THE USE OF A FIBULAR STRUT ALLOGRAFT WITH DBM, CANCELLOUS CHIPS AND BMP FOR A 10 CM HUMERAL SHAFT INFECTED NON-UNION: A Case Report

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ABSTRACT

Humeral shaft non-unions occur in 2-10% of all fracture cases. Increased incidence of these non-unions can be associated with ORIF, comminution, high impact injuries, bone loss or fracture gaping. Treatment guidelines for fracture non-union state that fractures with gaps greater than 4 cm should be treated with vascularized fibular autografts or transportation with an external fixator. Unfortunately these modalities carry considerable donor site morbidity and patient will experience considerable discomfort, especially when dealing with an external fixator. This report demonstrates how the use of a nonvascularized fibular strut can be effectively utilized as an alternate treatment modality for large humeral shaft non-union gaps. Further studies should be conducted to support this method as a viable treatment option for non-union gaps greater than 4 cm.

Index words: fibular, strut, allograft, cancellous, chip, humeral, shaft, infected, non-union

INTRODUCTION

Humerus fractures make up about 5% to 8% of all fractures and 10% of all long bone fractures (1-4). Approximately 30% of all humeral fractures occur at the diaphysis. Most of these fractures can be treated non-surgically with excellent outcomes; Sarmiento et al (5) reported union rates of 94% for open and 98% for closed fractures of the humeral shaft after functional bracing. Nonunion of the humeral shaft occurs in 2% to 10% of non-surgically treated fractures and close to 15% of fractures treated by open reduction and internal fixation (4-7). Increased incidence of nonunion is associated with open fractures, high impact injuries, bone loss or fracture gapping, soft tissue interposition, unstable fracture patterns, segmental fractures, impaired blood supply, infection, and initial treatment with traction (4). A humeral fracture is classified as nonunion if no progression towards healing is witnessed in three months or there is evidence of a lack of union six months (7). Union is expected to occur between 12 to 16 weeks. Risk factors for developing nonunion include both biologic host factors (smoking history, disrupted blood supply, medical comorbidities) and mechanical (fracture displacement and inadequate immobilization) factors. Patients who fail nonsurgical management for humerus fractures and develop a nonunion should preferably undergo surgery with the ultimate goal of creating a biological environment that favors bone healing and providing a stable mechanical construct that allows for early motion. Currently, the standard of care for humeral nonunion is open reduction and internal fixation of the defect with rigid compression plating and autogenous bone grafting (8). Success has been reported with the use of demineralized bone matrix (DBM) with or without bone morphogenic protein (BMP) along with plating (9-12). Biologic augmentation with BMP-2 and BMP-7 has been performed but to our knowledge, there is no study that documents their efficacy in humeral non-union. There are other techniques that have been recently described which include intramedullary fibular strut autograft for atrophic proximal nonunions and augmentation of compression plating in cases of previous surgical treatment (13, 14), and dual compression plating for humeral shaft nonunions with poor bone quality such as with patients who have osteoporosis or osteopenia (9, 15, 16).

Bone loss can complicate fracture healing and, as previously mentioned, is a risk factor for developing nonunion. Managing patients with extensive bone loss can be a challenge and advanced treatment techniques are needed. A defect of 3 to 4 cm can undergo acute shortening and plate fixation, as functionality and motion of the arm is not impaired. For defects greater than 4 cm, the literature supports the use of vascularized fibula transfer and bone transport (17-20); however they offer significant donor site morbidity and the utilization of an external device for extended periods of time (respectively).

To our knowledge, the use of fibular allograft (nonvascularized) as a strut graft for large gaps of bone loss (> 4 cm) has not been described. In this report, we present the case of a diabetic woman who presented with history of humeral shaft infected nonunion that failed two prior attempts of surgical treatment at another institution, and presented with loose hardware and a 10 cm gap of bone loss with positive CRP and ESR parameters. We will describe the use of a fibular strut allograft for augmentation of dual compression plating and the use of both BMP and DBM for biologic augmentation of fracture healing, which resulted in excellent bone formation with a rigid fixation and functional arm.

Figure 1: X-rays taken two years prior to visit, showed internal fixation with loose hardware and evidence of nonunion with poor bone formation and mild sclerosis around compression plating. A compression non-locking plate with wire cerclage was used.

