Surgical fixation of extra-articular distal humerus fractures with a posterolateral plate through a triceps-reflecting technique

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\textbf{Background:} Surgical management of extra-articular distal humerus fractures results in predictable fracture alignment. Open reduction and internal fixation also decrease the soft tissue complications and frequent follow-up required with functional bracing. A triceps-reflecting posterior approach provides excellent exposure to the humerus and minimizes trauma to the triceps. An anatomically precontoured plate on the posterolateral surface of the humerus provides stable fixation of these injuries and is placed directly through the interval developed by the triceps-reflecting approach.

\textbf{Methods:} We retrospectively reviewed the trauma databases at 2 level I academic trauma institutions during a 5-year period for all patients with an extra-articular distal humerus fracture treated with a triceps-reflecting approach and an anatomically precontoured posterolateral distal humerus plate. Patient and fracture characteristics were recorded, as were QuickDASH functional scores and visual analog scale scores for pain, function, and quality of life.

\textbf{Results:} Forty patients were eligible for our study. Average follow-up was 88 weeks. Thirty-eight (95\%) patients went on to union. Seven (20\%) patients required a secondary procedure. The average QuickDASH score was 17.5 (range, 2.6-56.8). The average visual analog scale scores were 1.9 (range, 0-7) for pain, 2.3 (range, 0-8) for function, and 1.6 (range, 0-5) for quality of life. Thirty-five (87.5\%) patients reported satisfaction with the outcome of their surgery.

\textbf{Discussion:} Surgical fixation of extra-articular distal humerus fractures through a triceps-reflecting approach with an anatomically precontoured posterolateral distal humerus plate results in predictable osseous union and overall excellent functional results for patients with this injury.

\textbf{Level of evidence:} Level IV, Case Series, Treatment Study.

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\textbf{Keywords:} Humeral fracture; distal humerus; extra-articular; triceps reflecting; posterolateral plate

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Open reduction and internal fixation of extra-articular distal humerus fractures provide immediate skeletal stability, allow early rehabilitation, and eliminate the soft tissue complications associated with functional bracing. The benefits of surgical fixation must be considered within the context of an increased risk of infection, iatrogenic nerve injury, and need for secondary procedures.\textsuperscript{5}

Fixation of extra-articular distal humerus fractures must provide stability to resist the torsional forces placed on the upper extremity as well as the forces realized with elbow flexion and extension. The location of the humeral fracture dictates the type of implant used. The distal humerus transitions from a cylindrical shape in the diaphyseal region to a wider fish-tail morphology distally with thinner cortices. Mid-diaphyseal fractures may therefore be amenable to a standard 3.5-mm or 4.5-mm plate, whereas more distal fractures may require 2 plates or an anatomically designed plate.\textsuperscript{6,8} The precontoured 3.5-mm posterolateral locking compression plate (LCP) (DePuy Synthes, West Chester, PA, USA) is designed to provide proximal diaphyseal as well as distal fixation for extra-articular middle- and distal-third humerus fractures.

The purpose of this study is to describe functional and radiographic outcomes, complication rates, and reoperations in a cohort of patients who underwent fixation of extra-articular distal-third humerus fracture by a triceps-reflecting technique, as described by Gerwin et al.\textsuperscript{3} and a single, posterolateral plate.

Materials and methods

A retrospective chart review was performed from the orthopaedic trauma databases of 2 level I academic institutions during a 5-year period (2008-2012). Both databases are maintained by residents trained in coding surgically treated fractures and entering data on the specifics of the operation, including implants used. The institutions’ databases were queried for all AO Foundation and Orthopaedic Trauma Association (AO/OTA) 12-A to 12-C and 13-A2 and 13-A3 fractures treated with a 3.5-mm posterolateral humeral LCP. Inclusion criteria were age $\geq$ 18 years, traumatic fractures of the humerus that were located within or extending into the distal third of the humerus (Fig. 1), use of a posterior triceps-reflecting surgical approach, and use of a 3.5-mm precontoured posterolateral distal humerus LCP. Exclusion criteria were age $<$ 18 years, fractures through a pathologic lesion, subjects with an incomplete or unavailable radiographic record, and subjects with follow-up $<$ 6 months.

