International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 06 | June - 2022 Impact Factor: 7.185 ISSN: 2582-3930

A REVIEW ON STUDY OF 3D PRINTINGON KNEE JOINT

Dr. B. Vijaya Kumar[1], Adepu Vinay[2], B. Vijay Kumar[3], Ch. Manoj Kumar[4]

[1]Dr. B. Vijaya Kumar Professor and HOD Mechanical & GNIT
[2] Adepu Vinay Mechanical & GNIT, [3]B. Vijay Kumar Mechanical & GNIT,
[4]Ch. Manoj Kumar Mechanical & GNIT

ABSTRACT

The main purpose of this review is to study the design and molding of the knee joint using Additive Manufacturing Technology [3DPRINTING]. A literature review was conducted of studies conducted by various authors regarding the design of the knee joint in print. It was observed that there are 5 papers that the authors have researched and worked on. 1. Knee joint design and manufacturing of smart transformer femoral artificial joint using aluminum alloy 6061, aluminum alloy 7075 and AISI4130 steel. 2. Oliver GrimaldoRuiz1 and YasinDhaher describe a novel method for developing multi-material realistic anatomical models in multi-color multi-color knee joints with unique features. In particular, the design of the fibrous matrix structure mimics the anatomy of soft tissue. 3 TTM.Kannan, R.Mohan are working to improve bone models of the human knee joint using 3D-printed technology to implement human bone grafts. This build model ensures that all bony parts of the human knee joint, such as the femur, tibia, fibula, and patella, are made exactly the same size, providing a good surface finish. 4D.Rajabhushan, R.Vishnuvardhanreddy proposes an artificial knee joint in a cost-effective and time-consuming manner. For this task in the shortest amount of time, we collect MRI digital data of a specific patient's knee joint and import it into 3D slicer software. 5 Comparison of femoral rollback using patient-specific 3D knee model. After total knee arthroplasty (TKA). This study focuses on how to detect these changes and their effect on knee movement after TKA. This approach can reduce complications and reduce the number of corrections in patients with postoperative pain. We observe that there is scope for experimentation and design of biomedical [orthopedic] joints to provide solutions to orthopedic problems.

1. INTRODUCTION

3D printing technology first appeared in the 1980s and during this period was referred to as rapid prototyping (RP) technology. The first patent for RP technology was made by Dr. 1985 Kodama. Hideo Kodama of Nagoya City Industrial Research Institute is generally considered to be the first three-dimensional object of digital design to be printed. 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 was a pioneer in the solid-state imaging process known as stereo lithography and the STL file format, which are still the most popular formats in 3D printing today. He is also believed to have started marketing high-speed 3D printers that are becoming increasingly effective and useful, lowering prices to make them more affordable.

3D printing is an additive manufacturing technology that prints 3D objects with the help of computer-aided design software. In this human knee joint model using 3D printing technology to simulate human bones. Significant advances in additive manufacturing in medical applications. An integrated approach to scanning technology has been applied to the software package and rapid prototyping ensures the creation of human bones. This manufacturing model states that all bony parts of the human knee joint, such as the femur, tibia, fibula, and patella, are manufactured with a good surface finish and exactly the same size. This knee joint is made of Acrylonitrile Butadiene Styrene (ABS) and made with Fusion Deposition Modeling (FDM) technology. The knee joint model was designed using Catia software. The 3D model is saved in STL format and sent to the 3D printer. The 3D printer prints the CAD design and then applies the printed materials layer by layer 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.

2. METHODOLOGY

The authors use the following methodology to conduct their research work:

Profession design

1. Fahad M Kadhim et al designed a prosthetic leg that consists of two parts of the design of the knee joint of a prosthetic leg, namely the upper and lower parts. Their name comes from their stand. These two parts are fixed with one screw. w Both parts act as artificial knee hinges that can be moved to create a moment in the knee joint. The driven motor presses or pulls the floor to generate a moment. This moment

flexes or lengthens the knee joint. It is attached to the shank with a drive motor joint.

Analysis

In the analytical model of the knee joint and the evaluation of stresses and strains, von Mie's must apply boundary conditions to the knee joint model. Boundary conditions include a 1200 N load on the hinged upper edge.

2. Oliver GrimaldoRuiz and YasinDhaher, Preoperative planning by dedicated software is an effective tool for determining implant type and size, predicting the postoperative biomechanical environment and reducing preoperative complications. TKA includes three important implants: the femoral liner, the tibia, and the joint.

