Proximal Humeral Nonunion Treated With an Intramedullary Tantalum Cylinder

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abstract

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Nonunion is uncommon after proximal humerus fracture surgery. There is no agreement about preferred method of treatment. Traditional approaches have included laterally based locking plates, autogenous grafting, and endosteal support to provide improved biomechanical stability. Open reduction and internal fixation (ORIF) of proximal humeral nonunion has been performed with various methods, including blade plates and bone grafting, as well as intramedullary support with autologous or allogenic grafts. Both malunion and nonunion have occurred after ORIF with locking plates. Endosteal support in the form of a fibular allograft incorporated into the locking plate construct can increase mechanical stability in selected cases.

An ideal implant for proximal humeral nonunion provides medial column mechanical support and osteoconductive and osteoinductive properties. Porous intramedullary tantalum metal may play a role in nonunion surgery as an alternative to fibular allograft because of its versatility of use and salutary biological effects. It offers many material advantages for use in nonunion surgery. Tantalum is extensively porous (75%-80%), has a stiffness close to that of native bone, and offers the possibility of being a carrier for osteoinductive materials. It may also be suitable for patients who refuse allograft material. This article describes a 65-year-old woman with recalcitrant proximal humeral nonunion who was successfully treated with revision ORIF with intramedullary tantalum cylinder augmentation with a lateral-based locking plate and autogenous cancellous bone grafting. At 5-year follow-up, she had excellent motion and clinical and radiographic union.
Nonunion of the proximal humerus is an uncommon complication and often represents a treatment dilemma. Endosteal support as a supplement to plate fixation has been used in proximal humeral surgery, usually in the form of a fibular allograft.

Proximal humeral nonunion can be the result of a failed surgical procedure or related to initial fracture displacement and soft tissue injury. Treatment can vary depending on the overall medical condition of the patient and may include benign neglect for severely debilitated or high-risk patients. Surgical options include open reduction and internal fixation (ORIF), prosthetic replacement, percutaneous pinning, and, rarely, external fixation. If ORIF is chosen, bone grafting is often needed due to the metaphyseal bone loss present. However, structural intramedullary support in the form of an autograft or allograft is also frequently necessary.

This article describes a patient with long-term follow-up in whom a proximal humeral nonunion was successfully treated with an intramedullary tantalum metal implant combined with a lateral locking plate.

**CASE REPORT**

A 65-year-old woman was referred from another hospital for pain after a proximal humeral nonunion. She had sustained a closed left proximal humerus fracture treated with ORIF using a lateral locking plate. She had undergone repeat ORIF with locked plate fixation and recombinant bone morphogenetic protein-2 performed by a second outside surgeon. The patient was a community ambulator without assistive devices or limitation to activities of daily living before her index injury. Six months after her revision procedure, she was unable to perform routine activities of daily living, had minimal ability to raise her arm in abduction or forward flexion, and was in severe pain. Preoperative laboratory studies (erythrocyte sedimentation rate and C-reactive protein) revealed no evidence of infection. She had clear evidence of chronic atrophic nonunion of the proximal humerus below the surgical neck with bone loss, plate pullout, and lucency around the screws (Figure 1). She was taken to the operating room and informed that off-label use of an intramedullary tantalum metal implant was planned.

Autologous cancellous grafting from the posterior iliac wing was performed. A deltopectoral approach was used, and the nonunion site was found to be sclerotic with extensive bone loss. A trabecular metal tantalum cylinder (Osteonecrosis Intervention Implant [OI] System; Zimmer, Allendale, New Jersey) was placed into the intramedullary canal with proximal threads manually impacted into the humeral neck (Figure 2). A lateral 3.5-mm stainless steel proximal locking plate was applied, and screw fixation through the tantalum implant was performed. Bony defects were filled with autogenous cancellous bone. Pendulum exercises were initiated immediately postoperatively, and dedicated therapy began at 6 weeks postoperatively.

At 5-year follow-up, the patient had no shoulder pain and was able to perform all desired activities. Radiographs revealed a healed proximal humerus with no change in implant position (Figure 3). She had near full shoulder range of motion (Figure 4).

**DISCUSSION**

Numerous techniques have been described for the treatment of displaced proximal humerus fractures, but there has been a trend toward treating these injuries with locking plates. These implants result in a fixed-angle construct that provides good initial stability, even in osteoporotic bone, and allow for earlier range of motion and rehabilitation. Although the overall results have been encouraging, failures due to screw migration into the glenohumeral joint, varus collapse, and loss of medial column support are not infrequent.

Proximal humeral nonunion is an uncommon condition that can frequently be disabling. Before engaging in operative intervention, an evaluation for metabolic deficiencies has been recommended, especially in patients with a recalcitrant nonunion after technically satisfactory surgery. The authors did not perform a metabolic workup in the current patient because she presented prior to the recommendation by Brinker et al. The authors would perform such a workup today. Ultimately, most of these patients with a symptomatic proximal humeral nonunion will need surgery.

Surgical options for proximal humeral nonunions include arthroplasty and sur-
gical repair with internal fixation and bone grafting. Precise indications for either strategy are not well defined, but arthroplasty is often reserved for older patients with more medical problems and fewer functional expectations.

Open reduction and internal fixation of proximal humeral nonunion has been performed with various methods, including blade plates and bone grafting, as well as intramedullary support with autologous grafts and allografts. Both malunion and nonunion have occurred after ORIF with locking plates. Perhaps recent technical advances will decrease these complications. For example, achieving inferomedial support with a locking screw allows for better maintenance of reduction. Additional endosteal support in the form of a fibular allograft incorporated into the locking plate construct can also increase mechanical stability in selected cases.

There has been a trend toward the use of fixed-angle locking plates as well as endosteal support with a fibular allograft. Bae et al. recently performed a biomechanical evaluation of unstable proximal humerus fractures and found that the addition of an intramedullary fibular strut graft to a locking plate construct increased maximum load to failure and stiffness compared with the locking plate alone.

The current authors believed that some form of medial column support for this nonunion would provide mechanical support and have osteoconductive and osteoinductive properties.

The OII System is a cylinder of porous tantalum metal developed to treat avascular necrosis of the femoral head by providing structural support. Its highly porous nature provides for osteoconduction, and it decreases the possibility of disease transmission associated with allograft. In addition to having the advantage of a predictable size, shape, and length, increased bone incorporation over allograft should theoretically occur. The relatively soft nature of tantalum metal may allow for screw insertion through the implant.

Metallic implants that promote bony ingrowth are not a new concept. Tantalum implants have been used in spine surgery as bone graft substitutes in tibial tubercle advancement, and in revision total joint replacement. They offer many potential advantages in nonunion surgery. Tantalum is extensively porous (75%-80%), has a stiffness close to that of native bone, and offers the possibility of being a carrier for osteoinductive materials, although the degree to which tantalum metal developed to treat avascular necrosis of the femoral head by providing structural support. Its highly porous nature provides for osteoconduction, and it decreases the possibility of disease transmission associated with allograft. In addition to having the advantage of a predictable size, shape, and length, increased bone incorporation over allograft should theoretically occur. The relatively soft nature of tantalum metal may allow for screw insertion through the implant.

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The described technique was used successfully in this case. It cannot currently be recommended for routine clinical use. However, the authors believe that further basic science and clinical investigation of tantalum metal in nonunion surgery is warranted.

References

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