Int J Clin Exp Med 2016;9(10):20242-20246
www.ijcem.com /ISSN:1940-5901/IJCEM0032344

Case Report

Treatment of 10 year humeral shaft nonunion with segment bony defect: a case report

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Received May 17, 2016; Accepted August 9, 2016; Epub October 15, 2016; Published October 30, 2016

Abstract: Humeral shaft nonunions with severe osteopenia presents challenges. Because of previous surgeries, complex anatomy of vascular, muscles and nerves at the nonunion site making the operation difficulty and risky. Vascularized fibula transfer and bone transporting are particularly useful in handling bone loss. However both methods require surgical experience and facility which are not available in many hospital. Furthermore, the method also needs time and resources. To our knowledge, no cases of 10 year humeral shaft nonunion with 7.5 cm segment bony defect treated by compression plating and autologous iliac bone grafts have been described. We report a 67-year-old man suffer duration of nonunion approximately 123 months since his initial injury, the nonunion site defects reach as large as 7.5 cm. He underwent osteosynthesis using a dynamic compression plate augmented with autologous iliac crest bone graft and cancellous bone. At the 27-months follow-up, bone union finally, the patient was free of pain and had no evidence of shoulder and elbow movements restrictions. Our method using dynamic compression plate augmented with autologous iliac crest bone graft and cancellous bone may provide an effective alternative in treating atrophic humeral shaft nonunion complicated by massive bone loss.

Keywords: Humeral shaft, nonunion, compression plate, bony defect, autologous bone graft

Introduction

Humeral shaft fracture is a common injury, whether surgery or conservative treatment can achieve satisfactory results. Most of patients can be managed conservatively [1]. The incidence of aseptic nonunion of humerus was 2% to 10% in the conservative treatment of patients, compared with 10% to 15% managed surgically [2-4]. Although literature have been published on operative treatment of humeral shaft nonunion with plating augmented with cortical allograft struts, interlocked nailing with autologous bone grafting and external fixator [5], humeral shaft nonunion remains challenging for orthopedic surgeon, especially those with segment bony defect.

To date, no cases of 10 year humeral shaft nonunion with 7.5 cm segment bony defect treated by compression plating and autologous iliac bone grafts have been reported in the literature. This report present a case of humeral shaft nonunion occurred in an 67-year-old men eventually healed adequately and achieved a satisfactory outcome.

Case report

A 67-year-old, healthy men suffered an isolated closed right displaced humeral shaft fracture he had sustained after falling underwent open reduction and internal fixation (ORIF) on July 2003. During a follow-up, radiographic shows no signs of bony healing and broken plate. Due to financial difficulty, appropriate treatment procedures was not taken, until October 2013 the patient could not endure pain and limited mobility in the right arm. He was referred to us for management of his persistent humeral shaft nonunion. Radiographs taken at that time showed an atrophic nonunion at the proximal/middle of the humeral shaft accompanied with segment bony defect and plate broken through the proximal hole (**Figure 1A**, **1B**).

The patient was admitted for surgical treatment. His medications included smoking for 30

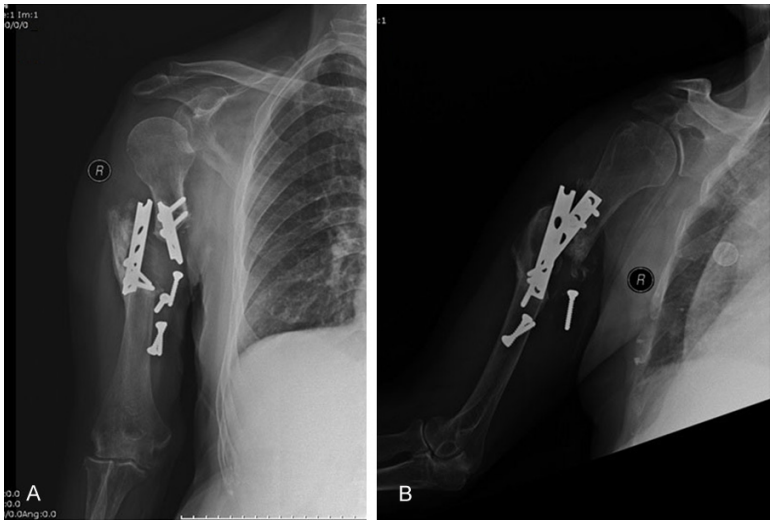

Figure 1. Preoperative anteroposterior (A) and lateral (B) radiographs showing humeral shaft atrophic nonunion and broken plate.

