Treatment of humeral shaft fractures by external fixation

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Abstract

Forty patients with open shaft of humerus fractures were treated with a monolateral external fixator. Five patients presented with nerve palsies. Two radial nerves were disrupted and required reaper. Three spontaneously recovered and one brachial plexus partially improved. All fractures healed. The average duration of external fixation was 24 weeks. Four patients required additional procedures prior to healing (external fixator reapplication - 2, plating and bone grafting. Eight patients developed pin tract infections, which all resolved with local care and antibiotics.

The results of treatment of closed humeral shaft fractures are excellent using a variety of techniques including bracing1,19,20,23, hanging casts6,8,17, plate fixation2,7,8,17,22, and intramedullary nailing4,12,21. There is less data available on the best technique of skeletal stabilization and outcome of patients with open humeral shaft fractures. Although open fractures are included in large series of humeral shaft fractures, analysis of this subgroup is often not reported separately2,4,7,12,19,20,22,23.

The purpose of this study was to determine the outcome of open humeral shaft fractures treated by a uniform technique of monolateral external fixation.

introduction

Forty patients with open humeral shaft fractures were treated with external fixation between January 2006 and May of 2011, at the authors' hospitals. . External fixators were chosen for the higher energy fractures and those with more severe soft tissue wounds.

Thirty four males and six females sustained twenty five fractures of the right arm and fifteen fractures of the left arm. The average patient age was 27 years (range seven to 42 years). The mechanisms of injuries were RTA (15), shot gun wound (16) and fall (9). Four patients had other major fractures of the ipsilateral arm (open acromioclavicular fracture dislocation-one, both bone forearm fracture-two, ulna-one). Ten sustained multiple systems injuries. Five had one or more nerve palsies associated with the open humerus fracture (radial nerve three, median nerve - one, ulnar nerve - one, brachial plexus - one).

The associated soft tissue wounds were classified by the method of Gustilo et al. as type I (15), type II (9), type IIIA (7), type IIIB (6) and type IIIC (3)11. All wounds were treated with emergent irrigation and debridement. Intravenous antibiotics were started at the time of admission and continued until twenty four hours after wound closure. With the exception of the brachial plexus injury, all patients with evidence of neurologic injury had exploration of the nerves during wound management., radial nerve, which was treated during subsequent procedures with nerve reaper . All other nerves were found to be in continuity.

Twenty wounds were closed by primary suture. Eleven patients were returned to the operating room for at least one repeat debridement prior to

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wound closure by delayed primary suture, split thickness skin graft (seven). One open wound was allowed to heal by secondary intention. Three fractures were bone grafted at the time of wound closure. One had delayed bone grafting. The fixator was applied to the humerus at the time of initial irrigation and debridement at an average of ten hours after injury. One fixator was applied during the second irrigation and debridement, two days after the injury. Two patients had delayed fixator application (nine and eleven days after injury).

MATERIALS AND METHODS

A monolateral fixator was applied to tapered pins. The fixator bodies and pins (4.5 millimeter tapered) are the same size as those used for lower extremity applications. Fixators are applied with the patient supine and the arm on a radiolucent table extension. Fluoroscopic control is required for fracture reduction and pin insertion.

The distal pins are inserted through a small incision over the lateral supracondylar ridge. Direct visualization of the supracondylar ridge facilitates predrilling and subsequent pin insertion in the narrow distal humerus. After predrilling, the most distal pin is applied one cm above the olecranon fossa perpendicular to the axis of the humerus. A template is then applied to this pin which determines the location of the other pins. The second distal pin is applied in the three or four position in the distal template clamp. Use of this location assures that the distal pins will be distal to the radial nerve .The proximal two pins are applied through the proximal template clamp percutaneously through the posterior third of the deltoid. Drilling and screw insertion is done through sleeves after carefully spreading the deltoid muscle fibers. All pins are placed through two cortices.

The optimal position for distal pin insertion is in the lateral supracondylar ridge just above the olecranon fossa. The distal pin cluster will then be below the radial nerve.

