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HIP JOINT CT SCAN DATA TO FABRICATION PROCESS USING 3D PRINTING MACHINE FOR DEMONSTRATION OF MEDICAL PURPOSE

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*Abstract— **Human hip joint is the one of the most complex joint in the body. Now a day's, many people are facing problems with hip pain. It is due to decrease in calcium content in the bones and wear in the hip joint. In order to reduce the hip pain doctors choose to replace original hip joint with artificial hip joint. Trial and error method is adopted by the doctors during the selection of artificial hip joint, which is almost similar to the original hip joint.***

Artificial hip joints are different sizes which suits the patient is preferred by the doctors, which increases the operation cost as well as time to perform the operation .The artificial joint one must fulfil the requirements of bio-compatibility, stability and mobility. Artificial hip joint with Ti-6Al-4V material can be manufactured traditional method as per the dimensions requires more cost and time. It is difficult to visualize for medical demonstration.

In such adverse conditions it provides a quick and precise solution to the problem. CT scan data of hip joint is used to fabricate the prosthetic part on 3D printing machine by PLA material. In this project highlights are CT scan digital images of hip are taken and these images are measured using 3D Slicer and 3D tool software's. These dimensions are used hip joint prosthesis three dimensional models are designed in Solid Works 18.0 software and all the components of hip joint prosthesis were fabricated in 3D printing machine. This is used mainly for medical demonstration.

*Keywords— **Hip joint, 3D Printing machine. 3D Slicer Software, 3D TOOL, Solid works Software.***

I. INTRODUCTION

3D printing is additive manufacturing process. Every 3D print starts as an electronic 3D arrangement record like a blue print for a physical inquiry. Trying to print without a structure record looks like endeavouring to print a chronicle on a sheet of paper without a substance report. This arrangement record is cut into thin a layer which is then sent to the 3D printer. From here on the printing methodology varies by development, starting from work zone printers that disintegrate a plastic material and lay it down onto a print stage to broad present day machines that use a laser to specifically condense metal powder at high temperatures. The printing can take hours to complete dependent upon the size, and the printed articles are as often as possible present arranged on accomplish the pined for wrap up. Open materials similarly change by printer type, reaching out from plastics to versatile, sandstone, metals and mixes - with a regularly expanding number of materials appearing accessible reliably.

II. LITERATURE SURVEY

[1]. Solehuddin Shuib[1], Amizi Nur[2], Shamsuddin Sulaiman[3] and Barkawi B. Sahari[4] : The number of total hip replacement processes is growing every year, and it is approximate that it has risen over 800, 000. Various manufacturing technique has been practiced to manufacture hip implant; such as grinding, injection moulding, extrusion, CNC.

[2]. L.C. Zhanga[1], E.C.S Kiat[2], A. Pramanikc[3]: The structure of hip joint prostheses should veer to provide food for various requests. The measure of the femoral head appeared in territories for the most part between 22 mm to 40 mm in breadth to suit singular patients. To enhance the execution of the aggregate hip prostheses, huge examinations have been done in the zones, for example, better assembling strategies, new stem structures and more exact means for portrayal. In the accompanying, we will initially feature a few huge issues and afterward center on cleaning as the precision completing advance of the prostheses created.

III. PROBLEM STATEMENT

Hip joint is an essential joint in human body. Any illness including hip joint prompts gigantic trouble in strolling, and results in extreme handicap. The hip joint is a round joint among the femoral head and the ace tabular in the pelvis. It mostly capacities to help the heaviness of the body in both dynamic and static positions. Hip joint is ball and socket joint. Hip joint consists of following:

1. Femoral stem.
2. Femoral head.
3. Acetabular component.

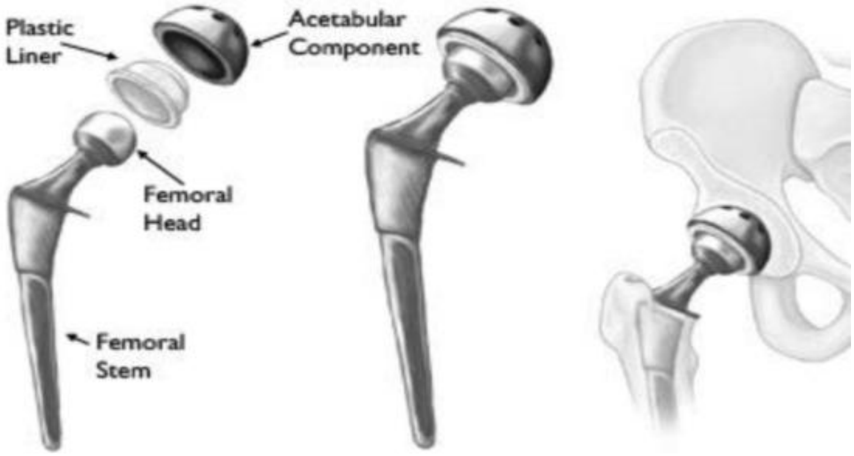

Fig 1. Components of Hip Replacement.

Iv. PROBLEM SOLUTION

Additive Manufacturing is the process in which material will store layer by layer to shape the required substantial item Additive Manufacturing is likewise called as 3D printing. 3D printing is aid for prototyping industry. Additive Manufacturing will be the third modern insurgency since 3D printing has new and growing specialized social and monetary effect especially in prototyping. 3D printing permits mass customization in industries like car, health cares aviation, training, customized blessings and shopper parts. It permits testing the structured parts physically in less time and permits planners and specialists for delivering remarkable and innovative parts. Prototyping is the main one which utilizes 3D printing. 3D printing machines produces physical items layer by layer to shape the required 3D model. It can make physical items as per structure, the plan document might be made in displaying programming resembles CATIA, PRO-E, SOLIDWORKS, AUTOCAD and so on. At that point configuration record is changed over into STL format. As indicated by the STL file 3D printing machine going to print the part.

V.EXPERMENTAL PROCEDURE

A. DICOM VIEWER

DICOM means **"Digital Imaging and Communications in Medicine".**

1) DICOM data in DICOM VIEWER Software:

- identified a person suffering from hip pain.
- CT data of hip joint of the person suffering from HIP pain is taken in DICOM format.
- The DICOM data is viewed in the DICOM viewer software for clear visibility.
- After uploading the DICOM data into software the images are seen like below structures.

Fig 2: View of the hip joint on DICOM viewer software.

B. 3D SLICER

3D slicer is a modular platform for image visualization and analysis. 3D slicer plays an important role in medical sector; particularly in orthopaedics it plays a very important role for identifying the cracks and defects in the bones. Also this software is very useful for the doctors to perform surgery. By using this technology doctors reduces the operation time.

1) 3D Slicer Work bench:

- after analyzing the DICOM data, identify whether the patient is in the first stage of hip pain i.e. posterior type of artificial hip joint.
- Then the DICOM data is imported to 3D slicer software by using DCIM – IMORT – DICOM - OK.
- after uploading the DICOM file in to 3D slicer software the views can be shown like below figure.

2) Volume rendering :

- In first step the DICOM images are visible in 2D only. You want to see a 3D object in slicer software, go to volume rendering click on ok.
- After every 2D image have an individual eye icon then click ok for which direction you want see in 3D view.
- In part of this work after clicking the icons the window was shown like above figure.

3) Crop volume :

- Select present option and by clicking on this option so many icons are displayed on to that again selected CT MIP then the work bench can be seen fig.
- In part of this work after doing this process bones are displayed on 3D slicer software in 3D view.
- In part of this work separate the femur joint by clicking on crop icon on that again select display ROI icon.
- In part of this work by clicking on these two icons the one white colure 3D box are displayed on 3D slicer software.

