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RESEARCH ARTICLE

3D PRINTING SIGNIFICANCE IN THA FOR THE PATIENTS WITH CROWE IV DDH

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ABSTRACT

Developmental dysplasia of the hip (DDH) is a common cause of secondary hip osteoarthritis. Adult patients with developmental dysplasia of the hip develop secondary osteoarthritis and end up with total hip arthroplasty (THA) at a younger age. Because of the altered anatomy of dysplastic hips, THA in these patients represents a technically demanding procedure. There are different classifications of dysplastic hips in adults. Since in the majority of the cases the diagnosis is formed based on the clinical exam and X-rays, most common classifications are based on X-rays of the pelvis and hips. The most common is classification according to the Crowe with 4 different degrees of dysplasia. Crow classification is based on two-dimensional analysis of the pelvic X-ray and on, basically, just a vertical displacement of the femoral head, it is still predominant classification due to simplicity and availability.With the development of highly accurate CT images, the 3D printing technology has provided high precision implants for surgical solutions, improving the success rate of complex and difficult surgeries. In this study, the time to weight loading in the 3D printing patients was less than that for the conventional hip replacement patients. Additionally, the postoperative Harris scores were higher in the 3D printing group. Indicating that the 3D printed prostheses are closer to patients' anatomical structures, and allow for better coordination of human biomechanics. Also, the 3D printing technology applied in hip arthroplasty speeded up the recovery of patients after surgery and improved their quality of life**.** Based on these results, we suggest that the 3D printing approach provides a better short-term curative effect that is more consistent with the physiological structure and anatomical characteristics of the patient, and we anticipate that its use will help improve the lives of many patients.

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INTRODUCTION

Inner Mongolian Autonomous Region, China, has a high incidence of developmental dysplasia of the hip (DDH) and the hip joint tuberculosis (hip TB) and the patients DDH level had been reached to Crowe III and IV (Zhao Jianjun, 2012). The total hip arthroplasty (THA) is considered to be basic surgical management for DDH, however, a number of difficulties regarding the lower extremities, not only the hip joint but even the thigh bone, could be occurred during the operation (Zhao Jianjun, 2012; Wang Wei, 2014). Recently, the orthopedics department at Inner Mongolian hospitals and clinics started to use three-dimensional printing (3D printing) technology in their surgeries, such as maxillofacial/mandible, cranioplasty, and arthroplasty of hip, knee, and ankle (Wang Wei, 2014).

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The 3D printing supposed to improve the operation safety and decrease the sudden difficulties during the surgery by detecting the possible obscurities and confirm the predicted problems fully. In other words, it has the following advantages: increase the percentage of operations success, decrease the obscurities, an important tool for making a treatment plan and the doctor-patient communication, for example, it is easy to explain the situation to the patients. Thus the 3D printing has a real significance in surgery and we see a big gap in its further application and development (Rengier et al., 2010).

Purpose: Evaluate the significance of the 3D printing technology by conducting the THA for patients with Crowe IV DDH.

Aims

- Make the full model of the appropriate hip for the preoperational plan by doing the 3D printing of the patient with severe DDH.

- Conduct the THA for the patient with Crowe IV DHH and estimate/analyze the significance/results
- Compare the post-THA/operation results with the hip function restoration

Case report: This study covered the patients with severe Crow IV DDH who referred to the Inner Mongolian Medical University Hospital. The THA done using 3D printing technology.

Materials and equipment/settings: 128 MDCT, Siemens Somatom Definition Flash, 3D model program: MIMICS 17.0, Materialise Mimics, Belgium, 3D printing equipment: Beijing, Aikang I Qen company, Concept laser 3D printing, 3D model materials: Polylactic acid (PLA).

3D model printing: The CT data of the hip joint that saved on Mimics program as STL model was transferred to 3D printing machine; and the preparation for printing - adjust the location and selecting the material/PLA will be held.

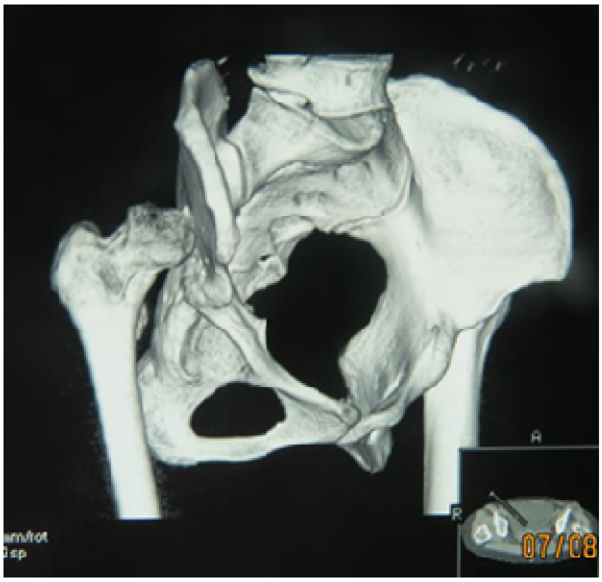
The study participant: Patient: JY,sex: female, age: 36.

