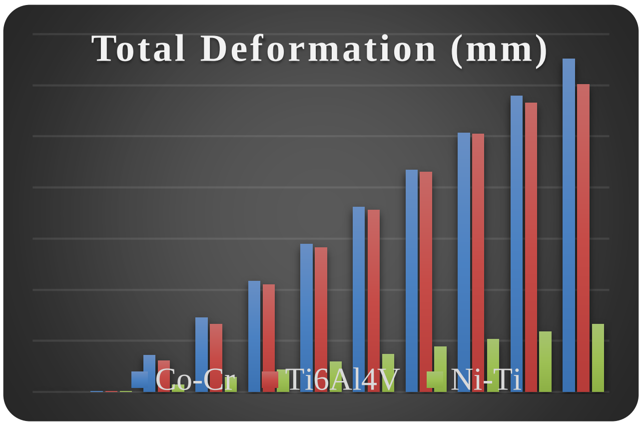
TOTAL DEFORMATION OF KNEE CAP MODEL



GRAPH.3 TOTAL DEFORMATION OF KNEE CAP MODEL IN MODAL ANALYSIS

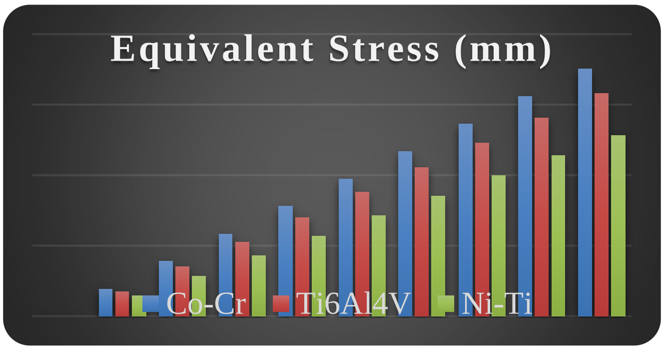
4.3. COMPARATIVE RESULTS OF KNEE CAP MODEL WITH DIFFERENT MATERIALS

1. TOTAL DEFORMATION OF KNEE CAP MODEL



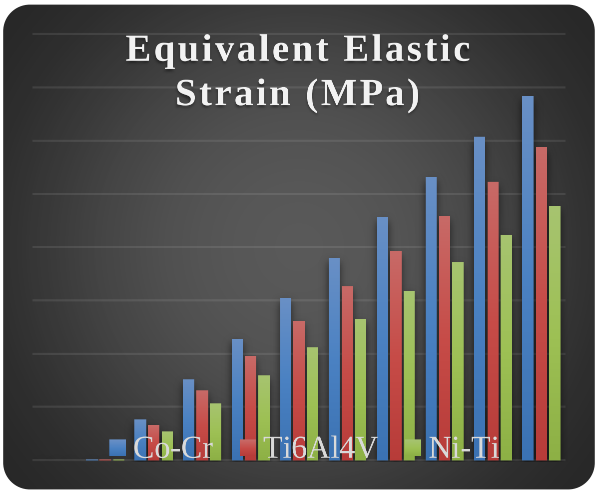
GRAPH.4 TOTAL DEFORMATION OF KNEE CAP MODEL

2. EQUIVALENT STRESS OF KNEE CAP MODEL



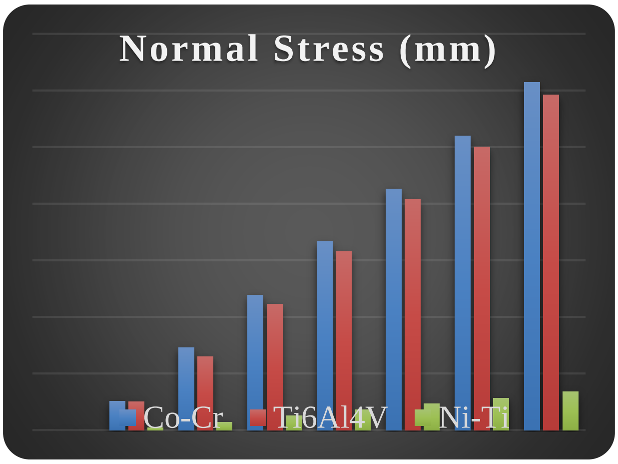
GRAPH.5 EQUIVALENT STRESS OF KNEE CAP MODEL

3. EQUIVALENT ELASTIC STRAIN OF KNEE CAP MODEL



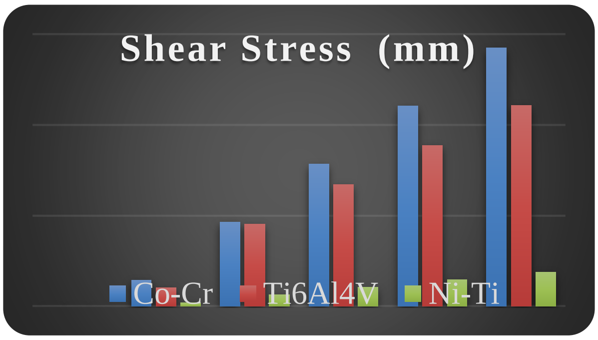
GRAPH.6 EQUIVALENT ELASTIC STRAIN OF KNEE CAP MODE

4. NORMAL STRESS OF KNEE CAP MODEL



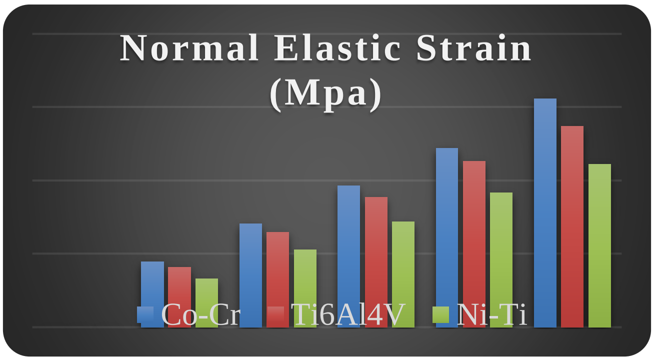
GRAPH.7 NORMAL STRESS OF KNEE CAP MODEL

5. SHEAR STRESS OF KNEE CAP MODEL



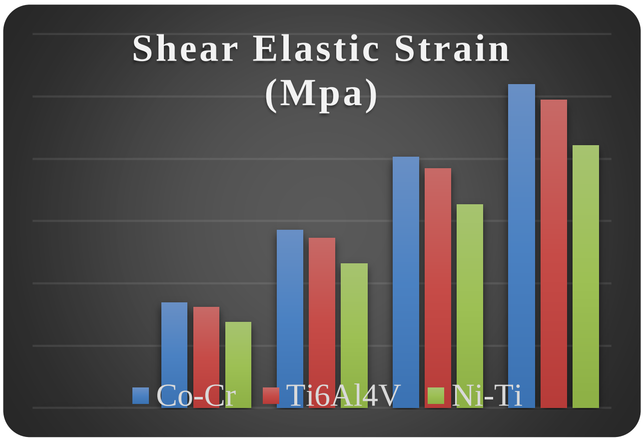
GRAPH.8 SHEAR STRESS OF KNEE CAP MODEL

6. NORMAL ELASTIC STRAIN OF KNEE CAP MODEL



GRAPH.9 NORMALELASTIC STRAIN OF KNEE CAP MODEL

7. SHEARELASTIC STRAIN OF KNEE CAP MODEL



GRAPH.10 SHEAR ELASTIC STRAIN OF KNEE CAP MODEL

CONCLUSION

Evaluated the effectiveness of total knee replacement on quality of life and use of non-surgical treatment in a recent patient with knee osteoarthritis. Compared with patients who did not undergo total knee replacement, generic quality of life scores (on SF-12 physical) and those related to osteoarthritis improved with performance of the procedure, with larger improvements generally in those with a lower SF-12 physical score at baseline. Changes in use of osteoarthritis pain medication and SF-12 mental scores were small and heterogeneous across the two cohorts. In a cost effectiveness analysis modeling the life courses of OAI patients with knee osteoarthritis with inclusion of utility values derived from the SF-12, current practice was more expensive and in some cases even less effective compared with scenarios in which total knee replacement was performed only in patients with lower physical functioning. At the group level, the economically most attractive strategy was performing the procedure in those with a SF-12 PCS<35, assuming a cost effectiveness threshold of $200 000 per QALY. These findings were reproduced among knee osteoarthritis patients from the MOST cohort. Extension of the use of total knee replacement to those with a SF-12 physical score of ≤40 would become financially attractive if the hospital admission costs fell below $14000.

Improvements in quality of life with total knee replacement were on average smaller than previously shown. Given its limited effectiveness in individuals with less severely affected physical function, performance of total knee replacement in these patients seems to be economically unjustifiable. Considerable cost savings could be made by limiting eligibility to patients with more symptomatic knee osteoarthritis. Only one randomized controlled trial has so far been published evaluating total knee replacement as an adjunct