4) Creating label and building model :

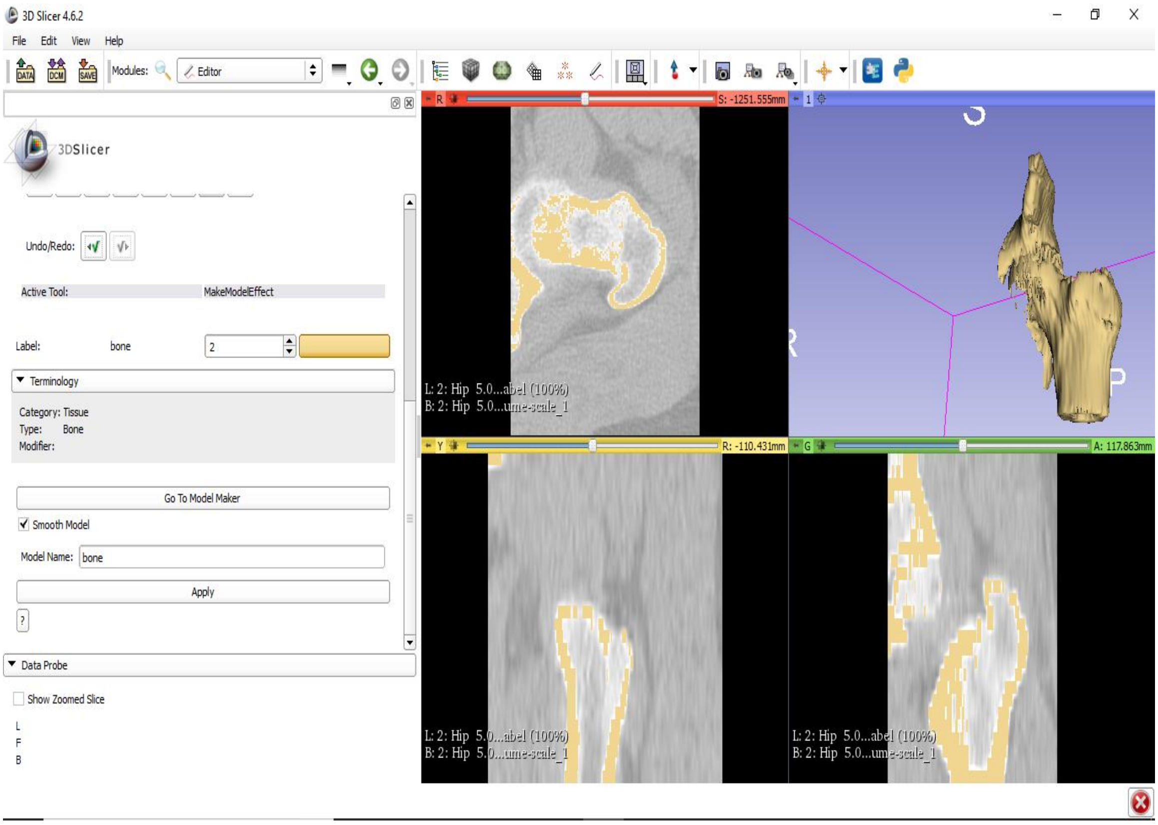

Fig 3: Loading and saving condition in 3D slicer software.

After cropping is done labels should be generated by using the editor tool to create 3d model. The 3dmodel should be saved in a.STL (Standard Tessellation) format.

C. 3D TOOL

3D Tool is used to measure the distances, radius, angles and wall thicknesses as well as to create cross sections and exploded views.

1) Load .STL file within 3D-Tool: Start 3D-Tool, and use Open function in the File tab or click Open in the Quick Access Toolbar. Then select the file(s) with the File open dialog, and click Open.

2) Measure and Mark up: Use the Measure/Mark up tool to add 3D dimensions and mark ups to the models, and images and text to the background. The Measure/Mark up tool is located in the Tools group of the 3D-Mode tab.

3) Measure Distance, Angle, Edge, Wall Thickness and Clearance: Measure distances, angles, edges, boundary boxes, wall thickness, and clearances. Click the Measure/Mark up tool in the Tools group. Click the Distance/Angle button to measure distances and angles or click the little black arrow in the button to select another measure function.