Onset Present patient history: From childhood, the patient suffered from hip joints pain on both sides and restricted hip mobility. The condition has never been treated at all. Gradually it developed to severe condition. A long-time conservative treatment has no results. Last three years the pain increased, and the patient was able to walk short distances.

Movement analyses at the moment of hospitalization: During the walking the patient limps. Both hip joints were deformed, Allis sign was positive (+), Right and left hip joint movements: abduction: 120º-0º, inward flexion: 35°, outward flexion: 35°, inward adduction: 20°, extension: 20°, the right leg was shorter in 1.5 cm than the left one. The diagnosis at the moment of hospitalization**:** The patient suffered from the Crowe IV, DDH on both sides. This case has an indication of THA management because it is considered as the most severe among the DDH. The patient’s age was relatively young;this it is required to conduct a good postoperative rehabilitation treatment. It means that after the surgery complications regarding the hip function and location recoveries can occur, also the sciatic and femoral nerve damages are possible to happen. In accordance with the computed tomography (CT) and magnetic resonance tomography (MRT), the acetabulum and femoral heads were dysformated (DDH) on both sides. The hip soft tissue atrophy was observed. The second damage: the knees bent outward, pelvic bone deformation, spine curvature.

Difficulties, challenges: 1. Restoration of hip joint 2. Selection of acetabulum socket and femoral implant locations 3. Localization/medialization complications: soft tissue loosening, short osteotomy 4. Protection of sciatic and femoral nerves.

Acetabulum socket restoration: Anatomical landmarks/peculiarities: 1. Towardcurvation 2. The acetabulum cup is not deep, small and triangular 3. The acetabulum anterior wall and the base are thin, but the posterior column is thick 4. It contains a lot of scarred tissues.



The study participant: Patient: JY, sex: female, age: 36.

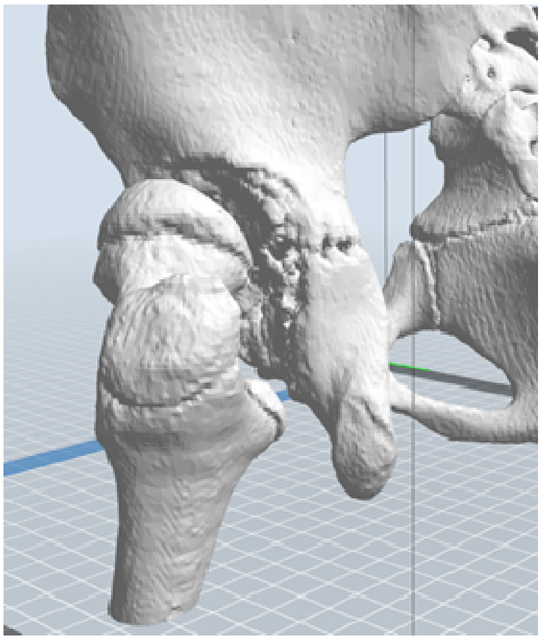


Figure 1. The patient JY, 36 year old, female. The Pelvic 3D printing image

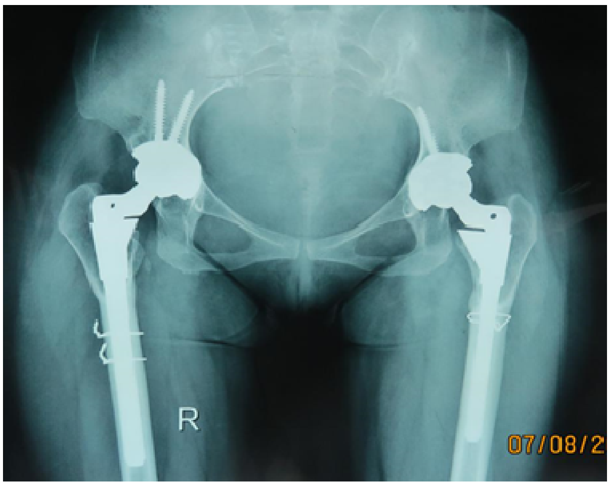


Figure 2. Patient JY, 36 year oldfemale with a diagnosis of DDH at Crowe IV stage. THA Postoperative imaging

Rehabilitation: a.true acetabulum restoration, relocate the rotation center inferiorly and inward. b. develop/strengthen the extensor muscles c. rehabilitate the hip joint biomechanic power.