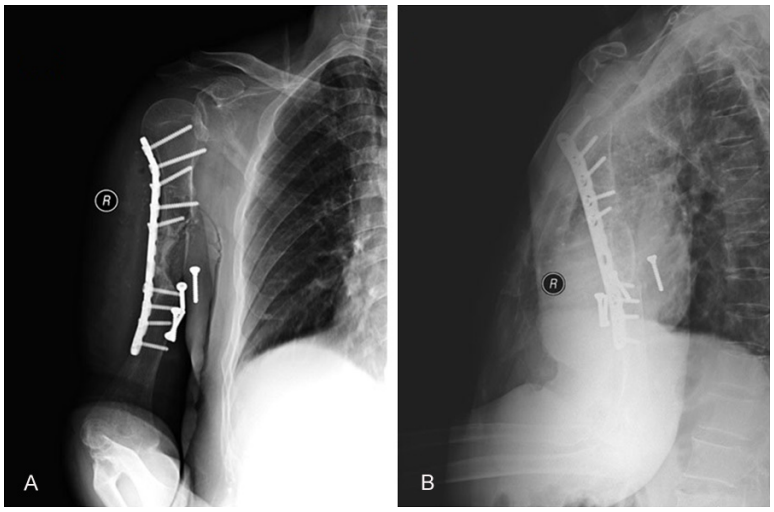

Figure 2. Anteroposterior (A) and lateral (B) radiographs after ORIF and bone grafting.

years one pack of cigarettes per day and daily excessive drinking for 40 years, denied hypertension, diabetes. On clinical examination he had a right arm with a shortened approximately 8 cm compared with the contralateral. There was no symptoms of nerve and blood vessels damage. Infection need be excluded and corresponding laboratory workup (eg, C-reactive protein level, complete blood count with differential, erythrocyte sedimentation rate) was obtained.

An extended deltopectoral approach was adopted to expose the humeral shaft, which was stretched to the dis-arm. The radial nerve is identified between the brachioradialis muscles and brachialis distally and protected throughout the surgical dissection. The broken plate were removed in their entirety, but four screw located medial side was not removed so as not to damage nerves and blood vessels. 7.5 cm segment bony defect was detected at the nonunion site, however no symptoms of infection were observed. A sample of the lesion tissue was taken to laboratory for pathology examination. The nonunion site was debrided until to expose healthy, bleeding bone. A drill was used to re-established the intramedullary canal. The proximal and distal fragments were then reduced and held in position with a reduction clamp. The nonunion site was stabilized with an autogenous iliac crest cortical bone grafts (length 7 cm), shortening of the bone of up to approximately 1 cm, was used to obtain contact between segments by maximal cortical contact to improve mechanical stability and osteosynthesis. A broad 4.5-mm limited contact dynamic compression plate (LDCP) (KangLi devices limited company, Suzhou city, China; length 11 holes) is then applied to fit the lateral surface of the humerus. Two tricortical compression screws were used to fix with at each sides of the nonunion site. This plate was secured in a compression mode with 4 screws used to fix the plate to the proximal and 3 screws distal ends of the humerus (**Figure 2A**, **2B**). In order to enhance the biomechanical environment for better healing, a working length of two holes was deliberately created at the nonunion site. Once secure filled with autogenous iliac crest cancellous bone around the ununion site, close the wound as usual and insert a drain.

The radiographs of postoperative indicated good implant placement and adequate reduction of the nonunion (**Figure 2A**, **2B**). The result

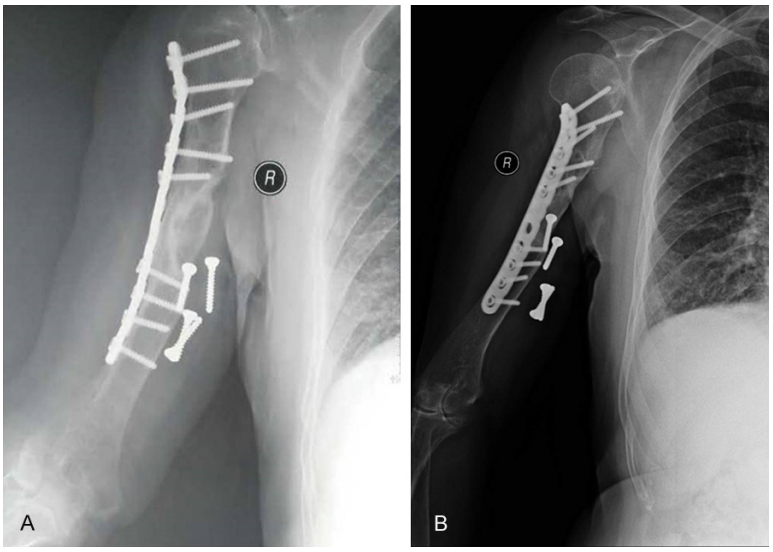

Figure 3. Clinical follow-up at 27 months after nonunion repair. Anteroposterior (A) and lateral (B) radiographs showing the fracture healed and cortical graft seems to be completely integrated.

Figure 4. The movement of the elbow and shoulder at 27 months postsurgery.

of the pathology examination was fibrous granulation tissue. The patient recovered well from the surgery and was discharged one week after operation. A sling was used to protect the arm for pain control at the first two weeks postoperation. Early active of the elbow and shoulder was encouraged. His neurovascular status remained intact following the surgery, and the fracture healed uneventfully at 27 months postoperation. The cortical graft seemed to be completely integrated (**Figure 3A**, **3B**). His postoperative shoulder and elbow was fully active with no restrictions (**Figure 4A**, **4B**, video 1 (Symmetric range of motion of the shouder was achieved, 27 months later, after nonunion repair)).