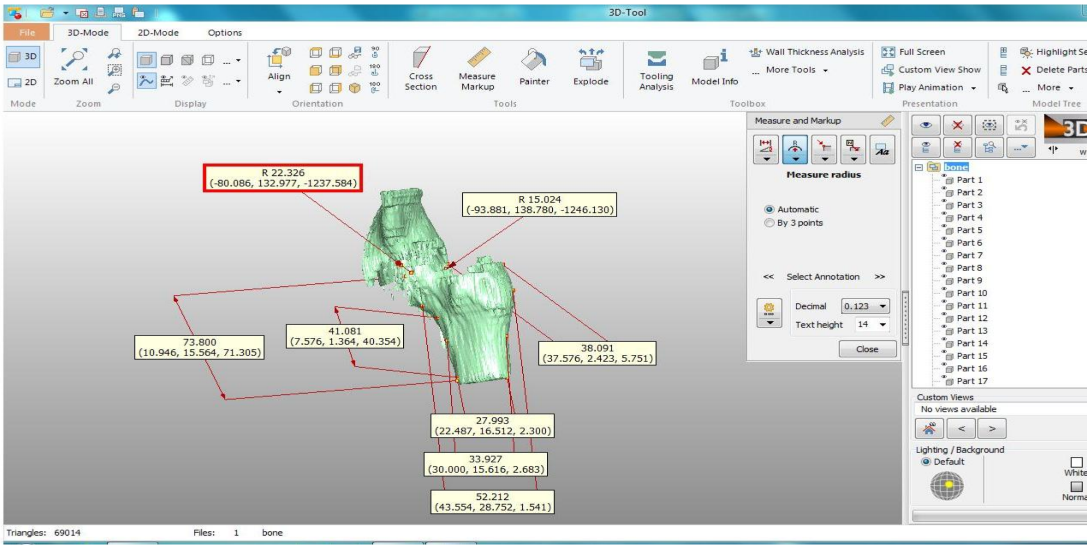

Fig4: Measuring the hip structure using 3D tool software.

D. SOLIDWORKS

Solid Works is a 3D solid modeling package which allows users to develop full solid models in a simulated environment for both design and analysis. In Solid Works, you sketch ideas and experiment with different designs to create 3D models. Solid Works is used by students, designers, engineers, and other professionals to produce simple and complex parts, assemblies, and drawings. Designing in a modeling package such as Solid Works is beneficial because it saves time, effort, and money that would otherwise be spent prototyping the design. Solid Works is published by Dassault Systems.

1) Solid work elements:

i . Part,
ii. Assembly,
iii. Drawing.

2) SolidWorks – Let's Begin:

● By default, no file is opened automatically when you start the program.
● To create a new file, click on File > New or click the New File icon in the main toolbar.
● This will open the New SolidWorks Document wizard.
● Let's begin by creating a new part. To do this, click on Part, then OK.
● Once you do this, you will be brought into the modeling view which should open several toolbars and panes.
● There are several important parts of the screen that needs to be identified before we continue.
● We have now completed the basic features of part modeling and it is now time to begin constructing more complex models in the form of assemblies.
● Recall that an assembly is a collection of parts that are connected using mates or constraints.

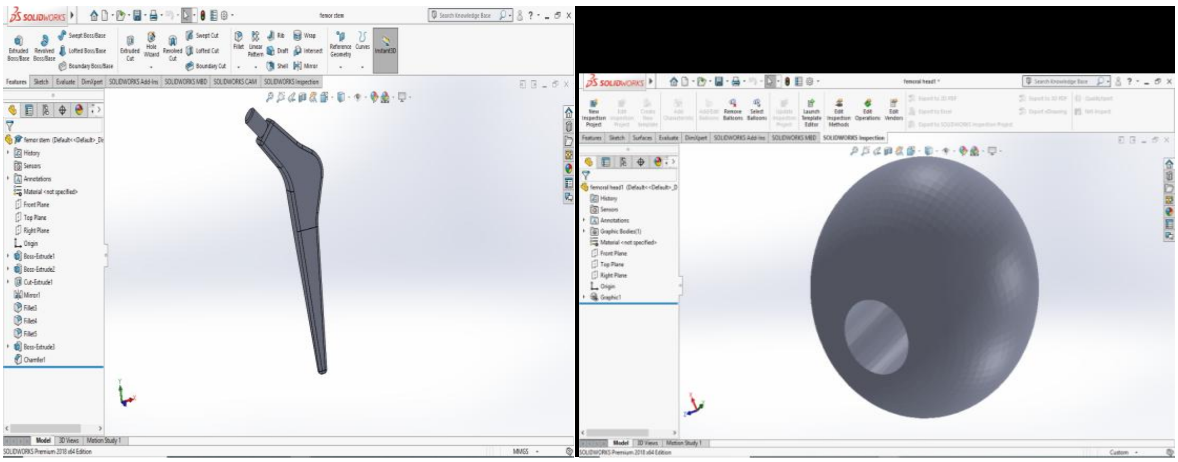

Fig 5: Modeling femoral steam and head using solid works software.