treatment to optimized non-surgical treatment, but it did not include results according to symptom status.7 Our findings emphasize the need for more research comparing total knee replacement with less expensive, more conservative interventions, particularly in patients with less severe symptoms, and research aiming to develop individualized prediction models for a better selection of patients with a predicted large net benefit from the procedure. These interventions can then be compared within cost effectiveness analyses, for which non-US data sources should be considered as well. In conclusion, the practice of total knee replacement as performed in a recent US cohort of patients with knee osteoarthritis had minimal effects on quality of life. If the procedure were restricted to patients with more severe functional status, however, its effectiveness would rise, with practice becoming economically more attractive.

Future scope

Finite element analysis proved as one of the efficient techniques for evaluation of the performance of prosthesis with different materials under day to day loading conditions. This study and research work can conclude the facts: The material Ti-6Al-4V is selected based on the results that are obtained from the analysis on the kneecap by assigning three different materials such as Ti-based alloy, Ceramic and Stainless Steel.

- ✓ It is clear from the results that the Titanium Alloys (Ti-6Al4V) is the best material of choice for knee implant because it shows the minimum Von-mises stress at the extreme loading conditions than the other materials.
- ✓ The result of the analysis showed us that Titanium could withstand the loads that fall on the knee bone better than that of other materials. Also, we know that Titanium is the strongest and the best Biocompatible metal that can be used.
- ✓ Although Stainless Steel and Ceramics are less costly compared to Titanium alloys, it is worth spending more initial cost on Titanium-based Kneecap because of its biocompatible nature and its strength to support the loads that fall on the Knee joint.
- ✓ Practical and clinical implementation should be done. Vibrational and Thermal analysis can be done.
- ✓ Research should be done on other materials which can be better than titanium alloy for knee implant.
- ✓ Dynamic analysis should be considered for a better understanding of knee mechanics.

CONCLUSION

To summarise, both computational and experimental methodologies are critical in the creation of dependable prostheses. In this work, a computational model was built to predict the micro-mechanical stimuli, such as stress and strain, fluid pressure and flow, of cells and their surrounding PCM in AF tissue using three-dimensional (3D) finite element models based on in situ morphology. This research gives Spatio-temporal information on the micromechanics of AF cells to help comprehend mechanotransduction in the intervertebral disc.

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