

Minimally Invasive Shortening Humeral Osteotomy to Salvage a Through-Elbow Amputation

CPT Michael J. Beltran, MC USA*; LTC Kevin L. Kirk, MC USA*;
LTC Joseph R. Hsu, MC USA†; Skeletal Trauma Research Consortium (STReC)

ABSTRACT Objective: Determine the efficacy of a novel surgical technique to salvage a through-elbow amputation and avoid revision transhumeral amputation. Methods: A 23-year-old soldier presented after sustaining a through-elbow amputation in a close-range blast injury with inadequate soft tissues to obtain closure over the distal humerus. A 2-cm anterior incision was made and a shortening osteotomy with percutaneous submuscular osteosynthesis was done. A myodesis was performed and a tension-free primary closure of the soft tissue envelope obtained. Results: At 3 months postoperatively the osteotomy and soft tissue envelope were healed. At 2-year follow-up the patient reports using a body-powered prosthesis for ADLs and recreational hobbies, citing excellent rotational control and ease of prosthetic suspension. Conclusion: Minimally invasive shortening humeral osteotomy in the setting of a through-elbow amputation is a safe and effective procedure, which allows primary soft tissue closure, prevents the need for more proximal amputation, and allows for ease of prosthetic fitting and suspension.

INTRODUCTION

Ninety percent of upper extremity amputations are the result of trauma.¹ The benefits of an elbow disarticulation over a transhumeral amputation include increased strength of the residual limb secondary to greater bone length and retention of full muscle units, active rotational control due to the presence of the condylar flare, and easier suspension of a prosthetic device.² However, problems often arise at this level in traumatic amputations, as soft tissue is frequently unavailable to obtain acceptable wound closure over the distal bone end. Limb shortening to allow soft tissue coverage has been described mainly in limb salvage of the tibia.³ Shortening diaphyseal osteotomy of the humerus, to obtain soft tissue closure, represents an attractive option to preserve an elbow disarticulation level and prevent proximal revision. Furthermore, percutaneous plate osteosynthesis of humeral shaft fractures has recently been described as an effective alternative to formal open surgical approaches, limiting surgical morbidity, and allowing for quicker soft tissue recovery and decreased complications.⁴ We present a case report of a minimally invasive shortening diaphyseal osteotomy across a humeral fracture site with percutaneous plate stabilization to obtain soft tissue closure and salvage an elbow disarticulation level in a patient with bilateral traumatic upper extremity amputations. The patient was informed that data pertaining to the case would be submitted for publication, and consent was obtained.

CASE REPORT

A twenty-three-year-old soldier serving in Iraq was disposing of an improvised explosive device when the weapon detonated, sustaining bilateral traumatic upper extremity amputations. At presentation to our facility, the amputation on the left was at the through-elbow level with a concomitant transverse diaphyseal humerus fracture. The contralateral limb was amputated at a long transhumeral level. Other injuries included bilateral orbital wall fractures, corneal contusions, and first degree facial burns. An additional debridement was performed on postinjury day 4 to both extremity wounds. On postinjury day 8, the wounds had viable muscle without signs of infection. The wounds were debrided and irrigated with normal saline at low pressure. The right side had adequate tissue for coverage of the patient's residual humeral limb and was closed with sutures. The left residual limb had inadequate soft tissue to obtain coverage of the distal humerus (Fig. 1 and Fig. 2, A and B).

Rather than shorten the distal end of the humerus to obtain coverage, we chose to perform a shortening osteotomy across the diaphyseal fracture site. An anterior 2-cm longitudinal incision was centered over the transverse humeral fracture and dissection carefully carried down to the fracture by retracting the biceps brachii medially and splitting the brachialis through its midline fibers. Periosteal stripping was kept to a minimum, only enough to visualize the fracture edges. Using a midsagittal saw, 0.5 cm of bone was resected from the distal fragment and 2 cm resected from the proximal fragment. The bone ends came into opposition easily. At this point it was determined that the distal soft tissues were amenable to closure over the distal humerus with partial release of the soft tissue envelope at the level of the condyles (Fig. 3). A Synthes 9-hole, 3.5-mm locking compression plate was placed in a submuscular manner across the osteotomy through the small osteotomy incision. It was first passed proximally beyond the osteotomy

*Brooke Army Medical Center, 3851 Roger Brooke Drive, Fort Sam Houston, TX 78234.