Implant selection: Bio acetabulum socket, small-sized - 46 mm, with the ceramic bearing surface, Pinicle, ™, etc.

Surgery/THA: To get remove the femoral head posterosuperior trochanteric osteotomy was performed and the muscles were cut before the articulation capsule incision After this, the iliac muscle was released, and the true acetabulum is accessed.

Technical features: 1. The acetabulum cup/socket is reamed to protect its anterior wall. 2. The acetabulum base can be shrunk, but the base damage was <25%, 3. Finally, we did the ream again. 4. The acetabulum coverage reached 70%, 5. The acetabulum is screwed 6. Its outward flexor/abduction angle measured as 35-40º , and toward curvation - 15-20º.

Femoral structure reconstruction: Anatomical landmarks/peculiarities:the femoral head was underdeveloped, the proximal femoral canal stenosis was observed, anterior/alpha (the anterior head-neck junction) angle was larger, the neck angle was large and smaller, the head rotation is outward.

Reconstruction: Correct the alpha angle, adjust (shortening) the femoral size avoiding limb lengthen.

Implant/prosthesis selection: Bio implants are selected based on the femoral canal characteristics: 1. Straight, 2. Cylindrical, conusoid, rectangle, 3. The S-ROM model was chosen. The pros of this prosthesis: 1. Both the distal and proximal femur was fixed stable. 2. Easy to fix the femoral anteversion. 3. Its most narrow part was 6 mm, which allows the easy penetration to the endings of the femur. 4. It is easily adapted after the osteotomy 5. It decreases soft tissue loosening.

Localization: 1. Release the soft tissues 2. Osteotomy of /Cut the proximal femoral small edge/tip, 3. Osteotomy of /Cut the proximal femoral large edge/tip, 4. Osteotomy of /Cut the proximal femoral thick edge/tip - the osteotomy position: 2 cm down along the thick side. The approach: Transverse, Oblique and Z-shaped osteotomy. The advantages to cut the thick part: operation steps are simple, the time can be shortened, less damaged soft tissues around the acetabulum. Reduce the sciatic and femoral nervous damages. And prevent the postoperative leg length discrepancy. The risks: the bone healing process can be long, the femoral medial fracture can be expected. Prevent the sciatic and femoral nervous damages: 1. choose the shortening osteotomy, 2. Protect the acetabulum and knee positions, adduct the lower extremities after the proper localization. 3. Do the electro muscular analysis during the operation. 4. Gradually extend and tighten the muscles after the surgery in order to adduct the knee and hip joint.

X-ray diagnosis: Multi-sliced CT and MRT of the pelvis, acetabulum, and lower limbs were loaded in a 3D printing machine through the specialized workstation. The real-sized model of the acetabulum, both sockets and femoral head of the patient with Crowe IV DDH was performed: 1. The surgery scope, continuity, the expected complications are revealed; 2. Plan the operation approach and steps; 3. Choose the proper implant (size, model), plan the additional instruments and materials, and try them on the model. Consequently, 3D printing can be useful in shortening the operation time and decrease the possible complications. The patient was operated in two steps - after 14 days of the successful THA of the right side, the left side THA was performed. It took a month to rehabilitate and the patient was released from the hospital on her legs.

Discussion: Computer-based 3D image in THA

Proper, or accurate definingof the acetabulum socket/cup size and depth; the proximal femur medial area is crucial for the selection of the implant, prosthesis. CT based 3D imaging produces the individual anatomical structures and this gives the opportunity to analyze and estimate the hip joint structure from the various points. In addition, it improves the safety and quality of the surgery.

Digital technology in THA: Improper placement of the acetabulum implant can lead to the movement limitation which serves as the major cause for hip dislocation (6). Digital technology helps in selection, reconstruction, angulation and depth analysis; even the patient's normal side model can be considered as the implant standard for THA (7). 3D printing complex treatment approach significantly efficient in making individual models and personal for the preoperative plans.

Conclusion

- 3D printing technology is efficient in THR for patients with Crowe IV DDH.
- S-ROM implant was the perfect option for patients with Crowe IV DDH.
- The osteotomy in the femoral large/wide portion was a safe way of shortening.
- Small acetabular cup and the narrow femoral implant was the most suitable variation.

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