openaccess Journal
SCIENCE LETTERS 2015 | Volume 3 | Issue 3 | Pages 98-101

Short communication

Advantages of 3D printed hip model over conventional imaging methods

Mujtaba Ansari, Qingqiang Yao*, Qiangrong Gu, Bo Wei, Shuai Liu, Xiang Zhang, Uzair Masood, Mohammed Ghouse, Liming Wang

Department of Orthopedics, Nanjing First Hospital, Nanjing Medical University, Nanjing, China

Abstract

This study was conducted to compare the advantages of a printed 3D hip model over the conventional imaging techniques such as X ray and CT scan. Out of all the patients that presented at our hospital with femoral neck fractures, one patient of age 51 was selected. Time taken for the investigation, cost effectiveness, the aid in preoperative planning, and the operative time of the surgery following the patient's investigation were compared between 3D printed model and the conventional radiograph techniques. The results were studied retrospectively. The visualization ability and the capability of localizing fracture lines and degree of comminution were of higher quality and precise for 3D printed models. The preoperative planning was precise with a 3D model which in turn led to a decreased operative duration. On the other hand, the cost required for doing a 3D print was significantly higher than the other conventional imaging techniques. Also the fact that a 3D printed model could only be prepared using the conventional radiographic images, the time required to obtain a 3D model was significantly higher than the other techniques. The 3D prints allow the surgeons to take the preoperative decisions preoperatively. This also aids in the decision of implant selection and the approach for the surgery. Subsequently owing to the better preoperative planning, the risk of post-operative complications can be reduced significantly.

Key words: 3D printing, femoral neck fractures, conventional imaging methods.

Received April 07, 2015 **Revised** May 29, 2015 **Published online first** June 30, 2015

***Corresponding author** Qingqiang Yao **Email** 13918415@qq.com

To cite this manuscript: Ansari M, Yao Q, Gu Q, Wei B, Liu S, Zhang X, Masood U, Ghouse M, Wang L. Advantages of 3D printed hip model over conventional imaging methods: a review. Sci Lett 2015; 3(3):98-101.

Introduction

With recent advancements in quality of life and persistent stress of the community on overall good health, people engage themselves actively in sports or in other strenuous activity. Also, the aged have realized that daily exercise can keep them healthy. The incidence of femoral neck fractures is comparatively higher in these patients. It can be summarized that femoral neck fracture occurs in two groups of patients: 1) Younger individuals that actively engage in strenuous activities (High energy injury) and 2) the aged people in osteoporosis (stress fracture)[1]. Femoral neck fracture can be treated in many ways like open reduction and internal fixation (ORIF), closed reduction and external fixation and total hip arthroplasty (THA). But in the elderly where the quality of life has been compromised, THA is preferred. The choice of the treatment depends on the extent of injury, amount of displacement, amount of comminution, whether circulation is compromised. THA patients can manifest a number of complications, out of which a number of them can be avoided with proper preoperative planning [2].

The complications which arise from total hip arthroplasty include implant failure, periprosethic fracture, preprosthetic infection, dislocation, leg length discrepancy, intra-operative fractures etc. [3]. Hip implant failure can occur for three reasons: the hip was designed with defects; it was manufactured improperly despite a good design; or it was improperly implanted. Such complications can be attributed to improper preoperative planning, which is the shortcoming of the conventional radiographs [4]. Preoperative planning of such complex deformities are often an area of concern for surgeons, because most of the major decisions concerning the surgery are thereby then taken after the patient is incised and the probability of errors cannot be ignored [5]. In cases of implant failure, the patient shall be subjected to a revision surgery which would be hazardous health-wise and monetary-wise as well [6]. Also the patient can issue a medical law suit on the practicing surgeon which would be troublesome for the doctor and the patient as well. The short comings of the conventional radiograph give rise to a need for a better imaging modality which could improve the preoperative planning and effectiveness of surgery [7].