Our initial search resulted in 51 patients. After application of inclusion and exclusion criteria, 40 patients were eligible for inclusion in our study. Eleven patients were excluded from the initial group because their humeral fractures were primarily diaphyseal without extension into the distal third of the humerus.

Patient demographics recorded were age, sex, and handedness. Injury details recorded included mechanism of injury, presence of a preoperative nerve palsy, and whether the fracture was open or closed. The pattern of the fracture was recorded as transverse or spiral oblique and noted to be simple or containing comminution. Comminution was defined as a fracture possessing 2 or more fracture fragments that were independent of the intact proximal...
and distal segments. Intraoperative records were reviewed for details of surgical exposure and technique as well as estimated blood loss. The medical record was reviewed for any intraoperative or postoperative complications (nonunion, infection, wound dehiscence, hardware complications). QuickDASH (including work and sports score) and visual analog scale (VAS) scores for pain, function, and quality of life were evaluated at final follow-up. In addition, satisfaction was assessed with the binary (yes/no) question, “Are you satisfied with the outcome of your surgery?” Inquiries were also made into recovery of any neurologic deficits (if present), presence of a painful scar, and any secondary procedures needed.

**Surgical technique**

The patient is placed in the lateral decubitus position. A beanbag or hip positioner is used to stabilize the body, and the injured extremity is placed over a radiolucent arm support.1

A longitudinal incision is made along the midline of the posterior arm and curves laterally around the olecranon. The incision is carried down sharply to the triceps fascia. A thick lateral skin flap is elevated, with care taken to avoid extensive medial dissection. Next, the posterior antebrachial cutaneous nerve is identified at the posterior aspect of the lateral intramuscular septum and traced proximally to the radial nerve. Once the radial nerve is identified, the intramuscular septum is divided distally to allow complete exposure of the nerve (Fig. 2). The triceps is bluntly reflected from the posterior humeral shaft and reflected medially for exposure of the fracture fragments. The median nerve and medial neurovascular bundle are not routinely explored.

A dental pick, pituitary rongeur, and low-pressure irrigation facilitate removal of organized hematoma from the fracture surfaces. The fracture is then reduced and held with point-to-point or “modified” clamps. Kirschner wires are placed out of the way of future interfragmentary screws and the plate to maintain reduction. If fracture surfaces can accommodate interfragmentary screws, 2.0-mm or 2.7-mm screws are placed in lag fashion. The near cortical surface must be countersunk before these screws are placed if the screw head will be on the posterior cortical surface of the humerus. Prominent screw heads will block proper placement of the posterolateral plate. If significant comminution is present, independent interfragmentary screws may not be possible or may be used only between fragments where an anatomic reduction is possible.

Fracture fixation is accomplished by application of the anatomically precontoured posterolateral LCP to the posterior surface of the humerus. The plate is side specific and contains locking/nonlocking combi-holes for the humeral shaft and a

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**Figure 2** (A) Intraoperative photograph demonstrating exposure of the posterior humeral surface through the triceps-reflecting approach. The Penrose drain identifies the radial nerve and takeoff of the posterior cutaneous branch. (B) Illustration of clinical photograph identifying exposure of the posterior aspect of the humerus after reflection of the triceps musculature (A). The relationship between the radial nerve (B), its posterior cutaneous branch (C), and the lateral intermuscular septum (D) are clearly seen.
tapered distal end with 5 fixed-angle locking holes oriented to optimize screw length into the capitellum and trochlea. The plate is placed on the posterior aspect of the humerus. Proximally, the plate should be centered on the diaphysis of the humerus. Distally, the curve of the plate is positioned against the cortical surface of the posterolateral distal humerus. The plate is then provisionally held to the bone with Kirschner wires placed through proximal and distal holes (Fig. 3). When significant comminution is present, the plate can be provisionally held to the intact proximal and distal humeral segments with clamps or wires and aid in maintaining humeral length, alignment, and rotation.