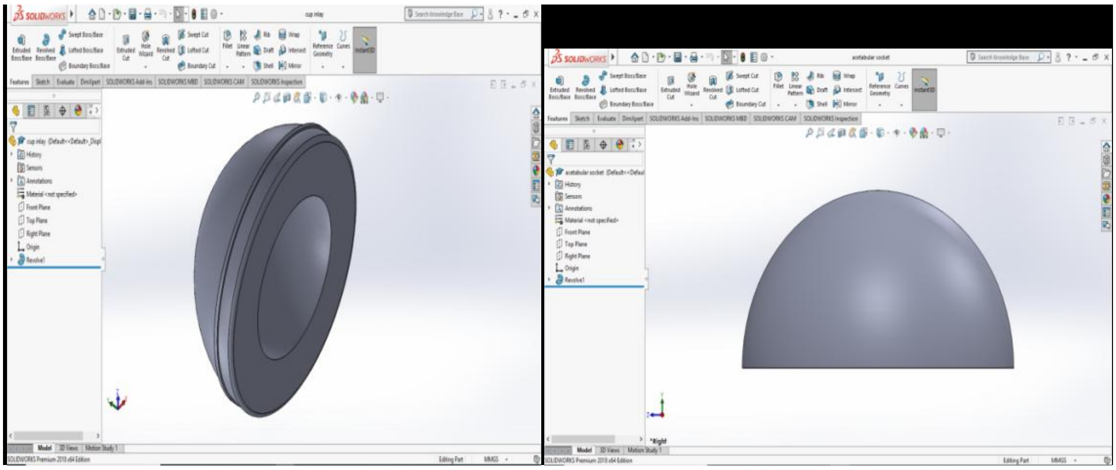

Fig 6: Modeling accetubular socket using solid works software.

● SolidWorks makes it very easy for us to create drawings from a part or assembly file.
●.The 3D model should be saved in a .STL (Standard Tessellation) format.

D. 3D PRINTING

1) Printing conditions of PLA filament in FDM machine:

● The printing conditions for the imported .STL files on 3D printing machine in for PLA material is as follows.

TABLE I
Printing Conditions for PLA Material.

PROPERTY	PRINTING CONDITION
Layer height	0.1 mm
Top/bottom thickness	1.2 mm
Shell thickness	1.2 mm
Nozzle temperature	215 °C
Bed temperature	60 °C
Fill density	60%
Filament flow	100%

● The saved .STL files are loaded into fracktory workbench.
● First open the fracktory software by double clicking on that icon, then clicking on the load option the .STL file Are clicked then ok. The .STL object is visible in 3D view.

