

3D Printing and 3D Models as a part of Preplanning for Complex Total Hip Arthroplasty

¹Kalaivanan Kanniyar, ²Shantanu Patil, ³Ashok Kumar PS, ⁴Vijay C Bose, ⁵Suryanarayan Pitchai

¹Consultant Revision Arthroplasty, ²Consultant Research Lead, ³Consultant Robotic Hip & Knee Replacement, ⁴Joint Director & Senior Consultant, ⁵Joint Director & Senior Consultant

¹Kalaivanan Kanniyar, Revision Arthroplasty & PJI, Bone Infection & Oncology Unit, AJRI @SIMS Hospitals,

¹Asian Joint Reconstruction Institute – AJRI @ SIMS Hospitals, No 1, Ortho counter No 5, 100 feet main road, Jawaharlal Nehru salai, vadapalani, Chennai, India, 600026.

ABSTRACT:

AIM: To assess the role of 3D printing and 3D Models, as a part of preplanning in patients undergoing Complex Total Hip Arthroplasty (CTHA) and their functional outcome.

MATERIAL AND METHODS: All cases were done in single institute which had a 3D printer facility within the campus during the period of October 2015 and October 2017 and their data with minimum follow up period of 2 years was reviewed retrospectively.

A total of 10 cases were included in the study and the case distribution as per their diagnosis are 05 cases of Secondary Osteoarthritis secondary to neglected Acetabular Fracture with no signs of infection, 03 cases of Secondary Osteoarthritis following Post Acetabular Fracture Fixation with positive signs of Infection, 01 case of Neglected Acetabular Fracture with failed Post Dynamic Hip Screw osteosynthesis and positive signs of Infection and 01 case of failed Septic Revision Total Hip Arthroplasty.

These 10 cases were grouped into three groups. Group A included 05 cases of Secondary Osteoarthritis secondary to neglected Acetabular Fracture with no signs of infection, Group B included with 04 cases of Secondary Osteoarthritis following Post Periacetabular osteosynthesis with positive signs of Infection and Group C included 01 case of Failed Septic Revision Total Hip Arthroplasty.

RESULTS: Out of 10, 8 cases had Road Traffic Accident (RTA), 1 case had Accidental Fall and 1 case had Ankylosing Spondylitis as their etiology. All cases were males. The mean age of all the patients was 39.5 years. The minimum follow-up period was 2 years and mean follow up period was 4.2 years. The mean 3D model making time was 8.2 hours for Group A, 6 hours for Group B and 6 hours for Group C.

5 cases of Group A underwent Complex Total Hip Arthroplasty (CTHA) done as one stage procedure. 2 out of 4 cases of Group B with normal blood parameters (ESR – Erythrocyte Sedimentation Rate, and CRP – C Reactive Protein) were done as Two stage procedure and 2 other cases with persistent infection and elevated blood markers (ESR, CRP) underwent excision arthroplasty. 1 case of failed revision arthroplasty underwent CTHA as two stage procedure.

The mean operative time of final surgery was calculated and found to be 220 minutes for Group A, 160 minutes for Group B and 260 minutes for Group C. The mean blood transfusion during the final surgery was found to be of Group A - 1.2 units, Group B – 2 units and Group C – 4 units. The percentage of pre operative and intraoperative plan matching was found to be 100% cup and 90% screw in Group A, 100% cup and 90% screw in Group B and 90% cup and 90% screw in Group C. None of the patients had a reinfection. The Preoperative mean Harris Hip Score (HHS) was 50.4 and the Postoperative Harris Hip Score was 70.2 at end of October 2019.

CONCLUSION: 3D printing and 3D model helped in a proper and precise preplanning, appropriate implant selection, decreased operative time, less infection rate and good functional outcome

KEY WORDS: 3D Model, 3D printing, 3D printer, Complex Total Hip Arthroplasty (CTHA), septic revision replacement, two stage septic revision, excision arthroplasty

INTRODUCTION:

Total Hip Replacement has been named as the “Operation of the century”, by Lancet (1). Correct placement of the acetabular and femoral component is the essential step of total hip Replacement to avoid complications (2). Acetabular component placement using the anatomical landmarks and Transverse Acetabular Ligament (TAL) is commonly used method (3). The orientation and placement of acetabular cup during Complex Total Hip Arthroplasty becomes problem and highly demanding in cases of post acetabular fracture. 3d printing has a great potential and higher efficiency in performing Complex Total Hip Arthroplasty using the 3D Models as a part of preplanning (4). This study is to assess the role of 3D printing and 3D Models, as a part of preplanning in patients undergoing Complex Total Hip Arthroplasty (CTHA) and their functional outcome.