The plate is then secured to the bone with locking or non-locking screws. In the setting of comminution, locking screws can be placed in the desired positions with the plate provisionally held to bone with wires or provisional clamps. This allows the plate to serve as a fixed-angle bridge plate. When interfragmentary compression is achieved, the posterolateral humeral plate serves as a neutralization plate. Nonlocking screws can be placed first to compress the plate to the bone surface. Nonlocking or locking screws are then used at the surgeon’s preference in the intact proximal segment. Distal to the fracture, our preference is to fill every possible hole to maximize purchase in the distal humerus, a location of potentially poor bone quality (Fig. 4).7

The wound is thoroughly irrigated, and notation is made of the hole at which the radial nerve crosses the plate for later documentation in the operative report (Fig. 5). A drain is placed at the surgeon’s discretion and a layered closure is performed. Patients are placed in a soft dressing and an edema glove to control swelling in the hand. The patient is made non-weight bearing, and range of motion of the shoulder, elbow, wrist, and hand is started immediately. Weight bearing is advanced on the basis of evidence of fracture healing during follow-up.

Results

Our study group comprised 30 men and 10 women. The average age at time of surgical procedure was 36 years (range, 17-84 years). Twenty-two (55%) patients sustained an injury to their dominant arm. Thirteen (32.5%) fractures were open fractures. Thirty-five fractures (87.5%) were spiral oblique fractures; 5 (12.5%) were transverse in nature. Eighteen fractures (45%) exhibited comminution. Preoperatively, there were 17 radial (42.5%) and 3 median (7.5%) nerve palsies noted. No patient sustained a vascular injury related to the fracture.

Surgical fixation was performed by 1 of 4 fellowship-trained orthopaedic traumatologists involved in this study. Indications for distal humeral fixation with a triceps-reflecting approach and 3.5-mm posterolateral LCP were based on fracture characteristics and surgeon preference. Specifically, sufficient bone, both proximal and distal to the fracture, was needed for single-plate fixation. There were no intraoperative complications noted. Estimated blood loss was specifically recorded in the operative notes of 30 patients and averaged 350 mL. Clinical and radiographic data were available for all 40 patients. Average follow-up was 88 weeks (range, 26-176 weeks). In postoperative follow-up, no new nerve deficits were noted. Eight of 17 preoperative radial nerve palsies resolved completely. All median nerve preoperative palsies (3) persisted. Of 40 patients, 38 (95%) went on to union after the initial surgery. There were 8 patients (20%) who underwent a secondary procedure (2, nonunion; 2, débridement for osteomyelitis; 2, removal of retained ballistic material; 1, soft tissue rotational flap; 1, painful hardware). Four patients reported continued pain along the incision.

The average postoperative QuickDASH score was 17.5 (range, 2.6-56.8). Twenty-two patients answered the “work”
component of the outcome measure. The average score was 15.8 (range, 6.3-100). Twelve patients completed the “sports” component, and the average score was 13.6 (range, 0-100). The VAS scores for pain, function, and quality of life were 1.9 (range, 0-7), 2.3 (range, 0-8), and 1.6, (range 0-5), respectively. Thirty-five patients (87.5%) reported that they were satisfied with the outcome of surgery. Three of 5 unsatisfied patients reported persistent postoperative motor nerve palsy. Three of 5 unsatisfied patients also required a secondary procedure, and overall these 5 patients had worse QuickDASH and VAS scores (QuickDASH, 27.5; VAS pain, 5.0; VAS function, 5.4; VAS quality of life, 3.2).

Discussion

Although indications and techniques for operative management of humeral shaft fractures continue to evolve, few studies report functional outcomes and complication rates in surgically treated patients. These data are essential for the surgeon in the preoperative counseling of a patient with a humeral shaft fracture. This study demonstrates that operative fixation of extra-articular distal humerus fractures with a single, anatomically precontoured posterolateral plate can allow stable fracture fixation, early range of motion, and satisfactory clinical outcomes, despite a 20% reoperation rate in our study population.