Case History

This is the case of a 47 year-old-woman with past medical history of hypertension and Diabetes Mellitus type II, taking Avalide and Amaryl, who presented to our Orthopedic clinics with instability in her left arm associated with decreased ROM of elbow of three years duration. Patient refers that she was in a car accident three years ago, which resulted in a humerus fracture, and required surgical intervention for open reduction and internal fixation by a community orthopedic surgeon at the time. X-rays films taken two years prior to visit showed internal fixation with loose hardware and evidence of nonunion with poor bone formation and mild sclerosis around compression plating (see Figure 1). Subsequent films three years after initial surgery showed progressive osteolysis, bone resorbtion and hardware loosening with continuing non-union with an 8 cm gap in the humeral shaft (see Figure 2).

Laboratory data revealed WBC count in 4.9, ESR level was reported at 96, CRP was found to be positive, glucose level was at 250, and HbA1c was at 8. Due to the high probability of chronic infection, the patient was scheduled for removal of hardware and bone saucerization. A posterior approach to the humeral shaft was taken. Areas of non-viable bone and a large area of fibrotic nonunion were found with no gross purulent discharge. The loose hardware was removed in its entirety as well as debridement of large areas of bone fragments, which left a 10 cm bone loss gap in the humerus. Cultures were taken and the area was irrigated with 3 liters of 0.9 normal saline solution. The incision was closed using vycryl (for muscle tissue) and prolene (skin). Patient was subsequently places in prophylactic IV vancomycin therapy for two weeks. During this time, pathology report showed no abnormality in tissue specimen except for necrotic fragments of bone, cartilage and connective tissue. Microbiology report from orthopedic device and tissues revealed no growth after 5 days.

Figure 2: Subsequent X-rays 3 years after initial surgery showed progressive osteolysis, bone resorbtion and hardware loosening with continuing non-union with an 8 cm gap in the humeral shaft

On the second week after the first surgery, patient was taken again to the operating room for open reduction and internal fixation. Patient was placed in right lateral decubitus position. Skin incision was done through previous scar. After verifying correct humeral length, non-union was fixed utilizing dual compression plates with 6 distal and 6 proximal screws. A 10 cm non-vascularized fibular allograft was then placed as a strut to act as support for the 10 cm bone gap and was fixed utilizing one screw distally. Cancellous chips were first placed around fibular strut, followed by demineralized bone matrix (DBM) paste around the cancellous chips. Bone Morphogenic Protein (BMP) was then placed between the plates, posterior to the DBM paste, cancellous chips and fibular strut construct. The wound was again closed using vycryl and prolene sutures.

Patient was discharged from orthopedic ward two days postop with only oral antibiotic prophylaxis

