DESIGN AND 3D PRINTING OF KNEE JOINT

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ABSTRACT

The objective is to study the wear of the knee joint using static structural analysis, degrees of freedom, joint probe and ansys software, and to develop a 3D modeling of the knee joint using CatiaV5. In this manufacturing model, all the bony parts of the human knee joint, such as the femur, tibia, fibula, and patella, are made exactly the same size and have a good surface finish. The bones of this knee joint are made of acrylonitrile butadiene styrene (ABS) and manufactured by a melt deposition modeling (FDM) technique. Design the knee joint model using CatiaV5 software. The 3D model is saved in STL format and transferred to the 3Dreality Slicer. Then the 3D slicer sliced the object layer by layer. The object design is then printed on a 3D printer and the print is overprinted until an accurate model of the natural joint is created. 3D artificial knees, like traditional artificial joints, can be made of metal, plastic, or a combination of the two. Use the FDM method to identify force problems acting between two extremes of a process. It can be seen that by applying an allowable load to the joint, the degree of freedom, wear, and friction load can be controlled.

INTRODUCTION

A 3D printer is an additive molding device in which 3D objects and components are created by adding multiple layers of material. This is an automated process and quickly builds 3D objects to the required size. The device is connected to a computer that contains the 3D model/design of the object. 3D printers are used in many industries such as aerospace, automotive, medical, construction and the manufacture of various household items. The 3D design is saved on your computer in STL format, which is sent to the 3D printer. You can create objects using a variety of materials, including acrylonitrile butadiene styrene (ABS), polylactic acid (PLA), and composite materials. The 3D printing process is derived from desktop inkjet printers.

HISTORY

3D printing technology first appeared in the 1980s, during which time it was called Rapid Prototyping (RP) technology. The first patent for RP technology was filed by Dr. Kodama in 1985. Hideo Kodama of Nagoya City Institute of Technology is generally thought to have printed the first three-dimensional objects from digital design.

Charles Hull is the co-founder of the 3D Company, one of the largest and most important companies in 3D printing and rapid prototyping. He pioneered the stereolithography and solid imaging process known as the STL file format, and is currently the most popular format for 3D printing. Commercial rapid prototyping is also believed to have begun.

Since 1984, technology has advanced, and 3D printers have become more effective and convenient, but at lower prices and more affordable. In 1990, the plastic extrusion technology most associated with the term “3D printing” was invented. Name of FusedDepositionModeling (FDM) by Stratasys. Between 1993 and 1999, the 3D printing industry emerged with a variety of technologies. Sanders Prototype and Z Corporation was established in 1996 to operate commercially and Arcam was founded in 1997.

Since the beginning of the 21st century, sales of 3D printers have increased significantly, and prices have been gradually decreasing. In 2004 the RepRap project was started, which consisted of a self-replicating 3D printer. This RepRap project started with 3D FDM desktops, 3D printers, and 3D printers. In the early 2010s, the terms 3D printing and additive molding evolved in ways that were alternate terms for AM technology. Both terms reflect the same principle that all technologies share a common process of adding materials layer by layer throughout a 3D workflow under automatic control.

THE FUTURE OF KNEE SURGERY

Knee replacement surgery costs the NHS millions of pounds every year. Any number of complications may arise from knee replacement surgery, such as infections, blood loss, pain, instability, and even deep vein thrombosis. Added to this, there remains a group of patients not fully satisfied after knee replacement surgery. The idea of using a 3D printer to create the knee implant allows for a more accurate match of the patient‟s bone anatomy, which would fit them better, restore their biomechanics and hopefully allow for a more satisfactory recovery and outcome. This would then translate to better function and return to an active lifestyle.

LITERATURE SURVEY

Mohammed Usman. In his research paper, he described the general procedures to be followed for the general printing of 3D objects in 3D printing technology, such as design, modeling, and cutting. He also described detailed software specifications for the final product printed by the Delta3D printer used in 3D printing technology.

Tuan D. Ngo, Alireza Kashani, Gabriele Imbalzano, Kate T.Q. Nguyen, David Hoy. In this article, major processing challenges for pore formation, anisotropic behavior, computer design limitations, and layer-by- layer appearance have been described, and biomaterials used in biomedical applications have been described. A thorough review of the main 3D printing methods and materials, and their development. In the trend, the application was made. In particular, innovative applications of AM in biomedical, aerospace, construction and protective structures were discussed.