The template is then removed and the fixator is applied to the pins. The humerus is then aligned by gentle axial traction and the reduction is confirmed fluoroscopically. Reduction is often assisted by direct visualization and occasionally manipulation of the fracture through the open wound. Examination of rotation of the shoulder is required to assure accurate rotational alignment of the arm. If the fracture pattern permits, a compression distraction apparatus is used to compress the fracture. Tight wraps are placed on the pins and the arm is supported in a sling.

Postoperatively elbow and shoulder range of motions are encouraged. Free use of the arm when necessary and weight bearing with crutches are permitted.

The charts and radiographs of all patients were retrospectively reviewed. Data collected included the number of days in the hospital, time to upper extremity weight bearing in patients requiring crutch use, time to clinical union, duration of external fixation, number of fractures requiring post fixation bracing, the range of motion of the elbow and shoulder, and the occurrence of any complications related to the fracture or fixator. Anteroposterior and lateral radiographs from the time of injury, post fixator application, at the time of fixator removal and at latest follow up were reviewed by all three investigators. Healing was defined as bridging callus on biplane radiographs. Angulation was measured both in the fixator and at

removal and was defined as greater than ten degrees of shaft angulation in any plane.
A questionnaire was used to assess the level of pain (mild, moderate or severe), functional limitations (mild, moderate or severe), work status and whether the patients were pleased or displeased with the outcome.

RESULTS

The number of hospital days averaged three (range one to seven days). Upper extremity weightbearing was required for crutch use in six patients with lower extremity injuries and was achieved at an average of sixteen days post injury (range 11 - 37 days). The average duration of external fixation was 20 weeks (range 12-32 weeks). Three limbs were protected after fixator removal with a Sarmiento brace.
The soft tissue wounds all healed. There were no infections. Eleven healed without further intervention other than replacement of a cracked fixator body in one patient. The average time to radiographic healing for these patients was 21 weeks (range 8-30 weeks)
Four patients required additional procedures prior to healing. Two patients experienced proximal pin breakage, one at 47 days and one at 44 days after placement of the fixator in both of these cases 4.5 millimeter and not six mm pins had been utilized. These are the only patients where the smaller pins had been used. Both were successfully treated, one with reapplication of the fixator and bone grafting and one with open reduction and plate fixation and bone grafting. Two patients were judged to be healed but developed recurrent motion after fixator removal at 60 and 80 days respectively. One was treated with fixator re-application and one was plated and bone grafted. Both healed after these procedures show fig (1).

The range of motion of the elbow was recorded both while in the fixator and after removal. While in the fixator, the average range of motion was from 20° of flexion to 104° flexion after the fixator was removed the average range of motion was from 8° flexion to 127° flexion. The only patient who did not achieve a functional arc of elbow motion (95° flexion) had distal intraarticular extension of his humeral fracture. Shoulder range of motion was at or near the contralateral shoulder range of motion in fourteen cases. One patient required shoulder manipulation under anesthesia to achieve full motion. The patient with brachial plexus palsy had a flail shoulder and restricted motion.
Twelve patients healed without angulatory deformity. Three patients had healed humeri with angulation measured greater than 10° (all apex anterior - 25°, 20° and 25°). All of these deformities were accepted at the time of fixator application, and none occurred during treatment.
Eight patients experienced pin tract infections. Three were treated with IV antibiotics during their initial hospitalization. The other five were treated as outpatients with oral antibiotics. All of these healed with local care and there were no cases of osteomyelitis secondary to pin infections show fig (2).
Thirteen patients were contacted, and completed the questionnaire at an average of 36 months after injury. Three patients reported having mild pain in their arm associated with increased activity. One patient reported moderate pain in the shoulder, which had required manipulation to increase range of motion. Another patient described moderate pain in the elbow, which occurred with weather changes.

The patients were asked whether they had functional limitations secondary to their arm injury. The patient with the brachial plexus palsy reported that he had functional limitation secondary to weakness. One patient described mild triceps and deltoid fatigue with overhead activity but denied specific limitations. One patient reported limitation in function and decreased elbow range of motion (5-95°). The patient requiring shoulder manipulation had mild functional limits with overhead activity and heavy lifting (eleven month follow-up) but reported continued improvement. Nine patients reported no functional limitations.