†United States Army Institute of Surgical Research, 3851 Roger Brooke Drive, Fort Sam Houston, TX 78234.

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FIGURE 1. Intraoperative photograph depicting the soft tissue envelope and exposed distal humerus following the final debridement before planned osteotomy and closure.

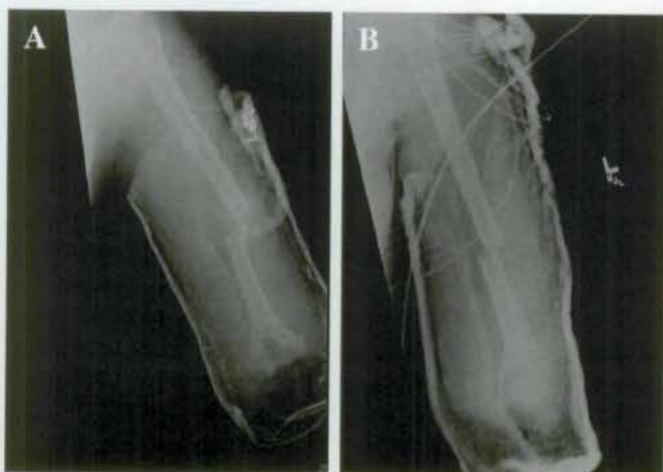


FIGURE 2. (A and B) Preoperative anteroposterior and lateral radiographs in plaster splint show transverse humeral shaft fracture with apex lateral angulation. The planned osteotomy was performed across this fracture site.



FIGURE 3. After osteotomy and locking plate application, soft tissue envelope over distal humerus comes together without tension.

then advanced distally to limit direct contact with the open wound. The osteotomy site was compressed by anchoring the plate to the distal fragment through stab incisions and using the dynamic compression slots in the proximal portion of the plate through stab incisions. A myodesis of the triceps, biceps brachii, and brachialis was performed through drill holes at the distal humerus. The soft tissue envelope and incision were closed with sutures, and a protective splint placed to aid with soft tissue rest (Fig. 4, A and B).

The patient's postoperative course was uneventful. Sutures were removed at 3 weeks postoperatively, at which time the patient was fitted for a right arm prosthesis. The patient was prevented from using the left residual limb for activities of daily living and was not fitted for a prosthesis until radiographic evidence of healing callus was visualized at 8 weeks. Significant heterotopic ossification was present at the distal soft tissue margin, but the patient remained asymptomatic, without any impact on prosthetic fitting or function. The patient successfully uses a body-powered prosthesis and has no desire to be fitted with an electric elbow. At 2-year follow-up, the patient's fracture was radiographically healed, and the patient reports using the limb for all activities of daily living as well as multiple recreational activities, among them painting. The patient notes excellent rotational control of her prosthesis during activities. Of interest, the patient reports greater satisfaction with the through-elbow amputation compared to the contralateral distal humeral amputation (Fig. 5 and Fig. 6).

DISCUSSION

Although the choice to preserve an elbow disarticulation remains controversial, it is generally accepted that preservation of the distal humeral condyles is recommended when soft tissue coverage will allow.^{2,5,9} This becomes of particular importance in the bilateral upper extremity amputee, who

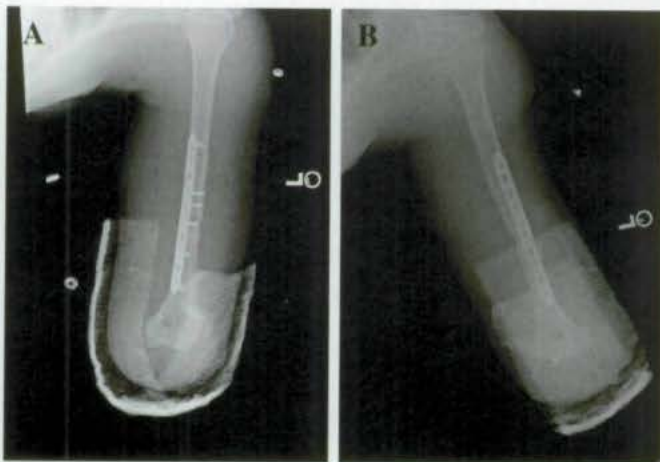


FIGURE 4. (A and B) Immediate postoperative anteroposterior and lateral radiographs reveal osteotomy with 9-hole Synthes locking compression plate in place. A plaster splint has been applied to facilitate soft tissue rest.