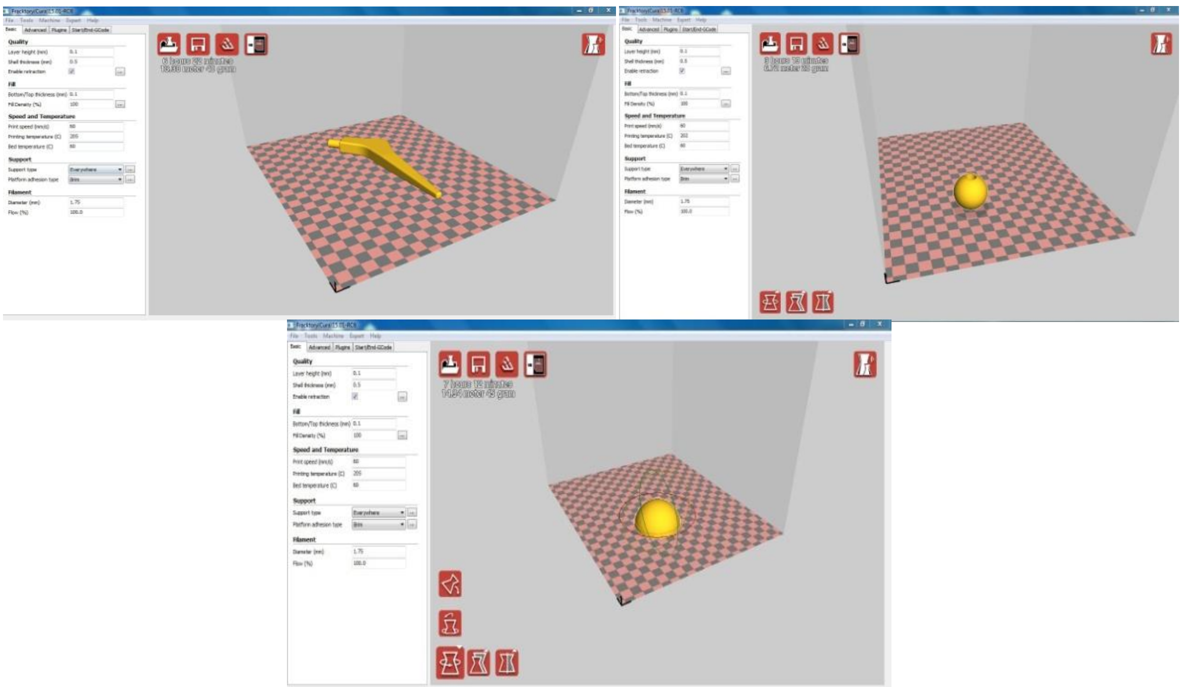

Fig 7: loading condition on fracktory work bench.

- Then adjust the printing conditions for PLA material mentioned in the table.
- The artificial hip joints are printed with PLA material with the loading conditions.

Fig 8: Final 3D printed components.

E. MOVEMENT ANALYSIS

The mobility of human joint is indicated by the relative motion between bones connected by the joint. This relative motion depends on the contact between bones and also the maximum strains of tissues surrounding the joint. If a natural joint is replaced, the joint replacement should be able to achieve the minimum movement of the natural one.

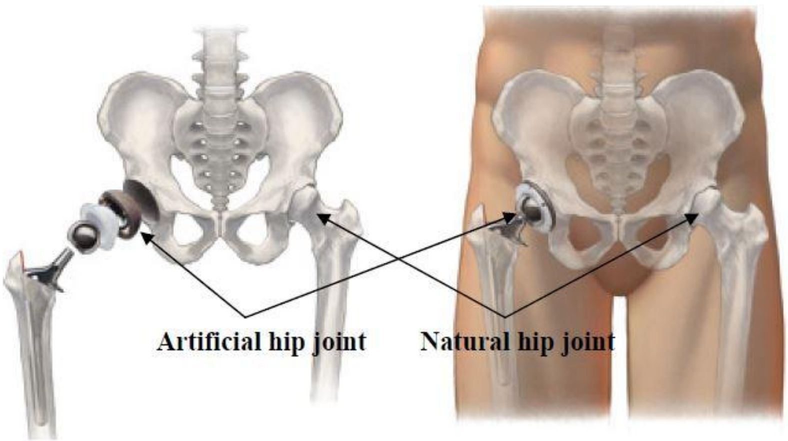

Fig 9: Compare movement between Natural and Artificial Hip joint.