One patient reported displeasure with the outcome secondary to elbow range of motion, and one because of brachial plexus palsy .The eleven other patients were pleased with their outcomes show fig (3).

DISCUSSION

Humeral shaft fractures associated with severe open wounds present complex management problems. As with other open fractures, the management of the soft tissue injury is of primary importance. This should include emergent surgery for irrigation and expert debridement. We feel that delayed closure is safest, although the five cases closed primarily did not develop infectious complications. Free tissue transfer was not required for soft tissue coverage, which was always obtained with the use of local tissues. The humerus has circumferential muscle cover and slight shortening to assist in closure was tolerated without obvious adverse functional outcome.

Nerve palsy frequently complicates open humeral shaft fractures seven of the forty arms (17%) had neurologic deficits. Two of the seven radial nerve injuries had complete anatomic disruption. Although this is lower than the 64%, anatomic radial disruption associated with open humeral fractures reported by Foster et al.10, we agree with their recommendations that radial nerve injuries associated with open humeral fractures should be explored. These patients require surgery for irrigation and debridement. The additional time and effort for nerve exploration during wound debridement is warranted based on the significant chance of anatomic disruption.

At an average follow-up of 63 months, these patients reported only relatively mild residual problems with their arm. Although the amount of soft tissue damage was extensive, only three reported functional deficits and only four had pain in either the elbow, arm or shoulder. Most were able to return to work.

The optimal choice for skeletal stabilization for open humeral shaft fractures is not well defined in the literature. Union rates are high with functional bracing19,20,23, but severe open fractures are less suited to this method. Zagorski et al.23, reported on a subgroup of open fractures treated with bracing, but noted that severe soft tissue injury or bone loss were contraindications.

A plate can often be applied to an open humeral fracture through the wound with little additional stripping. Vander Griend et al.22, reported on thirteen open fractures treated with plating, all of which united within one year. However, the severity of the grade of the open wounds was not described or classified. Two of those patients had superficial wound infections. Bell et al.2, included 14 open fractures among a larger group treated with plating, but most were low grade wounds and the results in this group were not specified. Brumback et al.4 and Hall et al.12 reported on eleven and twenty-eight open fractures treated with IM rodding, but most were low grade wounds secondary to hand guns, and the results in these subgroups were not specified. Stern et al.21 reported that delayed and nonunion occurred in 33% of the open fractures in their humeral rodding study.

There is little data available on open fractures of the humerus treated by external fixation and the results have varied. Browner et al.3, reported good results with the use of Hoffman external fixation in 20 complex humerus fractures. Included in this group were 13 Grade III open fractures and three closed fractures with vascular injuries. In this severe group of open fractures, seventeen united.

Smith and Cooney18, reported that six of nine high energy humerus fractures treated with external fixation achieved a good to excellent result. However, they had significant complications which included delayed union in five, pin loosening in two and chronic osteomyelitis in one.

Humeral external fixation was well tolerated in our patients. When required upper extremity weightbearing was achieved with the fixator in place. Fixators were not removed early for pin tract problems or pain. Pin tracts caused no long-term complications. Shoulders and elbows were actively moved in the post operative period. We observed only modest reduction in range of motion while the fixator was in place, and little evidence of long term joint impairment.

All of our patients healed, but significant complications occurred in four of fifteen prior to healing. Although this is a high incidence; this method was selected for only the most severe fractures, making it hard to make valid comparisons with other methods of skeletal stabilization. External fixator pins broke proximally, causing two of these complications. In both cases, the pins were small diameter (4.5 mm/3.5 mm tapered) usually recommended for forearm applications. We have not seen pins similar in size to those utilized in the lower extremity (6 mm/5 mm tapered) break, and recommend that this size pin be used for all adult humeral applications. This technical error compromised the overall results in this series.

In summary, monolateral external fixation is easily applied remote from the fracture site. It provides rigid fixation, for early joint mobilization and weight bearing, and there is good access to the wound. There were no wound infections. Patients tolerated the humeral fixator remarkably well. For these reasons we have continued to use external fixation for the most severe open fractures of the humerus.

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Fig 1

Fig 2

Fig 3