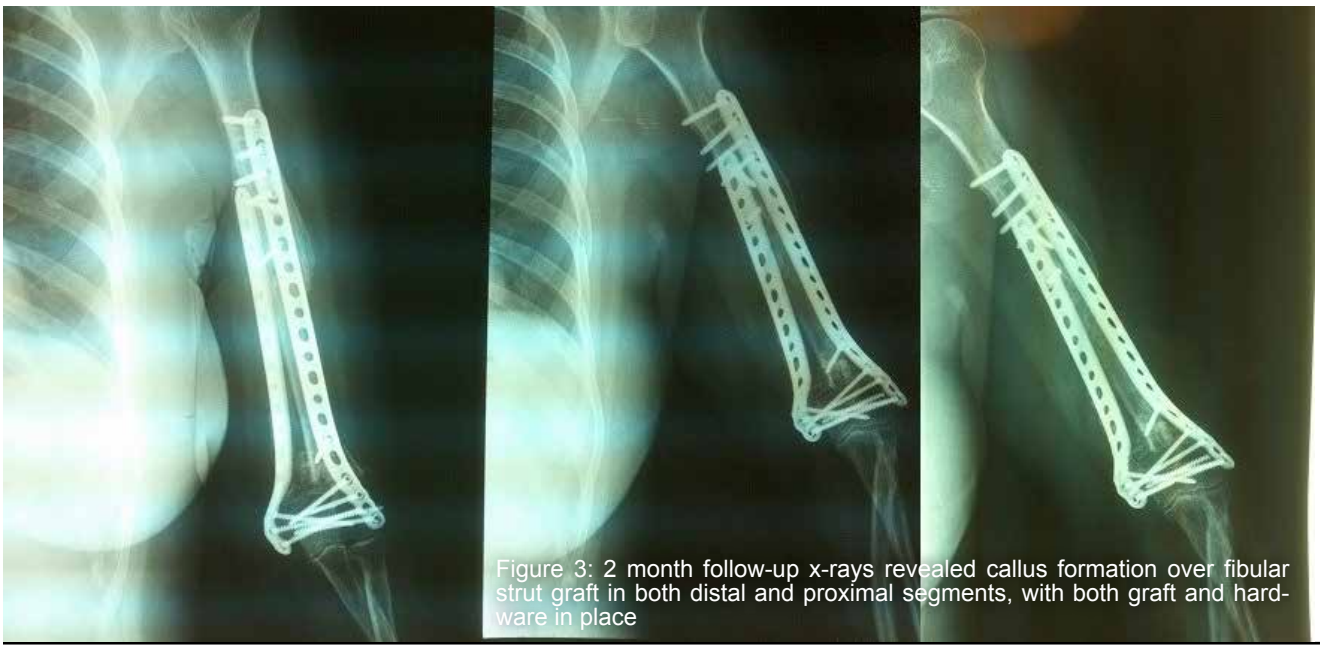

Figure 3: 2 month follow-up x-rays revealed callus formation over fibular strut graft in both distal and proximal segments, with both graft and hardware in place

Figure 4: Two years after most recent surgery, graft remains in place and fracture non-union appears rigid with no instability.

with instructions for limited motion and no lifting of objects. After two months of follow-up and physical therapy, x-rays revealed callus formation over fibular strut graft in both distal and proximal segments, with both graft and hardware in place (see Figure 3). Elbow range of motion improved significantly from 30 degrees of extension to 20, and from 80 degrees of flexion to 90 degrees. Laboratory results showed CRP levels less than 6 and an ESR level of 20. The patient was judged to have a fixed humeral shaft non-union and was returned to full activity and asked to return every four months for the next year to follow up fracture healing. After two year follow up, no evidence of deterioration or infection was found and patient reported return to full activity with no pain (see Figure 4). Physical examination showed rigid construct with no instability. Patient was discharged from clinics and asked to return as needed.

DISCUSSION

Recommended treatment for humeral shaft non-union with a gap greater than 4 cm includes the utilization of vascularized fibular autograft for restoration of length while providing live bone tissue. Another described alternative is the use of external hardware for bone transport. While effective, both these techniques have serious downfalls: Autologous bone transport has significant donor site morbidity, while bone transport is a lengthy procedure that can take months to complete, all with an uncomfortable external device.

This article describes a possible alternate treatment for large gap non-union humeral shaft fractures, specifically those greater than 4 inches with great instability. The 47 year old woman described most likely attained her non-union due to chronic infection, possible facilitated by her uncontrolled diabetes mellitus, as evidenced by her elevated blood sugar and HbA1c levels. This patient with a 10 cm humeral shaft non-union gap was adequately treated using non-vascularized fibular allograft as a strut to maintain gap length, while utilizing DBM, BMP and cancellous chips to create a osteogenic and osteoinductive environment that eventually caused callous formation that effectively closed the 10 cm gap and completely healed the non-union in two months as evidenced by serial x-rays films.

The use of a non-vascularized fibula along with BMP, DBM and cancellous chips can be effectively utilized as an alternate treatment modality for large humeral shaft non-union gaps. Unlike the current treatment recommendations, the use of non-vascularized fibula as a strut has no donor site morbidity and contains no external hardware, therefore providing the patient with a much more comfortable recovery. Future studies can be directed towards determining the safety and efficacy of this treatment option compared to fibular autograft and bone transportation.

REFERENCES

1. Volgas DA, Stannard JP, Alonso JE: Nonunions of the humerus. Clin Orthop Relat Res 2004;(419):46-50.
2. Green A, Norris TR: Proximal humeral fractures and glenohumeral dislocation, in Browner BD, Levine AM, Jupiter JB, Trafton PG, Krettek C, eds: Skeletal Trauma: Basic Science, Management, and Reconstruction, ed 4. Philadelphia, PA, Saunders Elsevier, 2009, pp 1623-1754.
3. Schemitsch EH, Bhandar M, Talbot M:Fractures of the humeral shaft, in Browner BD, Levine AM, Jupiter JB, Trafton PG, Krettek C, eds: Skeletal Trauma: Basic Science, Management, and Reconstruction, ed 4. Philadelphia, PA, Saunders Elsevier, 2009, pp 1593-1622.
4. Ward EF, Savoie FH III, Hughes JL Jr: Fractures of the diaphyseal humerus, in Browner BD, Jupiter JB, Levine AM, Trafton PG (eds): Skeletal Trauma: Fractures, Dislocations, Ligamentous Injuries, ed 2. Philadelphia, PA: WB Saunders, 1998, vol 2, pp 1523-1547
5. Sarmiento A, Zagorski JB, Zych GA, Latta LL, Capps CA: Functional bracing for the treatment of fractures of the humeral diaphysis. J Bone Joint Surg Am 2000;82:478-486.
6. Rosen H: The treatment of nonunions and pseudarthroses of the humeral shaft. Orthop Clin orth Am 1990;21:725-742.
7. Jupiter JB, von Deck M: Ununited humeral diaphyses. J Shoulder Elbow Surg 1998;7:644-653.
8. Healy WL, White GM, Mick CA, Brooker AF Jr, Weiland