The types of joint movement are

1. Abduction,
2. Adduction
3. Flexion,
4. Extension, and
5. Rotation.

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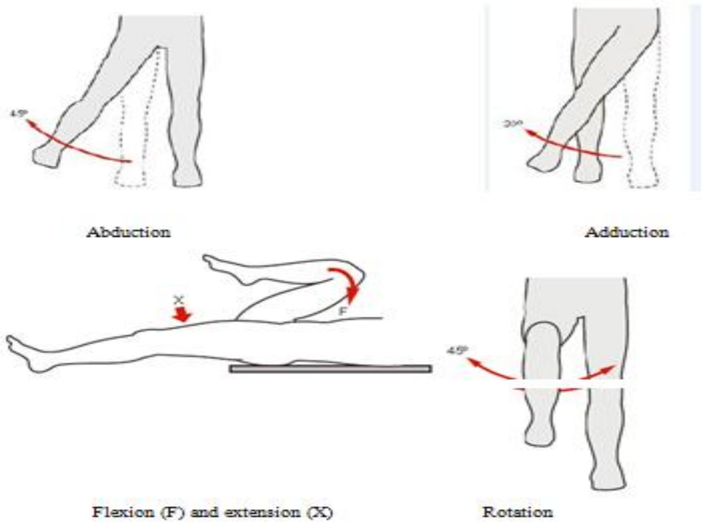
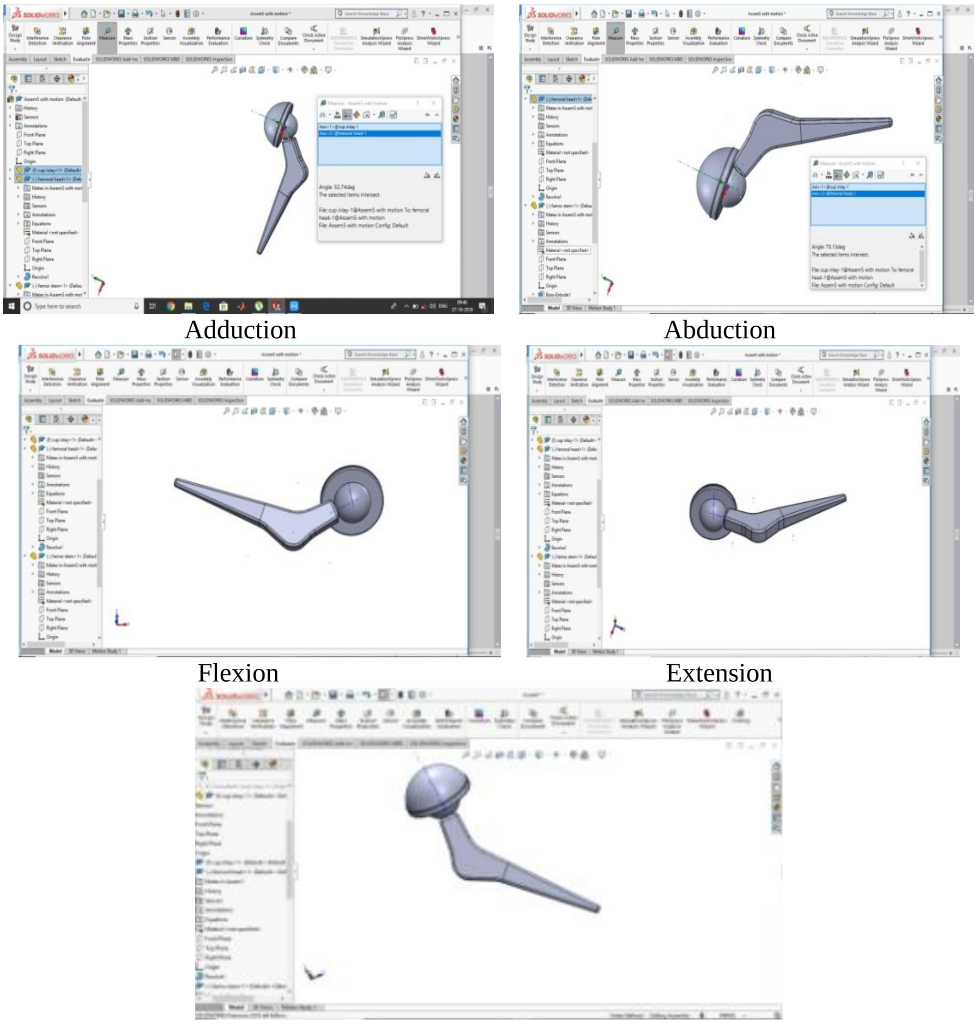


Fig 10: Normal range of motion (ROM) of a human hip joint.