DISCUSSION: 3D printing improves efficiency of the surgeon and the operating room team in terms of operative time, reduced infection rate and patient functional score. It has a great potential in treating in Complex Total Hip Arthroplasty cases. The CT, MRI scan images are stored as digital imaging and communications in medicine (DICOM) image and the stereolithographic (STR) file format is prepared (figure 1). The essential 3D modelling software and 3D slicing software is used to make the 3D model prototypes (5,6). Won *et al.* demonstrated that the 3D printing rapid prototype can essentially plan almost all the steps preoperatively and can reduce intraoperative complications (7).

All cases were done in single institute which had a 3D printer facility within the campus (figure 2) during the period of October 2015 and October 2017 and their data with minimum follow up period of 2 years was reviewed retrospectively.

A total of 10 cases were included in the study and the case distribution as per their diagnosis are 05 cases of Secondary Osteoarthritis secondary to neglected Acetabular Fracture with no signs of infection, 03 cases of Secondary Osteoarthritis following Post Acetabular Fracture Fixation with positive signs of Infection, 01 case of Neglected Acetabular Fracture with failed Post Dynamic Hip Screw osteosynthesis and positive signs of Infection and 01 case of failed Septic Revision Total Hip Arthroplasty.

These 10 cases were grouped into three groups. Group A included 05 cases of Secondary Osteoarthritis secondary to neglected Acetabular Fracture with no signs of infection, Group B included with 04 cases of Secondary Osteoarthritis following Post Periacetabular osteosynthesis with positive signs of Infection and Group C included 01 case of Failed Septic Revision Total Hip Arthroplasty.

Results: Out of 10, 8 cases had Road Traffic Accident (RTA), 1 case had Accidental Fall and 1 case had Ankylosing Spondylitis as their etiology. All cases were males. The mean age of all the patients was 39.5 years. The minimum follow-up period was 2 years and mean follow up period was 4.2 years. The mean 3D model making time was 8.2 hours for Group A, 6 hours for Group B and 6 hours for Group C.

5 cases of Group A underwent Complex Total Hip Arthroplasty (CTHA) done as one stage procedure (figure 3). 2 out of 4 cases of Group B with normal blood parameters (ESR – Erythrocyte Sedimentation Rate, and CRP – C Reactive Protein) were done as Two stage procedure (figure 4) and 2 other cases with persistent infection and elevated blood markers (ESR, CRP) underwent excision arthroplasty. 1 case of failed revision arthroplasty underwent CTHA as two stage procedure (figure 5).

The mean operative time of final surgery was calculated and found to be 220 minutes for Group A, 160 minutes for Group B and 260 minutes for Group C. The mean blood transfusion during the final surgery was found to be of Group A - 1.2 units, Group B – 2 units and Group C – 4 units. The percentage of pre operative and intraoperative plan matching was found to be 100% cup and 90% screw in Group A, 100% cup and 90% screw in Group B and 90% cup and 90% screw in Group C. None of the patients had a reinfection. The Preoperative mean Harris Hip Score (HHS) was 50.4 and the Postoperative Harris Hip Score was 70.2 at end of October 2019.

Hung *et al.* conducted a retrospective comparative study of 30 patients with the above method and reported a 70-min reduction in surgical duration, a 270-ml reduction in blood loss, fewer complications (8).

The 3D printing rapid prototype needs extra dose of radiation (CT scan), additional time in making 3D model as part of preplanning and bit expensive. But the usage of 3D printers in production of patient specific hip and knee implants and instrumentation in improving the precision and clinical outcome of surgical procedures (9).

CONCLUSION: 3D printing and 3D model helped in a proper and precise preplanning, appropriate implant selection, implant placement, decreased operative time, less infection rate and good functional outcome in case of Complex Total Hip Arthroplasty following complex acetabular fracture.

