Reconstruction of Carpal Bone Loss of Septic Wrist Arthritis Using Induced Membrane Technique

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J Hand Microsurg;2020;12(suppl S1):S54–S57

Abstract

Keywords

- septic arthritis
- bone defect
- reconstruction
- induced membrane

The induced membrane technique has been widely used for the reconstruction of the segmental bone defect. The technique requires two-stage surgery. The first surgery is debridement of the affected bone and replacement of the defect by cement spacer. The spacer is removed at the second surgery, and the defect is filled with cancellous bone. The use of the technique for septic wrist arthritis treatment has not been reported. We report two cases of septic wrist arthritis treated by the induced membrane technique. Radical debridement including the carpal bones was performed as a first surgery. The cement spacer was placed into the bone defect after first surgery; then cancellous bone was transplanted into the induced membrane several weeks later. External fixator or plate fixation was performed simultaneously. Bone formation was observed in both cases at several months after the reconstruction surgery. There was no pain or recurrence of infection in both cases. We consider this technique is a possible method for reconstruction, especially in a difficult case.

Introduction

Reconstruction of the bone defect of the limb is challenging to surgeons. Bone transportation technique or bone grafting have been mainly used for segmental bone loss in the limbs. Induced membrane technique was first reported by Masquelet.¹ The technique consists of two-staged surgeries: first surgery is debridement of necrotic tissue and implantation of cement spacer into the dead space, and the second surgery is the removal of the cement then transplant the cancellous bone into the induced membrane combined with plate fixation or external fixator. So far, various types of bone defect have been treated using this technique.² This grafting method is capable of reconstructing segmental bone defects measuring several centimeters in length, and its bone union rates are reportedly 82 to 100%.³ Most publications used the technique for the treatment of segmental bone defects in the lower extremities. On the other hand, there are few reports of managing bone defects in the upper extremities.^{3–5} Furthermore, the use of induced membrane technique for septic wrist arthritis has not been reported. In this report, we present two cases of septic wrist conditions treated with induced membrane technique.

Case 1

A 49-year-old man with right wrist joint pain was referred to our institute. Four months ago, he was diagnosed with septic wrists joint arthritis. He underwent synovectomy of the wrist joint via dorsal approach two times under local anesthesia. However, the infection was not controlled; then he was referred for further treatment. As a past medical condition, he had suffered from diabetes mellitus for 20 years and rheumatoid arthritis for 10 years. He was treated with insulin, oral prednisolone, and methotrexate. His wrist joint was swollen, and he could not move his wrist joint because of the pain. *Enterobacter cloacae* was detected from his wound, and X-ray imaging showed osteolytic change in his distal radius and carpal bones (►Fig. 1A). Computed tomography (CT) also showed bone erosion at his wrist joint (►Fig. 1B). As a first step of the staged surgery, debridement was performed under general anesthesia. The longitudinal skin incision was made on a dorsal aspect of his wrist joint, and all the necrotic tissues including extensors, carpal bones, distal radius, and distal ulnar were removed. Cement spacer sized 5 × 3 × 2 cm was placed into the defect (►Fig. 1C).

Intravenous antibiotic treatment was continued for 6 weeks after the first surgery, and the second surgery was performed 8 weeks after the first surgery. Thick induced membrane covered the cement spacer, and the cement was removed by splitting the membrane. Cancellous bone harvested from the posterior iliac crest was transplanted into the induced membrane. The membrane was sutured with 3-0 absorbable suture, and the external fixator was placed to bridge the defect. (►Fig. 2A) The fixator was adapted for 10 weeks after the second surgery. After that the patient used a wrist brace for 4 months. Twelve months after the surgery, bone formation at the defect was observed. The bone union between the metacarpal bone and graft was achieved. On the other hand, bone union was not seen in the graft and distal radius (►Fig. 2B, C). His grip strength was 8 kg in affected side and 11 kg in contralateral side. He had no wrist pain and returned to his previous job as a taxi driver.

Case 2

A 72-year-old woman suffered from left wrist joint swelling and pain for 9 months after an osteosynthesis surgery for distal radius fracture. Soon after the initial surgery, methicillin-resistant *Staphylococcus aureus* was detected from

the wound. She underwent the removal of the plate due to surgical site infection at 3 months after the osteosynthesis. However, the infection was not controlled. Six months after the plate removal, she was referred to our institute. She did not have a remarkable medical history. Her wrist joint was swollen, and there was discharge from the wound. Plane X-ray showed an osteolytic change in his distal radius and carpal bones (►Fig. 3A). CT also showed bone erosion at the wrist joint (►Fig. 3B). She was diagnosed as the septic nonunion of distal radius fracture; then debridement under general anesthesia was performed. The skin incision was made on a volar aspect of the forearm; then proximal carpal row, distal radius, and distal ulnar were removed. Synovectomy of flexor tendon sheath was also performed. After the radical debridement, the cement spacer sized 6×3×2 cm was placed into the bone defect (►Fig. 3C). After 6 weeks of the treatment of intravenous antibiotics, the patient underwent second reconstruction surgery. Cortical block bone was placed distal to the cement spacer, and cancellous bone from the iliac crest was transplanted into the induced membrane. Cortical block bone and midshaft of the radius were bridged with locking plate (►Fig. 4A, B). For postoperative treatment, 8 weeks of forearm casting followed by 4 weeks of bracing was performed. At 9 months after the second surgery, bone union was achieved

Fig. 1 (A) Plane X-ray at 4 months after the onset. (B) CT findings at 4 months after the onset. (C) Plane X-ray after the debridement surgery.