AJ: Nonunion of the humeral shaft. Clin Orthop Relat Res 1987;(219):206-213.
9. Prasarn ML, Achor T, Paul O, Lorich DG, Helfet DL: Management of nonunions of the proximal humeral diaphysis. Injury 2010;41(12):1244-1248.
10. Hierholzer C, Sama D, Toro JB, Peterson M, Helfet DL: Plate fixation of ununited humeral shaft fractures: Effect of type of bone graft on healing. J Bone Joint Surg Am 2006;88(7):1442-1447.
11. Ring D, Kloen P, Kadzielski J, Helfet D, Jupiter JB: Locking compression plates for osteoporotic nonunions of the diaphyseal humerus. Clin Orthop Relat Res 2004;(425):50-54.
12. Taylor NL, Crow SA, Heyworth BE, Rosenwasser MP: Treatment of humeral nonunions with allograft, demineralized bone matrix, and plate fixation. Osteosynthesis and Trauma Care 2005; 13(2):105-112.
13. Vidyadhara S, Vamsi K, Rao SK, Gnanadoss JJ, Pandian S: Use of intramedullary fibular strut graft: A novel adjunct to plating in the treatment of osteoporotic humeral shaft nonunion. Int Orthop 2009;33(4):1009-1014.
14. Willis MP, Brooks JP, Badman BL, Gaines RJ, Mighell MA, Sanders RW: Treatment of atrophic diaphyseal humeral nonunions with compressive locked plating and augmented with an intramedullary strut allograft. J Orthop Trauma 2013;27(2):77-81.
15. Badman BL, Mighell M, Kalandiak SP, Prasarn M: Proximal humeral nonunions treated with fixed-angle locked plating and an intramedullary strut allograft. J Orthop Trauma 2009;23(3):173-179.
16. Cole PA: Endosteal allograft plating for the treatment of recalcitrant nonunions. Techniques in Orthopaedics 2004;18(4):344-355.
17. Patel VR, Menon DK, Pool RD, Simonis RB: Nonunion of the humerus after failure of surgical treatment: Management using the Ilizarov circular fixator. J Bone Joint Surg Br 2000;82:977-983.
18. Ackerman G, Jupiter JB: Non-union of fractures of the distal end of the humerus. J Bone Joint Surg Am 1988;70:75-83.
19. Jupiter JB: Complex non-union of the humeral diaphysis: Treatment with a medial approach, an interior plate, and a vascularized fibular graft. J Bone Joint Surg Am 1990;72:701-707.
20. Wright TW, Miller GJ, Vander Griend RA, Wheeler D, Dell PC: Reconstruction of the humerus with an intramedullary fibular graft: A clinical and biomechanical study. J Bone Joint Surg Br 1993;75:804-807.

RESUMEN

Las seudoartrosis (no-unión) de diáfisis de humero ocurren en 2-10% de todos los casos de fracturas. Entre los factores asociados a una mayor incidencia de seudoartrosis, se encuentran las fracturas tratadas con reducción abierta y fijación interna, cominución, fracturas de alto impacto, pérdida de hueso y distracción de las fracturas. Las guías de tratamiento para seudoartrosis indican que las fracturas con una distracción mayor de 4 cm deben ser tratadas con injerto autólogo de fíbula vascularizada o transportación ósea con fijador externo. Desafortunadamente estas modalidades traen una gran morbilidad de la zona donante y los pacientes pueden experimentar incomodidad significativa, especialmente cuando se trata de un fijador externo. Este reporte demuestra como el uso de injerto alogénico de fíbula no-vascularizada puede ser utilizado como una modalidad de tratamiento alterna para las seudoartrosis de diáfisis de húmero con una distracción de más de 4 cm. Se deben realizar más estudios para apoyar la viabilidad esta modalidad.