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Case Report

Repeated Dislocation of 3D Printing Lunate Prosthesis: A Case Report

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Abstract

Background: Avascular necrosis (absence of blood supply to the bone) can result from fracture of the carpal bones. Nonunion of the wrist bones can in turn result in arthritis, which is associated with several problems, including pain, reduced range of motion, weakened grip strength, and joint instability.

Case Summary: A 21-year-old male was admitted to the department with a 3-year history of severe wrist joint pain, reduced range of motion, weakened grip strength, and joint instability. The early symptoms of Kienbock's disease are not typical, and it is easy to miss diagnosis, making the later treatment difficult. Using three-dimensional (3D) printing lunate prosthesis is a new reconstructive surgery to treat collapse of the lunate bone. We used 3D printing lunate prosthesis to perform lunate bone replacement in a patient with lunate collapse. After the surgery, the prosthesis was repeatedly dislocated, then we changed the size of prosthesis and repaired the surrounding tissues. Prosthetic dislocation on plain radiographs were not showed after 6 months. It suggested that the size of lunate prosthesis should be fully evaluated before surgery.

Conclusion: 3D printing lunate prosthesis is a good choice for lunate replacement.

Keywords: Kienbock's Disease; Lunate Collapse; 3D Printing Technology; Prosthetic Dislocation

Introduction

The Kienböck's disease was first reported by Robert Kienböck in 1910[1]. It is a chronic disease with slow progression and eventual cause collapse of the lunate and alteration of the carpal architecture. Nowdays, the etiology of Kienböck's disease still remains unclear [2,3]. The main clinical manifestations of Kienböck's disease include dorsal tenderness, swelling, reduced grip strength and wrist motion. Lacking typical clinical manifestations, when Kienböck's disease was diagnosed there is usually a lunate bone collapse. To treat collapse of the lunate bone is a great challenge for orthopeadic doctor. Three-dimensional (3D) printing prosthesis is a new technology for bone replacement, and it was used to treat collapse of the lunate bone [4,5]. For this new technology, there are some issues that need to be addressed in the clinical application. In this case report, we present a case of repeated dislocation of 3D printing lunate prosthesis, and the size of prosthesis was changed to obtain the stability.

Case Presentation

Chief complaints

A 21-year-old male was admitted to the department with a 3-year history of severe wrist joint pain, reduced range of motion, weakened grip strength, and joint instability, which seriously affected his quality of life.

Medical history

Prior to our department, the patient had been taking NSAIDS drugs for more than 6mo. However, the symptoms did not improve but instead continued to worsen.

History of past illness

No past illnesses were documented and the patient had no relevant traumatic history.

Personal and family history

Unremarkable.

Physical examination

Physical examination showed significant tenderness on the lunate region and the activities of wrist were limited in each direction.

Patient's progress and assistant examinations

A 21-year-old man visited to our hospital because of left wrist chronic pain for 1 year after an accidental fall in physical training. In the past few days, wrist chronic pain was aggravated with mild swelling, grip strength was decreased and wrist activities were limited. Plan X-ray and MRI revealed the collapse of the lunate (Figures 1a-1c).

Figure 1: Preoperative plan X-rays(a,b) and MRI (c) showed the collapse of the left lunate.

Final Diagnosis

Lunate prosthesis.

Treatment

A 3D printing lunate prosthesis was designed and produced according to the unaffected right lunate. Then the left necrotic lunate was exposed with the dorsal incision and replaced by the titanium prosthesis. Intraoperative C-arm fluoroscopy showed the prosthesis was well matched with anatomic position, and wrist motion was checked to confirm stability of the prosthesis. The left wrist was fixed with a plaster for 4 weeks after the surgery, and then started functional exercises to improve the motion of wrist (Figures 2a-2d).

Figure 2: Plan X-rays of 3D printing lunate prosthesis after first surgery.
(Left wirst with a plaster-a,b; left wirst without a plaster-c,d).