3. TTM. Kannan et al. The knee is designed using ABS material. ABS has a toughness of 215 J/m, a Young's modulus of 3.2 GPA, a stiffness of 2.4 GPA, a tensile strength of 43 MPa, and an elongation of 6%. It is a biocompatible material used to fabricate artificial knee bones by melt deposition modeling techniques.

4. D.Rajabhushan, R.Vishnuvardhan reddy adopted three models of artificial joints to reduce cost. So they took three models of the patient-friendly design they used to print the models and applied them to the patient.

5. If the prosthesis is not properly placed, movement is impeded, lift is visible, or flexion does not continue naturally. The hypothesis was formulated in terms of rollback, one of the most frequently discussed parameters, and then modified in the case of knee arthroplasty following the surgeon's routine. Experiments should show that the shape of the prosthesis affects the movement of the knee joint. A limitation made in this study by using a four-bar linkage to guide the bones is that they can focus on geometrical influences on joint kinematics. Validation of the hypothesis focused on the effectiveness of the prosthesis and tested one form and one orientation to compare mechanical parameters before and after surgery.

3 LITERATURE SURVEY

1. Fahad M Kadhim, Jumaa S Chiadand Ayad M Takhakh described how to upgrade a passive prosthesis to a microcontroller-based transfemoral prosthesis. A computer program can be used to perform finite element analysis (ANSYS) and to evaluate the conclusions to know whether the proposed prosthesis can withstand a particular load. The results were discussed and evaluated for the new model proposed by this study.

2. Oliver Grimardo Luis 1 and Yassin DajaThe correlation of the stress-strain curve pattern in the elastic region, stiffness

and modulus of the proposed combination has been described in the published literature. Therefore, No. 1. 4 with elastic modules between 0.76 and 1.82 MPa were chosen for 3D printing of soft tissue.

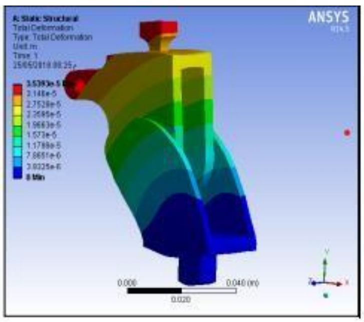
3. TTM. Kannantal talked about a model of the human knee joint using 3D printing technology to implement human bone grafts. This fabricated model builds all the bony parts of the human knee joint exactly the same size, including the femur, tibia, fibula, and patella, providing a good surface finish. This knee joint is made of acrylonitrile butadiene styrene (ABS) and is created using melt deposition modeling (FDM) technology. Bone hardness of the knee joint of the artificial scaffold was measured with a coast durometer (standard ASTM D-2240) and compared with human bone. We intend to apply artificial boneless craft to human transplantation.

4. D.Rajabhushan, R.Vishnuvardhan reddy proposed to develop an artificial knee joint in a cost-effective and short time. For this task, digital MRI data of a specific patient's knee joint is acquired and imported into 3D slicer software. Check the dimensions of the plate. Patient fit knee with 3D slicing software. Print the patient's right knee using a 3D printer with ABS or PLA filament. If the 3D printed knee is suitable for replacement, the artificial knee will be printed with Ti-6Al-4V filament.

5. Alexandra Mercader et al: Described a 3D model of a patient's knee created by measuring motion with a medically certified infrared stereo camera. These measurements were previously combined with 3D models of the patient's bones segmented on CT scans. The models are 3D printed, some are mechanisms to track the patient's movements, and others are 3D copies of the femur and tibia. Knee arthroplasty was performed directly on the model, and the resulting rollback was measured before and after TKA.

4. RESULT AND DISSCUSSION

1. The color range refers to the various displacement values distributed throughout the artificial knee joint. Since the lower part of the artificial knee joint is set to be fixed, the displacement of that area is 0 mm. High displacement in the red/orange region distributed in the upper region for all types of material. The maximum displacement was recorded as 0.035 mm for aluminum alloy 6061. Then followed by aluminum alloy 7075 0.034mm, AISI4130 steel 0.012mm. The displacement of AISI 4130 steel is very small and recommended. Although aluminum alloy 6061 recorded a maximum displacement of 0.035 mm.