The aim of this study is to assess the advantages of 3D printed model over the conventional radiographs and how we can use the 3D print to overcome the shortcomings for an accurate preoperative planning and thereby decrease the complication rate.

Patient selection

In this study, out of all the patients that presented at our hospital with femoral neck fractures, one patient of age 51 was selected. Informed

openaccess Journal
SCIENCE LETTERS
2015 | Volume 3 | Issue 3 | Pages 98-101

consent was taken from the patient. A plain radiograph was advised which revealed the fracture location and the fracture line. The degree of displacement and the amount of comminution was not revealed in the X-ray [Fig 1].

Fig. 1 Plain radiograph showing the anteroposterior (AP) view of a femoral neck fracture.

CT scan

Thereafter a CT was performed, which demonstrated the degree of displacement and amount of comminution. These results were used in the preoperative planning of the surgeries that were to be performed on these patients. In the preoperative period, many aspects need to be discussed and decided beforehand. This includes the type of implant, the level of femoral cut, orientation of the acetabular cup, approach and the technique of the surgery. The conventional radiograph gave an idea of the nature of the fracture and the above mentioned aspects which were well discussed preoperatively. The discussion was not satisfactory as the chances of the errors were not significantly reduced and hence the head surgeon advised to prepare a 3D printed model on the basis of CT results.

3D printing technique

The models were prepared at the Nanjing first hospital using a "MIMICS 17.0". The type of filament that was used was PLA 1.75mm (Printing temperature 190-240, color: white, Batch number 02150102A190304). The DICOM images of the CT were uploaded in the mimics 17.0 system which was converted the images into .STL. These .STL images were then uploaded in the "MAKERBOT DESKTOP" which converted the images into .X3g. This format of the images was recognized by the printer and thereby a 3D printed model was prepared using a HY-500 3D printer. The 3D printed model images are shown in Fig. 2.Visual ability of the 3d printed model can be implicated. The degree of displacement, angulations and prominence of anatomical landmarks can be clearly visualized.

Results and Discussion

The 3D printed model proved to be a better aid in the preoperative planning providing a better understanding about the choice of the implant, orientation of the acetabular cup, the level of the femoral cut and the necessary approach of the surgery [8]. The visualization ability and the capability of localizing the fracture and the comminution were significantly of a higher quality and precise for 3D printed models (Fig. 2). The preoperative planning was precise with a 3D model which in turn led to a decreased operative duration. Also because of the pictorial model of the joint, errors that occur due to improper technique and improper placement of the implant can be avoided as the surgeon can manipulate the model very similar to the way he would during the surgery prior to the patient being incised. Also it allowed the decision as to how the proper anatomical and mechanical axis would be retained. On the other hand, the cost required for doing a 3D print was significantly higher than the other conventional imaging techniques. Also the fact that a 3D printed model could only be prepared using the conventional radiographic images, the time required to obtain a 3D model was significantly higher than the other techniques.

Preoperative planning of complex deformities are often an area of concern for surgeons, because most of the major decisions concerning the surgery are there by taken after the patient is incised and the probability of errors cannot be ignored. The short comings of the conventional radiograph give rise to a need for a better imaging modality which could improve the preoperative planning and effectiveness of surgery [4].

The 3D print model is of high detail and specificity with no magnification or minimization which is in exact accordance with the values provided by the CT that is to say that it is very much similar to the exact human anatomy. Therefore, it is

hardly debatable that the visual capability of the conventional radiographs is not better than that of a

Fig. 2 The 3D printed model images.

3D print. This allows us to properly identify the anatomical landmarks, fracture line, comminution of the fracture and as to how it should be properly reconstructed or replaced so that a proper anatomical and mechanical axis can be achieved [9].

