External Fixation for Displaced 2-part Proximal Humeral Fractures

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abstract

Studies have reported conflicting results regarding external fixation for displaced proximal humeral fractures. Compared with open reduction and internal fixation, external fixation for displaced proximal humeral fractures avoids dissection and soft tissue stripping and leads to higher union rates, a lower incidence of avascular necrosis, less scarring of the scapulohumeral interface, and faster rehabilitation. Some authors have reported good or excellent results and minimum complications compared with open reduction and internal fixation; however, others have reported that external fixation does not ensure acceptable reduction and fracture stability, especially in patients with osteoporosis.

This article describes 18 patients with displaced 2-part fractures of the surgical neck of the humerus treated with closed reduction and external fixation using the Tension Guide Fixator (Gexfix SA, Carouge, Switzerland) external fixation system between 2010 and 2011. The patients included 14 women and 4 men with a mean age of 39 years. Mean follow-up was 18 months (range, 15-24 months). Fracture union; function using the Constant score, University of California Los Angeles score, Oxford score, and Quick Disabilities of the Arm, Shoulder and Hand shoulder score; and complications were evaluated. All patients experienced fracture union at a mean of 11 weeks (range, 9-13 weeks). The Tension Guide Fixator was removed without anesthesia at the outpatient clinic at a mean of 6 weeks (range, 4-8 weeks) with no loss of reduction or secondary displacement after removal. At 1-year follow-up, mean Constant and University of California Los Angeles scores were excellent, mean Oxford score showed satisfactory joint function, and mean Quick Disabilities of the Arm, Shoulder and Hand score showed minimal pain with no disability.

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Figure: Fluoroscopic images showing fracture reduction and introduction of 2 Kirschner wires from a superior entry point into the medullary canal (A) and insertion of the 2 half-pins in the humeral diaphysis (B).
Proximal humeral fractures account for 4% to 5% of all fractures; elderly women with osteoporosis are more commonly affected. The majority (85%) of these fractures show minimal or no displacement and can be treated successfully with conservative treatment and early mobilization. In contrast, conservative treatment of displaced proximal humeral fractures often results in malunion and poor shoulder function. In these patients, surgical treatment is recommended.

The widely accepted treatment of severely comminuted intra-articular proximal humeral fractures is hemiarthroplasty or total shoulder arthroplasty. However, the management of 2- and 3-part displaced fractures, especially in young patients, is still debated. Several surgical treatment options, such as closed reduction and percutaneous (external) fixation, open reduction and internal fixation with a variety of constructs, intramedullary proximal humeral nailing, and shoulder arthroplasty, have been used with relatively good outcomes.

Few studies have reported external fixation for displaced proximal humeral fractures. Compared with open reduction and internal fixation, external fixation techniques for displaced proximal humeral fractures avoid dissection and stripping of the soft tissue, leading to higher union rates, a lower incidence of avascular necrosis, less scarring of the scapulohumeral interface, and faster rehabilitation. However, reports conflict regarding external fixation for these fractures. Some authors reported good or excellent results and minimum complications compared with open reduction and internal fixation, whereas other authors reported that external fixation is technically demanding, is applicable mainly in 2-part humeral head fractures, and does not ensure acceptable reduction and fracture stability, especially in patients with osteoporosis.

Therefore, to address these conflicting reports, the authors studied a selected cohort of patients with displaced 2-part proximal humeral fractures treated with closed reduction and external fixation. The rationale was that closed reduction and external fixation for displaced proximal humeral fractures can be performed easily and safely, with satisfactory clinical results and minimum complications.

**Materials and Methods**

A series of 18 consecutive patients with displaced 2-part fractures of the surgical neck of the humerus were treated with closed reduction and external fixation using the Tension Guide Fixator (Gexfix SA, Carouge, Switzerland) external fixation system between January 2010 and January 2011. The study cohort comprised 14 women and 4 men with a mean age of 39 years (range, 20-75 years). The mechanism of injury for all patients was a fall from a standing or walking position. Mean follow-up was 18 months (range, 15-24 months); no patient was lost to follow-up. All patients gave written consent to be included in the study after being informed about the benefits of external fixation, including a less-invasive surgical technique and minimal dissection and stripping of soft tissue, and the possible complications of external fixation, including loss of reduction, pin migration, pin-track infection, and discomfort in the course of treatment.

This study was approved by the institutional review board and ethics committee of the authors’ institution.

Fractures were classified according to Neer’s classification, which includes 2-, 3-, and 4-part fractures and fracture-dislocations, including head-splitting fractures. One fragment or part is the humeral shaft, so the simplest displaced fracture is the 2-part fracture. According to Neer, displacement of a fracture fragment by more than 1 cm or angulation of greater than 45° is considered significant; in these cases, surgery is necessary to preserve shoulder function. All patients in the current series had displaced fractures of the surgical neck of the humerus.