Discussion

To our knowledge, this is the first case to report a nonunion after initial surgical management of humeral shaft fracture for as long as 123 months that has been successful treated. Ring, D et al [6] showed a case of 76-year-old woman whose ununited fracture had been present for 192 months, but with a persistent nonunion. What is more, there is rarely research that has tested the use of autogenous iliac crest cortical bone grafts for the purposes of salvaging humeral shaft nonunion complicated by segment bony defect with length of 7.5 cm. In order to obtain compression and contact between segments, the bone was shortened up to approximately 1 cm, and we actually used an 7 cm autogenous iliac crest cortical bone grafts.

The causes for this case developing nonunion including smoking, alcohol abuse, long time disuse, poor patient compliance ect. Humeral shaft nonunion associate with large stock bone defect present challenges. Many strategies are recommended for treatment, ranging from Autogenous Cortical Bone Grafts (Dual fibular graft), compressive locking plate combined with intramedullary strut allograft, autogenous cancellous bone graft and augmented with a bridging plate, locked plating and opposite cortical allograft in conjunction with mesenchymal stem cells and BMP-7, interlocked nailing and autologous bone

grafting, vascularized fibular transfer combined with plate fixation, Ilizarov external fixation [6-12].

But each method has its disadvantage. Clinically, single fibular graft has a high failure rate when segmental defects in large tubular bones need to be reconstructed. So dual grafts were used for humeral shaft nonunion [7, 13]. Chhabra et al [14] suggest a segmental bone loss of >6 cm as indication for using vascularized autogenic fibular grafts. Others propose vascularized fibula transfer in patients accompany with bone defects >3 cm and poor stability at the nonunion site. But vascularized bone grafting requires facility and surgical experience, vascular thrombosis may worsen the result of vascularized fibula transfer. So it has disadvantages too, for example the possibility of damage nerves and blood vessels, difficulty of application and pain. The complexity and technical difficulty tempered ilizarov technique. Infections of the pin tracts and superficial infections are regarded as cautioned in daily clinical practice. Intramedullary nailing offers less axial stability and rotational control leading to less consolidation of the humeral shaft nonunion. The complication of the bone strut technique is the morbidity in donor side which including nerve damage, superficial infection, and intermittent pain.

So optimal surgical technique for treating humeral shaft nonunion is still controversial. Investigator seems to agree on the principles that are improving the suboptimal biologic response and achieving mechanical stability by rigid fixation in treating atrophic humeral shaft fractures. Healy, W. L. and G. M. White et al [15] demonstrated that ORIF is the standard of care with rigid compression plating and autogenous bone grafting. we used LCDCP combine with an autogenous iliac crest cortical bone grafts (length 7 cm) and cancellous bone treated this troublesome case successfully. Some may worry that segmental autogenous cortical bone grafts incorporate very slowly, so their ability to hypertrophy is limited that lead to fatigue fractures. Previous study suggested that the length of the bone loss did influence the number of stress fractures but it did not influence the incidence of nonunion. The shorter grafts were about 7.5 to 12 centimeters while the longer grafts 12 to 25 centimeters. The incidence of stress fractures in the shorter grafts (17 per cent) was much lower than that in longer the grafts (58 per cent) [7]. Ring and Jupiter et al [6] demonstrated a case to achieve union across atrophic diaphyseal defects as large as 6 cm using wave-plate with autogenous cancellous bone graft alone.

The use of 11 holes LCDCP can limit contact which is important for increasing the blood supply to the bone and enhancing the biologic aspects of healing. A working length of two holes at the nonunion site provide enough stress be transmitted to the grafts to stimulate the repair and allowing healing by callus during this period. The gold standard for providing osteoinductivity, osteoconductive, osteogenic stimuli for bone healing is autologous iliac crest bone graft (ICBG) [16]. Autogenous iliac crest cortical bone grafts provide scaffolding and skeletal stabilization, while cancellous bone ensure sufficient mesenchymal cells, growth and differentiating factors to promote early healing [17]. Shoulder and upper arm present a well-vascularized envelope of muscle which makes autologous cortical bone grafts placed in a well-vascularized bed. It is crucial for rapid revascularization and incorporation. ICBG may accompany with some severe complications, for example blood loss and donor site morbidity, which is the disadvantage of this surgical technique [18, 19].

Conclusions

This report has demonstrated that LCDCP combine with autologous iliac crest cortical bone graft and cancellous bone has proven successful in treating humeral shaft nonunion with segment bony defect. The protocol is achievement of biologically friendly and biomechanically stable construct. It may provide an effective alternative for treatment of atrophic humeral shaft nonunion complicated by massive bone loss. The main advantages of this technique for treating humeral shaft nonunion include decreased morbidity, rigid stabilization, osteogenic, osteoinductivity, and osteoconductive assuring union. It is easy to operate and decreases hospital stay.

Disclosure of conflict of interest

None.

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