After 3 months, left wrist pain and activity obstacle occurred again when the patient was doing functional exercise, and subsequent plan X-ray revealed subluxation of the lunate prosthesis (Figures 3a-3b). An surgery was performed to take the lunate prosthesis out and then wrapped the lunate prosthesis with iliotibial tract autograft. The necrotic and proliferative tissue were removed before the lunate prosthesis was implanted again. Furthermore, the lunate prosthesis was sutured with surrounding tissue to gain better stability. Intraoperative fluoroscopy showed the prosthesis was well matched and wrist motion was checked. The left wrist was fixed with a plaster in the functional position and postoperative X-ray also revealed good position of the lunate prosthesis (Figures 3c-3d). However, subluxation of the lunate prosthesis occurred again when the patient had a regular review after 1 week of the second surgery. As T. Viljakka found that the size of the prosthesis may have no effect on the outcome [6], we reduced the size of lunate prosthesis to one half of its original size using 3D printing technology and drilled three holes through the prosthesis in the coronal, sagittal, and horizontal positions. The smaller prosthesis was also wrapped with iliotibial tract autograft. The original lunate prosthesis had been taken out using an original surgical approach and removed proliferative tissue. Then the original lunate prosthesis was replaced by the smaller lunate prosthesis. To gain better stability, the smaller lunate prosthesis and scaphoid were fixed with Kirschner needle and the smaller lunate prosthesis was sutured with surrounding tissue. Intraoperative C-arm fluoroscopy fluoroscopy showed the prosthesis was well matched and wrist motion was checked. The left wrist was fixed with a plaster in the functional position and postoperative X-ray also revealed good position of the smaller lunate prosthesis (Figure 4). After 4 weeks, the Kirschner needle and plaster were removed, and functional exercises were started.

Figure 3: Subluxation of 3D printing lunate prosthesis after the first surgery (a,b) and the left wirst with a plaster after the second surgery (c,d).

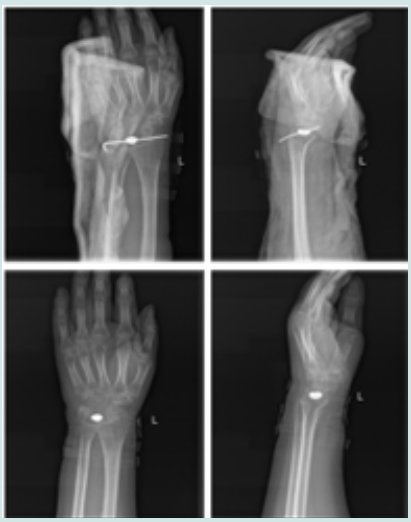

Figure 4: The smaller lunate prosthesis with Kirschner needle (a,b) and without Kirschner needle(c,d).

Outcome and Follow-Up

The patient recovered nearly full range of left wrist motion and grip strength after 6 months. Plan X-ray showed no prosthetic dislocation and degenerative arthritis (Figure 4). Following up for one and a half years, his wrist is the same as normal.

Discussion

3D printing is a digital fabrication technology to produce 3D solids using geometrical data. This technology has being widely used in industry, inculing the medical field [7-9]. It can use geometrical data derived from medical images to produce patient-specific prosthesis with limitless geometrical complexity, and this vast advantage is unachievable with traditional technology.

Although in early stage of Kienbock's disease surgery is not necessary, when lunate collapse occurs surgery is inevitable. There are various methods to treat lunate collapse, such as replacement procedures. Lippman described lunate replacement with vitallium prostheses in 1949 [10]. After long years of progress, titanium and pyrocarbon prostheses have been used for clinical [11]. Because of the inherent instability, lunate replacement by prostheses have not been popular [12]. However, compared with bone transplantation and traditional prostheses, 3D printing prostheses is highly individualized and well match with anatomic position, and the stability of prostheses has been improved. Thus, 3D printing technology offers a new option to create a suitable lunate prostheses for patients with lunate collapse. Mei-Ming Xie reported a case of Stage IIIc Kienböck's disease treated with 3D printed prosthesis and achieved good clinical results [5]. In our report, the patient had not been diagnosed in early stage of Kienbock's disease leading to lunate osteonecrosis. However, when we used the individualized 3D printing lunate prosthesis as the same size of the original, repeated dislocation of the prosthesis occurred in a short time. When we reduced the size of prosthesis to one half of its original size, the wrist function of the patient recovered well, and the prosthesis was not dislocated in half a year. This suggesting that although individualized 3D printing technology can increase the stability of prostheses, dislocation of prostheses can still happen and change the size of 3D printing prostheses maybe a feasible method to deal with prostheses dislocation. Unfortunately, the research focusing on the appropriate size of 3D printing lunate prosthesis are scarce. We changed the lunate prosthesis to one half of its original size and achieved good clinical results; however, this size may not the best size. To determine the appropriate size of individualized 3D printing lunate prosthesis, a practical evaluation system needs to be established.

Conclusion

In conclusion, with the wide application of 3D technology in prosthetic replacement 3D printing lunate prosthesis is a good choice for lunate replacement, but it still has some problems and needs to be improved.

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