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Miss Lavanya Chandrasekar , Physician Assistant, Asian Joint Reconstruction Institute – AJRI @ SIMS Hospitals, Chennai , India.

FIGURES:

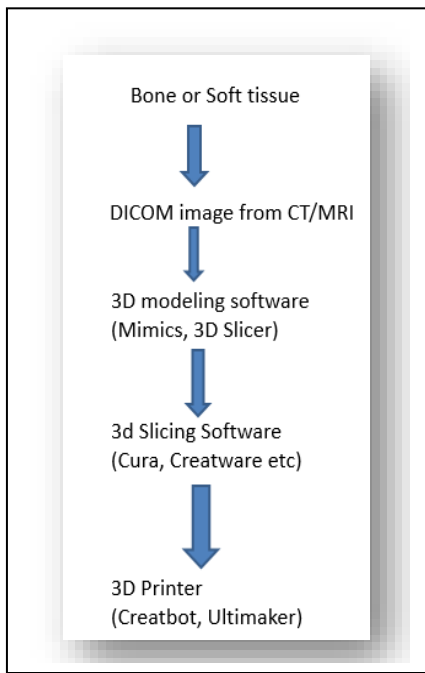


Figure 1: steps of creating a 3D model



Figure 2: 3D printer



Figure 3: Complex Total Hip Arthroplasty of Group A

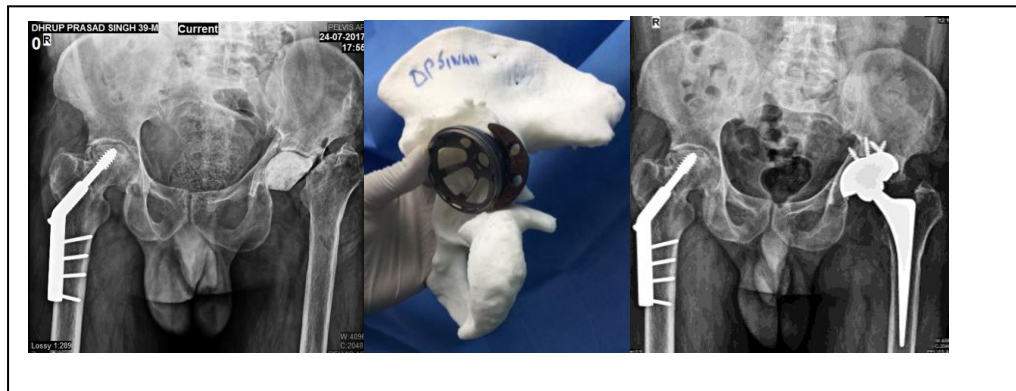


Figure 4: 2 stage Complex Total Hip Arthroplasty of Group B.

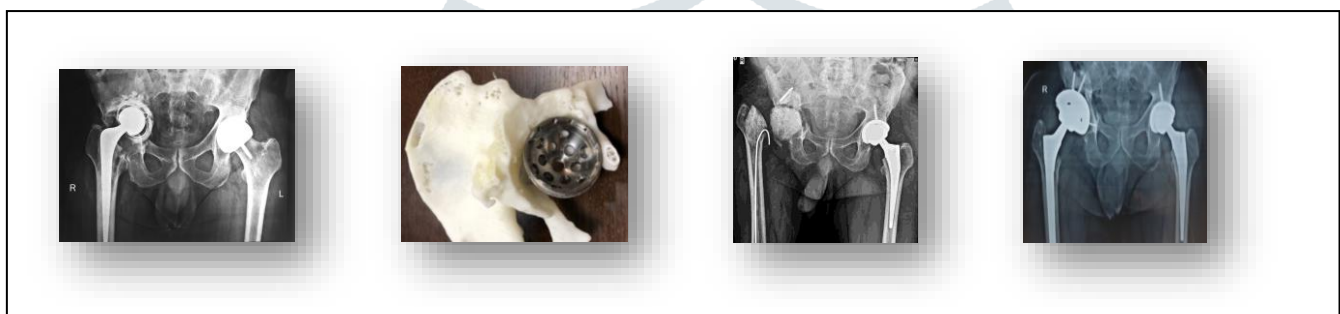


Figure 5: 2 stage Complex Total Hip Arthroplasty for septic failed revision of Group