Professor Alfonso Fiorelli. [3] His article describes the preoperative plan for the implementation of 3D body parts performed as surgical treatment of chest wall disease, and comparison with controls receiving conventional treatment was reported in four studies, in all studies. A satisfactory morphological correction has been reported. Six studies reported good implant fit while minimizing the need for intraoperative adjustment of the implant body part. There were no major complications during or after surgery in both studies.

Professor Yahya Bozkurt and Elif Karaye. This study describes the introduction of 3D printing technology, describes various 3D printing methods, and describes the use of this technology in biomedical applications. Surgery, pharmaceutical industry, disease modeling, custom implant development and Applications of prosthetics, organ printing, veterinary medicine, and tissue engineering are described, and these new methods are compared with traditional methods used in biomedical fields. In addition, this survey includes future opportunities that are expected to be widespread and developed in the future.

L.-C. Zhang, H. Attar1, M. Calin, and J. Eckert.Their article discusses the importance of titanium materials, selective laser melting (SLM) techniques, and the work done on the selective laser melting (SLM) fabrication of titanium materials commonly used in biomedical applications such as microstructures and machines. Evaluate easily. Properties of the obtained material. Successfully created by high-density bulk parts (Ti, Ti–24Nb–4Zr–8Sn, Ti–6Al–4V, Ti–6Al–7Nb, Ti–TiC and Ti–TiB) and selective laser melting (SLM) porous structures When post-femoral deviations are reported when using conventional instruments, such as the light beam, PSI has intrinsic advantages with respect to guiding femoral amputation.

Caillouette and Anzel reported local embolism during intravenous treatment of traditional TKR. However, there were no complications in PSI knee arthroplasty. Moreover, the PSI group’s approach avoided opening the femoral canal, resulting in reduced blood loss.

Abdel et al. PSI previously reported improved rotational alignment as well as postoperative alignment at par. Aneez D.B. Ahmed, Praziwara S. Prakash, and Thiamin Lee Cynthia. [9] In his surgical medical report showing a case study of two elderly patients with chest wall cancer who need repair with some steel alloy, the second case requires repair with a titanium plate to support rib pressure.

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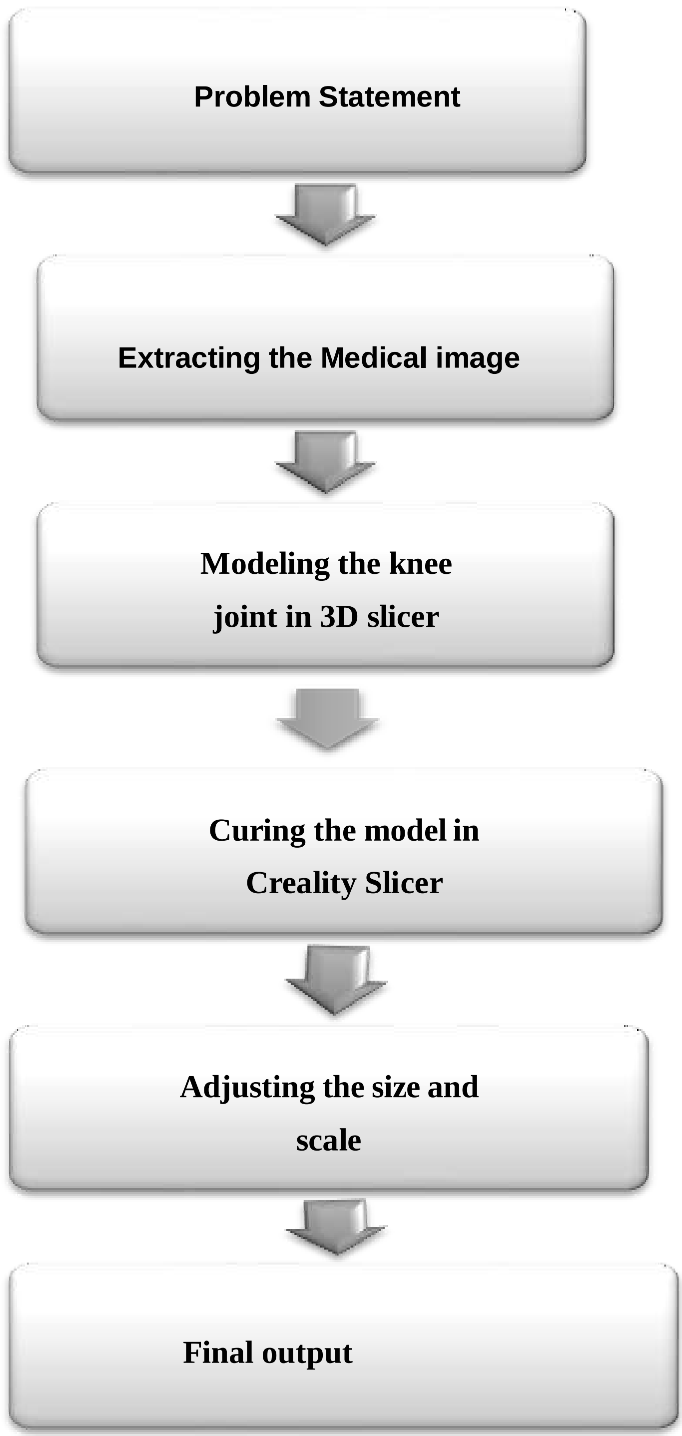
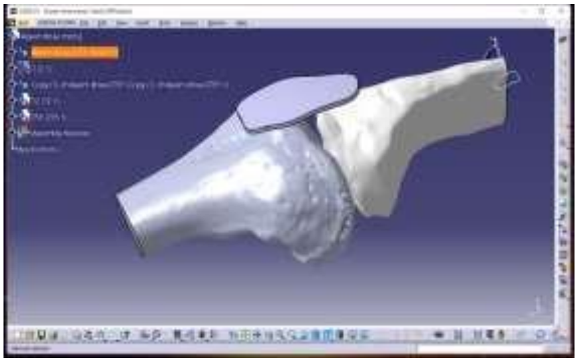
METHODLOGY