Indications for external fixation included displaced 2-part fractures of the surgical neck of the humerus excluding isolated fractures of the tuberosities, and skeletal maturity of the patients. Contraindications included nondisplaced or 3- or 4-part proximal humeral fractures, comminution at the fracture site or a large medial calcar that may preclude stable closed reduction, pathological fractures, skeletal immaturity, and smoking habits of the patients. Although an open proximal humeral fracture was not considered a contraindication for external fixation, all patients in this series had closed fractures. Within the study period, 54 patients presented to the authors’ institution with proximal humeral fractures. Twenty-one patients had nondisplaced or angulated tuberosity fractures and underwent conservative treatment. Thirteen patients had 3- or 4-part proximal humeral fractures; these patients underwent open reduction and internal fixation (8 patients) or shoulder hemiarthroplasty (5 patients). Two patients had pathological proximal humeral fractures and were treated with proximal humeral resection and megaprosthetic reconstruction after staging. None of these abovementioned patients were included in this study. The remaining 18 patients had displaced 2-part fractures of the surgical neck of the humerus; these patients were treated with external fixation and were included in this study.

**Surgical Technique**

The Tension Guide Fixator for proximal humeral fractures is based on 2 Kirschner wires placed under tension and stabilized by 1 pin into the humeral diaphysis, connected by a single “L” body (Figure 1). All surgeries were performed with the patients under general anesthesia in the supine position. Using fluoroscopy, the goal was closed reduction of the 2-part fracture with intraoperative manipulation; reduction was considered anatomical or acceptable if displacement less than 1 cm and angulation less than 45° was achieved. Fifteen patients obtained anatomical or acceptable closed

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reduction of their fracture. In these patients, after fracture reduction, a Kirschner wire was introduced to the head fragment from a superior entry point (upper lateral part of the humeral head) with caution to avoid the articular cartilage and advanced into the medullary canal. Then, a second Kirschner wire was introduced parallel to the first in a similar pattern (Figures 2A, B). With the fracture reduced and temporarily stabilized with the 2 Kirschner wires, 2 half-pins with continuous threads were drilled into the humeral diaphysis. The Kirschner wires were tensioned and connected to the “L” body and the half-pins (Figures 2C, D). In 3 patients in which closed reduction with manipulation was not possible, reduction was achieved by introducing the first Kirschner wire to the head fragment and then using it as a joystick to assist reduction of the fracture. Using this technique, anatomical or acceptable reduction of the fracture was obtained in all 3 patients.

The position and stability of the final construct was tested in full range of motion of the shoulder joint under fluoroscopy. The Kirschner and half-pin sites were covered with sterile gauze, and the arm was immobilized in a sling. Mean operative time was 45 minutes (range, 30-90 minutes).

Postoperative rehabilitation included pendulum, passive, and active-assisted range of motion exercises of the shoulder as tolerated. All patients were discharged within 2 to 4 days (mean, 3 days) with instructions for continuous physical therapy and daily care of the pin sites.

Routine follow-up, including clinical examination and radiographs of the shoulder and proximal humerus, was performed every 4 weeks for the first 2 months, every 2 months for the next 6 months, and then annually thereafter. Clinical examination included assessment of pain and pin sites for pin-track infection, and evaluation of the Constant score (pain, function, range of motion, and strength), University of California Los Angeles (UCLA) score (pain, function, active and strength of forward flexion, and patient satisfaction), Oxford score (pain and function in activities of daily living), and Quick Disabilities of the Arm, Shoulder and Hand (DASH) shoulder score (pain and ability in activities of daily living and sports). Radiographic examination included evaluation of fracture union as documented by trabeculation across the fracture site or callus bridging in 3 of the 4 cortices. Complications were recorded.

RESULTS

All patients experienced fracture union at a mean of 11 weeks (range, 9-13 weeks).
The Tension Guide Fixator was removed without anesthesia in the outpatient clinic at a mean of 6 weeks (range, 4–8 weeks) with no loss of reduction or secondary displacement after removal. At 1-year follow-up, mean Constant score was excellent (mean, 93 points; range, 87–98 points), mean UCLA score was excellent (mean, 31.7 points; range, 24–35 points), mean Oxford score showed satisfactory joint function (mean, 43.2 points; range, 35–48 points), and mean Quick DASH score showed minimal pain with no disability (mean, 5.3 points; range, 0–27.3 points).