2. The stress-strain curve pattern of the elastic region, stiffness and modulus of the proposed combination was correlated with the published literature. Therefore, No. No. 1. 4 with elastic modules between 0.76 and 1.82 MPa were chosen for 3D printing of soft tissue. Finally, the knee joint 3D-printed model was manually tested by simulating a 50-cycle flexo elongation without causing damage.

3. In this work, including CT scan images, digital files, and rapid prototyping, the recovered knee joint model is imported from computed tomography and converted into digital files with software. During the printing process, a 3D print of artificial human bones was created using a layer thickness resolution of 0.254 mm. Using ABS as a raw material, all parts of the knee bone, such as the femur, tibia, fibula, and patella, are molded layer by layer to finally form the necessary scaffold shape. After fabricating the artificial knee joint, the hardness value was measured and compared with the human bone.

4. 200 normal knee MRI scans (100 females and 100 males from 18 to 60 years of age) were obtained for analysis. Linear (anteroposterior (AP), mesiolateral (ML) and aspect ratio (AR)) measurements of the planned resection planes of the distal femur (f) and proximal tibia (t) were evaluated.

We observed the difference in rollback before and after TKA in the 5.3D printed model. The change in the size and shape of the femoral implant compared to the natural femoral condyle is one of the reasons for the change in the rollback effect. The rollback after insertion of the prosthesis is halved. This supports the fact that the shape of the femoral prosthesis influences knee kinematics.

5 CONCLUSIONS

1. Model aluminum alloy 6061 is optimally selected for use in the manufacture of artificial knee joints, which provides more stability and comfort to the amputee due to its low cost, light weight and acceptable safety. .

Maximum recorded von Mises stress when using AISI4130 steel with a value of 41.6 Mpa

The maximum safety factor was recorded with the use of aluminum alloy 7075 with a value of 12.31.

The greatest deformation was seen with Alloy6061 with a value of 0.035 mm.

The minimum recorded weight when using Alloy 6061 is rated at 0.192 Kg.

2. The proposed anatomical model offers a wide range of applications. It can be viewed as

an alternative to cadaveric specimens for medical training, preoperative planning, research and educational purposes, and validation of predictive models. It is emphasized that although the values of modulus and linear stiffness are different, the mechanical patterns and stiffness obtained with polymer-mimicking soft tissue are qualitatively equivalent. The results showed that the proposed soft tissue anatomical artificial material is strong enough to withstand deformation during flexion-extension. The reported methodology for the design of fibrous matrix structures can be considered as a starting point for developing new patterns and types that can mimic soft tissue.

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

4. The time it takes to manufacture the artificial knee joint by trial and error is more than 10 days and the cost is 45.000/-, but in this work, by using FDM technology, the time and cost are reduced to less than 7 days. It is reduced to 18.000/-. Therefore, the FDM technique is the most effective method compared to the trial and error method.

5. In conclusion, this study provides a different perspective of TKA by simulating the biomechanics of the knee before and after surgery using a 3D printed machine model based on the anatomical structure of the real knee. A model with limited flexion was created by directly measuring the patient's knee movement with an infrared camera. Because this model does not include ligaments, the surgeon can manipulate and implant the prosthesis according to the TKA technique according to the surgical procedure planned for the patient. Experiments in a real patient knee model showed a reduction in rollback after surgery. Therefore, TKA alters the kinematics of the joint and these changes can cause patient dissatisfaction. This 3D printed model allows you to observe axial reconstruction, rotation, component removal, details of knee movement such as ligamentous hypertension, and rollback changes between pre- and post-operative models. In an expanded future study, it would be interesting to increase our understanding of the general outcome of TKA, which broadens the technical aspects by examining different knee sets, the placement of different components, or comparing the outcomes of different surgical techniques discussed.

6. REFERENCES

- Gailey R S, Roach K E, Applegate E B, Cho B., Cunniffe B, Licht S, Maguire M and Nash MS., 2002 The Amputee Mobility Predictor: An instrument to assess determinants of the lower-limb amputee's ability to ambulate, Arch. Phys. Med. Rehabil. vol .83(5), pp. 613–627.