FIGURE 5. Lateral radiograph taken 8 months postoperatively reveals a healed fracture and significant asymptomatic heterotopic ossification at the distal humerus.



FIGURE 6. Patient's residual limb with healed soft tissue envelope.

gains significant function from ease of prosthetic suspension and the ability to actively rotate the residual limb. The major drawback of maintaining this level in an elbow disarticulation level amputee is the difficulty of fitting these patients for a prosthetic elbow device. Prosthetic elbows, although quite functional, are cosmetically unappealing due to their cumbersome size and asymmetric appearance of the arm and forearm.² This drawback can potentially be reduced or even eliminated if the humerus is shortened, providing room for the prosthetic components. An open shortening osteotomy through the distal humeral metaphysis has recently been described to facilitate use of an electronic elbow prosthesis.⁶ A shortening osteotomy of the humerus allows for both preservation of the condylar flare and associated ease of prosthetic fitting; the prosthesis remains more easily suspended and room is made to accommodate the prosthetic elbow components.

Angular osteotomy has been popularized by Marquardt and Neff in the above-elbow amputee population to facilitate ease of prosthetic suspension.⁷ This procedure is a potential option in the long transhumeral amputee who seeks easier prosthetic fitting but lacks the condylar flare. However, this

is a nonanatomic reconstructive procedure we believe to be inadequate in the elbow disarticulation-level amputee who can maintain ease of prosthetic fitting through the preservation of the native distal humerus.

Recent evidence suggests that dissection through the zone of injury in patients that have sustained traumatic amputations predisposes to the formation of heterotopic ossification.⁸ A blast injury, like that sustained by our patient, was also cited as a risk factor for the formation of heterotopic ossification. On the basis of this evidence, it appears prudent to avoid amputation revision to a more proximal level through the zone of injury when percutaneous shortening osteotomy through the diaphysis provides a safe and reliable alternative that allows soft tissue closure and minimizes the risk of developing heterotopic ossification. Our patient nonetheless developed heterotopic ossification at the end of the residual limb; to date it has remained asymptomatic and has not caused pain or influenced the use of the patient's prosthesis. We believe that for the typical civilian trauma patient requiring a through-elbow amputation, shortening osteotomy of the diaphysis, away from the zone of injury, is likely to reduce the incidence of clinically

significant heterotopic ossification, particularly when taking into account that blast mechanisms are an uncommon cause of upper extremity amputation in the civilian sector.

The case report by DeLuccia and Marino cited above reports on the use of shortening distal metaphyseal osteotomy to aid in prosthetic fitting of an elbow disarticulation.⁶ Although novel, their osteotomy nonetheless requires an open technique and the associated morbidity that comes with an open approach to the distal humerus. No article to our knowledge has discussed the use of diaphyseal osteotomy and percutaneous plate osteosynthesis in an effort to preserve a through-elbow amputation level. The presence of a diaphyseal fracture in our patient made the decision to proceed with shortening across the fracture simple. In the future, patients without an associated fracture could simply be shortened anywhere along the diaphysis, sufficiently away from the distal humerus and the relative zone of injury, with a similar postoperative and rehabilitative program to our patient.

Percutaneous plate osteosynthesis is a popular method for the treatment of both fractures and osteotomies. The reasoning behind this trend lies in the theoretical reduced incidence of delayed union and nonunion as a result of the preservation of blood supply through the adjacent soft tissue envelope achieved with a minimally invasive technique. Although a diaphyseal osteotomy is associated with a greater risk of nonunion when compared to a metaphyseal osteotomy, this risk is minimized using minimally invasive surgery. In addition, percutaneous approaches utilize smaller incisions, reducing postoperative pain and the incidence of wound complications.

This case report suggests that minimally invasive shortening diaphyseal osteotomy and plating of a traumatic elbow

disarticulation is a safe and effective way to gain distal soft tissue coverage while retaining the humeral condyles for prosthetic fitting and support of an elbow prosthesis.

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