- Abduction is the movement of joint member outward the body axis.
- Adduction is the movement toward the body axis.
- Flexion is the movement to bend the joint.
- Extension is to straighten the joint.
- Rotation is the movement of joint member around its centre.



Adduction Abduction

Flexion Extension

Rotation

Fig 11: Adduction, Abduction, Flexion, Extension Angles
Are measured using Solid Works Software.

TABLE 2
Range of motion of artificial hip joint.

Movements	Range Of Motion
Adduction	Maximum 52°
Abduction	Maximum 71°
Flexion	Maximum 95°
Extension	Maximum 92°
Rotation	Maximum 45°

VII. RESULT AND CONCLUSION

In this work an attempt has been made to manufacture artificial hip joint by 3D printing technique. 3D printing offers the original potential to fabricate organized tissue constructs. CT scan digital images of hip are taken and these images are converted to 3D printing language using 3D Slicer, 3D Tool, and Solid Works software's. The hip joint is printed by 3D printing machine through PLA filament. If the 3D printed hip is used mainly for medical demonstration. Artificial hip joint with Ti-6Al-4V material can be manufactured traditional method as per the dimensions requires more cost and time required. By doing these the ordering cost as well as processing time can be reduced. And Compare movement between Natural and Artificial Hip joint.

TABLE 3
Compare movement between Natural and Artificial Hip joint.

Type of Movement	Range of motion of Natural hip joint	Range of motion of Artificial hip joint
Adduction	Max. 45°	Max. 52°
Abduction	Max. 30°	Max. 71°
Flexion	Max. 125°	Max. 95°
Extension	Max. 30°	Max. 92°
Rotation	Max. 45°	Max. 45°

The following conclusions were drawn from this work.

REFERENCES

[1]Solehuddin Shuib, [1]Amizi Nur, [2]Shamsuddin Sulaiman and [1]Barkawi B. Sahari. Regional Conference on Engineering Mathematics, Mechanics, and Manufacturing & Architecture "MANUFACTURING METHODS OF IMPLANT FOR USE IN ORTHOPEDIC APPLICATIONS: HIP PROSTHESIS."

[2] Sachin G. Ghalme[1]*, Ankush Mankar[2], and Yogesh Bhalerao international journal of material science and engineering. "Boimaterial in hip joint replacement".

[3] L.C. Zhanga, E.C.S Kiat, A. Pramanikc. " The structure of hip joint prostheses."

[4] SantoshKumarMalaya* and Ravi Kumar. Y International Journal of Recent Scientific Research. "A REVIEW ON RAPID PROTOTYPING TECHNOLOGIES IN BIOMEDICAL APPLICATIONS"

[5] B.R.Rawal, [1]Rahul Ribeiro, [2]Rajesh Malhotra and [1]Naresh Bhatnagar design and manufacturing of short stmelesh femorl hip implant based on CT images [1]Siddharth Bhandari, [2]B Regina. International Journal of Computer Science and Information Technology Research. "3D Printing and Its Applications."

[6] [1]Siddharth Bhandari, [2]B Regina. "3D printing when contrasted with to conventional methods of manufacturing."

[7] Andrew J. Hughes, [1]Cathal DeBuitleir, [1]Philip Soden, [1]Brian O'Donnchadha, [2]Anthony "3D Printing Aids Acetabular Reconstruction in Complex Revision Hip Arthroplasty."

[8] Shanshan Wang[1]*, Li Wang[3]*, Yan Liu[2], Yongfang Ren[3], Li Jiang[2], Yan Li[2], HAO EXPERIMENTAL AND THERAPEUTIC MEDICINE. "3D printing technology used in severe hip deformity."

[9] Eko Saputraa*, Iwan Budiwan Anwara, J. Jamarib, Emile van der Heidea The Malaysian International Tribology Conference.

[10] Asbjbrn roaas & Gunnarb. J.Andersson "Finite Element Analysis of Artificial Hip Joint Movement during Human Activities.". Deparment orthopaedic surgery. "Normal range motion of the hip knee and ankle joints in male subjects, 30 -40 years age."