DESIGN OF KNEE JOINT

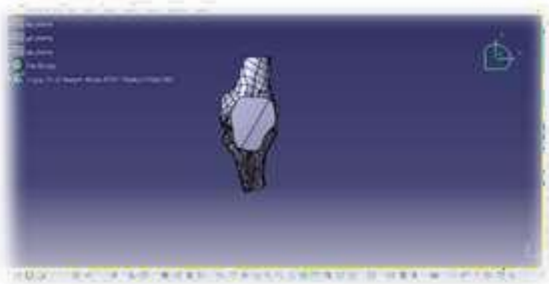
Computer Aided Three-Dimensional Interactive Application (CATIA) is a cross-platform software package for computer-aided design (CAD), computer-aided manufacturing (CAM), computer-aided engineering (CAE), 3D modeling, and product lifecycle management. (PLM), developed by the French company DassaultSystems.

To support the different stages of product development from conceptualization, design, engineering to manufacturing, it is considered CAD software and is also referred to as a 3D product lifecycle management software package. Like most of its competitors, its integrated cloud service facilitates co- engineering and supports use in a variety of fields including form and surface design, electrical, fluid, and electronic systems design, mechanical engineering, and systemsengineering.



Layout of knee joint

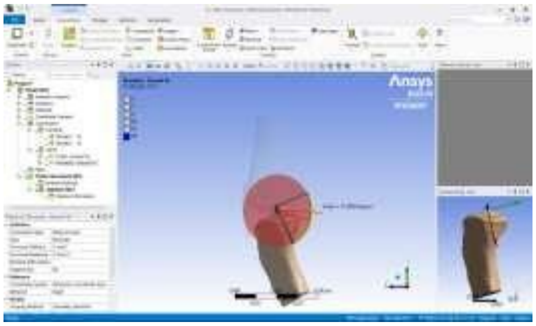
Slicers act as an intermediary between the 3D model and the 3D printer. When you model an object for 3D printing, it is saved to an STL file. Here we use two major slicing software tools to obtain full 3D knee joints in standard tessellation language (STL) file format.



Front view of knee joint

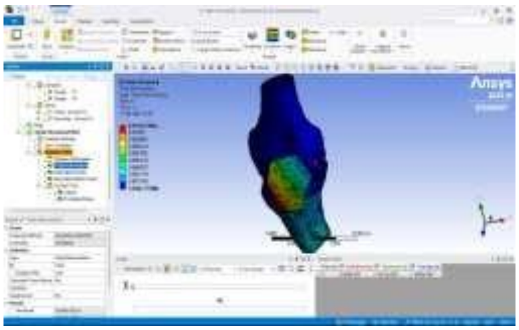
ANALYSIS IN ANSYS

Create geometry in Catia workbench, save file in igs format, open Ansys workbench, apply engineering data (material properties), create or import geometry, apply model (mesh), apply boundary condition (settings) and display the results (stress, strain, strain, shear).