Fig. 2 (A) Plane X-ray after the reconstruction surgery. (B) Plane X-ray at 12 months after the reconstruction surgery: anterior-posterior view. (C) Lateral view.

Fig. 3 (A) Plane X-ray at 9 months after the onset. (B) CT findings at 9 months after the onset. (C) Plane X-ray after the debridement surgery.

Fig. 4 (A) Plane X-ray after the reconstruction surgery: anterior-posterior view. (B) Lateral view. (C) CT findings at 9 months after the reconstruction surgery.

(► **Fig. 4C**). The range of motion of her wrist was 30 degrees in extension and 10 degrees in flexion. She had no pain in her wrist joint.

Discussion

Septic wrist joint arthritis is a relatively rare condition.⁶ The incidence of the condition is reportedly 4–10 per 100,000 patients per year.⁷ Septic wrist arthritis accounts for 4% of all septic arthritis.⁶ Jennings et al reported that among the patients who had a painful wrist without trauma, 1.5% of them were confirmed as the septic wrist joint arthritis.⁸ Risk factors of these conditions are rheumatoid arthritis, multiple drug abuse (ex. psychotropic drugs), chronic alcohol abuse, previous intraarticular corticosteroid injections, cutaneous ulcers, and insulin-dependent diabetes, as well as surgical intervention to the wrist joint.⁷ The gold standard for acute arthritis is joint aspiration followed by antibiotic administration.⁹ However, when articular destruction or

osteomyelitis of the carpal bone or distal radius is suspected, surgical intervention by irrigation and debridement should be considered.¹⁰ Some reports recommend arthroscopic treatment because it is less invasive and requires shorter hospital stay.^{10,11} In these cases, the findings from imaging indicated osteomyelitis of the carpal bone and distal radius. Therefore, we performed radical debridement including excision of the carpal bone and distal radius. Agreement exists that the key to treatment is to remove any infected tissues in combination with an individual and selective antibiotic treatment.¹²

The clinical outcome after septic wrist arthritis is poor and disappointing in most cases. Up to 73% of cases, the condition results in a partially destroyed joint or may result in amputation.^{13,14} Therefore surgeons should have a clear plan of reconstruction during the treatment. Several methods have been reported for wrist joint reconstruction after the septic wrist joint destruction. Quadlbauer et al reported spontaneous radioscapulohumeral fusion at 14 years after the septic wrist

arthritis.⁶ However, this case is very rare and surgical reconstruction is usually required. Deml et al reported total wrist arthrodesis using vascularized iliac bone autograft.⁷ The use of vascularized fibular grafting has also been reported.¹⁵ These techniques require microsurgical approach and are technically demanding. Nonvascularized corticocancellous bone grafting is a widely used technique for segmental bone loss.¹⁶ However, this technique cannot be used for the large bone defect. Lengthening of bone using external fixator is another option to treat the segmental bone loss.¹⁷ Successful outcomes have been reported even in a septic nonunion of the forearm.^{18,19} The drawbacks of these bone transportation system are long duration of the treatment period and risk of pin site infection. The bone lengthening speed is considered as 1 mm/day. Therefore, it takes more than 40 days to complete bone transportation for the 4-cm bone defect.

Another approach for segmental bone loss defect is to use of induced membrane technique.¹ Karger et al reported 84 cases of segmental bone loss treated by the induced membrane technique. The bone union rate was 90%, and 14.4 months were required to achieve union.² The technique could reconstruct 25-cm bone defect.²⁰ Regarding the treatment for the septic nonunion condition, Scholz et al treated 13 cases of septic nonunion in tibial, femoral, or radial bone defects. In this series, the second reconstructive surgery was performed at 9.8 weeks after the first surgery, and the bone union was achieved in all cases.²¹ Septic nonunion of radial shaft fracture with a 4.5-cm defect was also successfully treated with this technique.³ In our first case, arthrodesis was attempted using external fixator. We avoided using plate fixation due to his poor skin condition. Although rigid bony fusion has not been achieved between the distal radius and transplanted bone, the carpal bone loss was reconstructed without wrist pain. In the second case, we combined iliac crest bone grafting and induced membrane technique. The iliac bone graft was used for a foothold for the screw fixation as well as to allow some motion between bone graft and distal carpal row. The bone union was achieved at 9 months postoperatively without wrist pain. We consider this technique is a possible method for reconstruction of the especially difficult case such as carpal bone loss due to septic arthritis.

Conclusion

The induced membrane technique is a possible method for reconstruction of the especially difficult case such as carpal bone loss due to septic arthritis. Because the reconstruction could be nonanatomical reconstruction, surgeons should have a clear plan during the treatment.

Conflict of Interest

None declared.

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