One patient experienced a pin-tract infection 3 weeks after treatment that was successfully treated with oral antibiotics, dressing changes, and Tension Guide Fixator removal 1 week later (Table). Mechanical failure or migration of the Kirschner wires or half-pins was not observed; no patient experienced avascular necrosis of the humeral head.

**DISCUSSION**

Open reduction and internal fixation of displaced proximal humeral fractures usually requires an extensive surgical approach that risks the already compromised vascular supply of the fracture fragments, increasing the risk of avascular necrosis of the humeral head and pseudarthrosis. Using an external fixator, such as the Tension Guide Fixator system, more invasive traditional methods can be avoided; thus, dissection and stripping of the soft tissue is minimized, union rates increase,

![Figure 3: Anteroposterior radiograph at 1-year follow-up showing fracture union.](image)

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*Abbreviations: DASH, Disabilities of the Arm, Shoulder and Hand; TGF, Tension Guide Fixator; UCLA, University of California Los Angeles.
acGexfix SA, Carouge, Switzerland.
baAt 1-year follow-up.
cPatient experienced a pin-tract infection.
avascular necrosis and scarring of the scapulohumeral interface are reduced, and rehabilitation improves.\textsuperscript{16,17,20-23} However, external fixation for proximal humeral fractures can be technically demanding, and the fracture reduction and stability that can be achieved may be compromised, especially in patients with osteoporosis.\textsuperscript{5,17,19} In the current series, the authors used external fixation for displaced fractures of the surgical neck of the humerus using the Tension Guide Fixator system. The results show that the system allows treatment of the fracture in a simple, quick, and efficient way and permits rapid mobilization of the arm, ensuring rapid union and functional recovery.

This study had 3 important limitations. First, the number of the patients was small and the follow-up was relatively short. However, to the best of the authors’ knowledge, the Tension Guide Fixator system has not been previously evaluated in a cohort of patients. In addition, the authors believe that 1-year follow-up is sufficient for the evaluation of shoulder function after proximal humeral fractures, and the use of 4 scores to evaluate the patients increases the power of the analysis regarding shoulder function.

Second, a control group of patients with similar fractures who had another type of treatment was not included. However, the management of these fractures is controversial.\textsuperscript{23} Many management options have been reported based on various factors, such as fracture pattern, associated injuries, patient age and activity level, bone quality, and surgeon preference. In this setting, summarizing the results and performing a comparative study is difficult.

Third, only displaced 2-part fractures of the surgical neck of the humerus were included, and isolated tuberosity fractures and other types of proximal humeral fractures were excluded. The authors acknowledge that this technique is applicable mainly in 2-part fractures; however, they believe that 50\% or more displacement of these fractures in active, healthy individuals is an indication for operative treatment.\textsuperscript{25} Provided that the fractures can be reduced by closed manipulation, these fractures are an ideal indication for external fixation. Even if closed reduction is not possible, which was not the case in any of the patients in the current series, a limited open reduction can be performed, and external fixation can also be effective.\textsuperscript{25}

Finally, the remaining types of proximal humeral fractures, including 2-part isolated tuberosity fractures and 3- and 4-part fractures, should be treated conservatively or with open reduction and internal fixation.

Open reduction and internal fixation has been the treatment of choice for displaced 2- and 3-part proximal humeral fractures, whereas hemiarthroplasty or total shoulder arthroplasty is the treatment of choice for displaced 4-part fractures.\textsuperscript{10,17,23,30} Although internal fixation offers satisfactory reduction and stability, the risk of damage to the blood supply of the humeral head, avascular necrosis, and infection is high.\textsuperscript{31} To avoid this risk, closed reduction with manipulation and external fixation has been reported with good or excellent functional results in 73\% to 80\% of patients.\textsuperscript{20-23}

The major disadvantages of closed treatment methods for proximal humeral fractures are poor reduction, instability leading to secondary fracture displacement, and prolonged rehabilitation.\textsuperscript{23,32,33} Complications, including loss of reduction, pin migration, and pin-tract infection, have been reported.\textsuperscript{8,16,34} Patient discomfort and morbidity in the course of treatment should not be underestimated.

**Conclusion**

This study describes the use of the Tension Guide Fixator system for the closed management of displaced 2-part proximal humeral fractures. The results show that this technique allows for fast and safe reduction, stable fixation, and early mobilization with minimal complications. The percutaneous insertion of 2 Kirschner wires from the upper lateral part of the humeral head through the medullary canal minimizes complications associated with other external fixation systems.\textsuperscript{20-23,33} Including injury to the axillary and musculocutaneous nerves, cephalic vein, tendon of the long head of the biceps brachii muscle, and articular cartilage of the humeral head. Using 4 functional scores for the shoulder, the results were good or excellent in the majority of patients.

**References**