This study specifically evaluated the use of a single, 3.5-mm posterolateral plate through a triceps-reflecting surgical approach. This is not a new concept as a single, modified 4.5-mm proximal tibia plate placed along the posterolateral surface of the humerus was described by Levy et al for fixation of extra-articular fractures. Dual plating is supported for these fractures, especially when significant comminution exists. In fact, recent biomechanical data indicate that 2 reconstruction plates in the treatment of an extra-articular distal humerus fracture create a stiffer construct compared with a single posterolateral locking plate. In a clinical study, Prasarn et al reported the use of a precontoured posterolateral distal humerus plate along with a supplemental 2.7-mm or 3.5-mm pelvic reconstruction plate along the lateral column of the humerus in 14 patients with extra-articular distal humerus fractures. Demineralized bone matrix was also used in 10 patients,

Figure 4  Final postoperative anteroposterior (A) and lateral (B) radiographs. Multiple independent interfragmentary lag screws are noted in addition to the plate.
and successful union was reported in all patients. The rate of successful union in our study was 95% without use of bone grafting and indicates that a single plate may be sufficient to allow rigid fixation, early range of motion, and reliable healing. In the absence of a higher complication rate, use of a single plate has substantial theoretical advantages, including less periosteal stripping, less muscle dissection, less blood loss, and shortened operative times.

A systematic review of radial nerve palsy associated with fractures of the humerus indicated that 23.6% of distal-third fractures were associated with a documented deficit. In a study of extra-articular distal humerus fractures, 22% of all patients and 57% of operatively managed patients reported a preoperative radial nerve palsy. Our findings that 50% of operatively treated patients reported a preoperative nerve palsy, the majority of which affected the radial nerve (85%), was consistent with what has been described in the literature. It was likely that the rate of nerve palsy in patients treated nonoperatively was lower than the 50% we observed in our cohort. Although the triceps-reflecting approach allowed identification and neurolysis of the radial nerve in all cases, only 45% of patients in our series demonstrated resolution of nerve deficits at final follow-up. In those patients with a median nerve deficit, exploration of the nerve was not routinely performed during initial fracture fixation; however, care was taken to ensure that the nerve was not entrapped within the fracture site during reduction and plate fixation. The majority of patients with residual motor nerve palsy did not report that they were unsatisfied after surgery. These findings probably reflect the high-energy nature of these injuries and underscore the importance of counseling patients that resolution of nerve palsy is unpredictable.

Patients should similarly be counseled about the risk for reoperation. Jawa et al reported a 15% reoperation rate in operatively treated distal humerus fractures. Other studies have reported a lower rate of reoperation after fixation of extra-articular distal humerus fractures in smaller series of patients. The overall rate of reoperation in our series (20%) probably reflected the high-energy nature of these injuries as well as the heterogeneity of our study population that included open and closed injuries, penetrating and blunt trauma, and variable levels of soft tissue injury. The reoperations for 2 patients were for reasons unrelated to their fracture or fixation (removal of ballistic material). All patients who returned to the operating room for nonunion (2), infection (2), or soft tissue coverage (1) sustained open or comminuted fractures. No patient in our series underwent a tendon transfer procedure during the defined study period. Such intervention would have increased the overall reoperation rate and may have affected the overall satisfaction and functional scores of those subjects.

Although to our knowledge this is the largest series of operatively treated extra-articular distal-third humerus fractures with clinical and radiographic follow-up, there are substantial weaknesses. Most significantly, this is a retrospective case series that lacks a comparative nonoperative or alternative surgical treatment group. As a result, our data are primarily hypothesis generating and do not establish a preferred treatment approach for these injuries. In addition, certain data parameters, such as strength, range of motion, and postoperative electromyography in nerve palsy patients, were unable to be evaluated.

**Conclusion**

This study reports outcomes in a consecutive series of extra-articular distal humerus fractures treated with a triceps-reflecting posterior exposure and an anatomically designed posterolateral distal humerus LCP. Stable fixation, reliable healing, and high patient-specific outcomes scores can be achieved with this surgical technique. Nerve palsy is a common complication after...
distal humerus fracture, and recovery is unpredictable after surgical treatment. In addition, it is important for surgeons to counsel patients about the possible need for reoperation.

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References