Rotation of Knee joint

Meshing of artificial knee prosthesis for analysis Knee implants and knees imported into AnsysWorkbench for meshing with static analysis are tetrahedrally meshed.



RESULT & DISCUSSION

Coordinate Systems

Model (B4) > Coordinate Systems > Coordinate System

Object Name	*Global Coordinate System*
State	Fully Defined
Definition	
Type	Cartesian
Coordinate System ID	0.
Origin	
Origin X	0. m
Origin Y	0. m
Origin Z	0. m
Directional Vectors	
X Axis Data	[1. 0. 0.]
Y Axis Data	[0. 1. 0.]
Z Axis Data	[0. 0. 1.]

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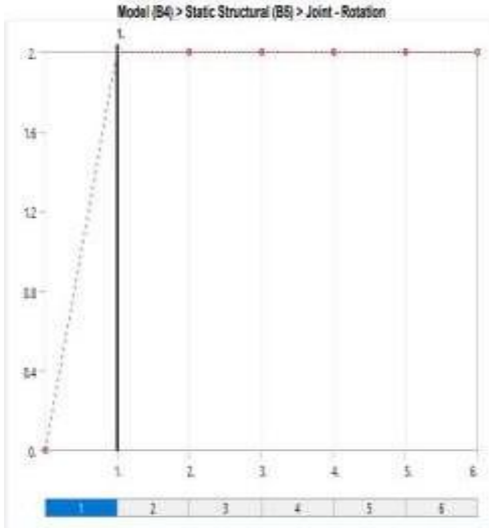
Static Structural



Model (B4) > Static Structural (B5) > Solution (B6) > Results

Object Name	*Total Deformation*	*Equivalent Stress*	*Equivalent Elastic Strain*	*Equivalent Stress 2*	*Total Deformation 2*
State	Solved				
Scope					
Scoping Method	Geometry Selection				
Geometry	All Bodies			2 Faces	1 Vertex
Definition					
Type	Total Deformation	Equivalent (von-Mises) Stress	Equivalent Elastic Strain	Equivalent (von-Mises) Stress	Total Deformation
By	Time				
Display Time	Last				
Calculate Time History	Yes				
Identifier					
Suppressed	No				
Results					
Minimum	2.4888e-028 m	5.481e-007 Pa	3.3206e-017 m/m	1.2869e+007 Pa	1.4214e-003 m
Maximum	3.7021e-003 m	4.3385e+009 Pa	2.4127e-002 m/m	4.3385e+009 Pa	1.4214e-003 m
Average	1.0859e-003 m	3.3715e+006 Pa	2.7155e-005 m/m	2.2027e+008 Pa	1.4214e-003 m
Minimum Occurs On					
Maximum Occurs On					
Minimum Value Over Time					
Minimum	3.1045e-033 m	3.3988e-007 Pa	2.8231e-017 m/m	3.6158e+005 Pa	1.4056e-003 m
Maximum	5.7662e-025 m	5.8742e-007 Pa	3.3206e-017 m/m	1.2869e+007 Pa	1.1814e-002 m
Maximum Value Over Time					
Minimum	3.7021e-003 m	1.219e+008 Pa	6.779e-004 m/m	1.219e+008 Pa	1.4056e-003 m
Maximum	1.2709e-002 m	4.3385e+009 Pa	2.4127e-002 m/m	4.3385e+009 Pa	1.1814e-002 m
Information					
Time	6. s				
Load Step	6				
Substep	1				
Iteration Number	25				
Integration Point Results					
Display Option		Averaged			
Average Across Bodies		No			

CONCLUSION

In this work, the knee joint was successfully fabricated on a 3D printer using a melt deposition modeling (FDM) technique. The generated model features all bony parts of the human knee joint, including femur, tibia, fibula, and patella, based on digital files. The bone hardness of the 3D printed scaffolds was measured on a standard coastal hardness tester (ASTM D 2240) and compared to human bones. 3D printed acrylonitrile butadiene styrene (ABS) knee bones are mechanically biodegradable, making them suitable for human implantation. We are working to apply the bone manufacturing technology of an artificial human knee joint using an Additive Manufacturing process.

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