Increase in operative time increases the risk of infection [9]. Peri-prosthetic infection is a major concern in the field of arthroplasty. Thus there have been constant efforts in search of techniques that would reduce the operative time significantly. One major way that comes to mind in doing so is by proper and appropriate pre-operative planning [4]. Conventional radiograph techniques are useful in aiding this process but there still lies certain scope of improvement which could increase its effectiveness. 3D print models can very well be manipulated by the surgeon in a way very similar to that he would do in a regular surgery. Bone cuts and other specifics of the surgery can be performed pre-operatively. So that when the surgeon incises the patient, the scenario is pretty much equivalent to the model prepared pre-operatively. This has been effectively proven to decrease the operative time, which in turn decreases the risk of post-operative infection. Also the errors due to improper technique and improper placement can be avoided. This can be easily understood as a major advantage of 3D printing [10].

There is a 3 fold increase in the cost to perform a 3D print over a CT. Moreover, the time taken for a CT report to be prepared is no more than 2 hours, whereas the approximate time taken to prepare a 3D model is 20 h. So there is a 10 fold increase in the time taken for the investigation. The increased cost cannot be borne by the people who live below the poverty line. Also, the increased time for the investigation can render it disadvantageous for its use in emergency purposes. The increased cost and increased time for investigation can be hence considered the disadvantages of the 3D printing [8].

The short coming of this study is that the sample of the patients is very small. So a larger sample randomized control prospective clinical trials are needed for further evaluation of the results. Also more objective measures shall be used to verify the efficacy of 3D printing. Moreover, there is a shortage of the literature for 3D printing articles and so other shortcomings of the study are still unknown. There is shortage of the instrumentation and experts that can handle 3D printers. Thereby a larger patient sample is going to be difficult to obtain. In future advances and with more literature over this topic, these shortcomings could be avoided.

Conclusions

It can be concluded from this study that the advantages of 3D printing are its aid in preoperative planning and subsequent reduction in the operative time. Whereas the disadvantages include increased cost effectiveness and increased time for investigation

References

[1] Requena G, Abbing-Karahagopian V, Huerta C, De Bruin ML, Alvarez Y, Miret M, et al. Incidence rates and trends of hip/femur fractures in five European countries: comparison using e-healthcare records databases.Calcif Tissue Int 2014; 94(6):580-589.

[2] Siopack JS, Jergesen HE. Total hip arthroplasty. West J Med 1995; 162(3): 243–249.
[3] MurrayDW, CrawfordRW. Total hip replacement: indications for surgery and risk factors for failure. Ann Rheum Dis 1997; 56:455-457.
[4] WinemakerM, PetruccelliD, KabaliC, de BeerJ.Not all total joint replacement patients are created equal: preoperative factors and length of stay in hospital. Can J Surg 2015; 58(3):160-6.
[5] Gilbert RE, Salehi-Bird S, Gallacher PD, Shaylor P. The Mayo Conservative Hip: experience from a district general hospital. 2009; 19(3):211-214.
[6] Pakpianpairoj C. Perception of leg length discrepancy after total hip replacement and its impact on quality of life.J Med Assoc Thai2012; 10:S105-8.
[7] Thien TM, Chatziagorou G, Garellick G, Furnes O, Havelin LI, MäkeläK et al. Periprosthetic femoral fracture within two years after total hip replacement: analysis of 437,629 operations in the nordic arthroplasty registerassociation database.J Bone Joint Surg Am 2014; 96(19):e167.
[8] Lee Ventola C. Medical applications for 3D printing: Current and projected uses.P T 2014; 39(10):704–711.
[9] Naranje S, Lendway L, Mehle S, Gioe TJ.Does operative time affect infection rate in primary total knee arthroplasty?ClinOrthopRelat Res 2015; 473(1):64-9.
[10] Schmidt-Braekling T, Waldstein W, Akalin E, Benavente P, FrykbergB, Boettner F. Minimal invasive posterior total hip arthroplasty: are 6 weeks of hip precautions really necessary? Arch Orthop Trauma Surg 2015; 135(2):271-4.