- Pitkin, M. R., 2010 Biomechanics of Lower Limb Prosthetics, Springer Berlin Heidelberg, Berlin, Heidelberg.
- Roozbeh Borjian, 2008 Design, Modeling, and Control of an Active Prosthetic Knee University of Waterloo, degree of Master of Applied Science in Mechanical Engineering.
- Lambrecht, B. G. A, 2008, Design of a hydbrid passive-active prosthesis for above knee amputees" University of California, Berkeley, Unpublished doctoral dissertation.
- Aeyels B. Peeraer L, Vander Sloten P and Vander Perre G, 1992, Development of an above knee prosthesis equipped with a microcomputer controlled knee joint: First test results, journal of Biomedical Engineering, vol. 14, pp. 199–202.
- Hata, N. and Hori, Y. 2002 Basic research on power limb using gait information of able-side leg,7th International Workshop on Advanced Motion Control, pp. 540–545.
- Kapti, A. O and Yucenur, M. S. 2006 Design and control of an active artificial knee joint,Mechanism and Machine Theory, vol. 41, no. 12, pp. 1477-1485.
- Fite, K. 2007 Design and control of electrically powered knee prosthesis. Paper presented at the Conference of Rehabilitation robotics, Noordwijk.
- Martinez E C, Weber J, Elliot G., and Herr H,2008 Design of an agonist-antagonist active knee prosthesis. Journal of Biomedical Robotics and Biomechatronics, vol. 11(5) pp. 19-22.
- V. N. Murthy Arelekatti and Amos G. 2017 Design and Preliminary Field Validation of a Fully Passive Prosthetic Knee Mechanism for Users with Transfemoral Amputation in India, ASME Journal of Mechanisms and Robotics.Mitsouras D, Liacouras P, Imanzadeh A, Giannopoulos AA, Cai T, Kumamar Radiographics.
- Mitsouras D, Liacouras P, Imanzadeh A, Giannopoulos AA, Cai T, Kumamaru KK, George E, Wake N, Caterson EJ, Pomahac B, Ho VB, Grant GT, Rybicki FJ. Medical 3D Printing for the Radiologist. Radiographics. 2015;35:1965–88. https://doi.org/10.1148/rg.201514032
- Chepelev L, Wake N, Ryan J, Althobaity W, Gupta A, Arribas E, Santiago L, Ballard DH, Wang KC, Weadock W, Ionita CN, Mitsouras D, Morris J, Matsumoto J, Christensen A, Liacouras P, Rybicki FJ, Sheikh A. RSNA Special Interest Group for 3D Printing. Radiological Society of North America (RSNA) 3D printing Special Interest Group (SIG):

guidelines for medical 3D printing and appropriateness for clinical scenarios. 3D Print Med. 2018;4:11. https://doi.org/10.1186/s41205-018-0030-y.

- Mitsouras D, Liacouras PC, Wake N, Rybicki FJ. RadioGraphics Update: Medical 3D Printing for the Radiologist. Radiographics. 2020;40(4):E21–3. https://doi.org/10.1148/rg.202019021
- George E, Liacouras P, Rybicki FJ, Mitsouras D. Measuring and establishing the accuracy and reproducibility of 3D printed medical models. Radiographics. 2017;37(5):1424–50. 583. https://doi.org/10.1148/rg.2017160165.
- Di Prima M, Coburn J, Hwang D, Kelly J, Khairuzzaman A, Ricles L. Additively manufactured medical products-the FDA perspective. 3D Print Med. 2015; 2(1):1–6. https://doi.org/10.1186/s41205-016-0005-9. 6. Anderson PA. 3D Printing for Education and Surgical Planning in Orthopedic Surgery. 3D Printing in Orthopedic Surg. Elsevier Inc. 2019:5 58118-9.00006-3.
- Bücking TM, Hill ER, Robertson JL, Maneas E, Plumb AA, Nikitichev DI. From medical imaging data to 3D printed anatomical models. Plops One. 2017; 12(5):1–10. https://doi.org/10.1371/journal.pone.0178540.
- s GG, Clarke S, Jaere M, Cobb J. 3D printing and unicompartmental knee arthroplasty. EFORT Open Rev. 2018;3(5):248–53. https://doi.org/10.1302/2058- 5241.3.180001.
- Qiu B, Liu F, Tang B, Deng B, Liu F, Zhu W, et al. Clinical Study of 3D Imaging and 3D Printing Technique for Patient-Specific Instrumentation in Total Knee Arthroplasty. J Knee Surg. 2017;30(8):822–8. https://doi.org/10.1055/s-0036-1597980.
- Soni A, Kumar Modi Y, Agrawal S. Computedtomography based 3D modeling and analysis of human knee joint. Mater Today Proc. 2018;5(11): 24194–201. https://doi.org/10.1016/j.matpr.2018.10.214.