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Minimally invasive plate osteosynthesis for proximal humeral fractures: clinical and radiologic outcomes according to fracture type

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Background: This study evaluated the clinical and radiologic outcomes, according to fracture type, of proximal humeral fractures treated by the minimally invasive plate osteosynthesis (MIPO) technique.
Materials and methods: Of 85 patients with proximal humeral fractures who were treated by the MIPO technique, 62 were evaluated: 27 with 2-part fractures, 24 with 3-part fractures, and 11 with 4-part fractures. An additional inferomedial screw or fibular allograft was used when severe medial cortical comminution was found in the proximal humerus. Clinical and radiographic outcomes were evaluated during the follow-up of 37 months.
Results: There was a significant difference in the Constant scores of patients with 4-part fractures compared with those with 3-part fractures ($P = .039$). The neck-shaft angle in 4-part fractures (121° ± 3°) at final follow-up was significantly lower compared with other fracture types (2-part: 129° ± 9°, $P = .036$; 3-part: 129° ± 2°, $P = .031$). Complication rates (72.7%) of 4-part fractures were significantly higher than with other fracture types (2-part, 7.4%; 3-part, 20.8%; $P = .001$). Sixteen fractures were fixed with an additional inferomedial screw, and 3 patients had insertion of a fibular allograft.
Conclusion: Satisfactory clinical and radiologic outcomes were obtained by the MIPO technique in proximal humeral fractures. In addition, medial cortical support can be performed with an inferomedial screw or fibular allograft in the MIPO technique. However, the MIPO technique for 4-part fractures showed relatively inferior outcomes compared with 2- and 3-part fractures. Conversion to open plating is also considered if adequate reduction, that is, a neck-shaft angle >120°, is not able to be obtained in the MIPO technique for 4-part fractures of the proximal humerus.
Level of evidence: Level IV, Case Series, Treatment Study.

Keywords: MIPO; proximal humeral fractures; fracture type; outcomes

The Institutional Review Board of National Medical Center approved this study (IRB No. H-1302/027-002), and informed consent was obtained from all participants.

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Various methods of surgical treatment for displaced proximal humeral fractures have been introduced, including external fixation, percutaneous K-wire fixation, open plating, and intramedullary nailing.[1,2,4,5] Among them, open plate fixation of proximal humeral fractures has shown rapid improvement in clinical outcomes with the

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development of the angular stable plate. However, open reduction and plating through the traditional deltopectoral approach may lead to several concerns, including nonunion from extensive soft tissue stripping, deltoid muscle injury, and devastating infection.

The minimally invasive plate osteosynthesis (MIPO) technique was developed to achieve biologic fixation and to minimize complications of open reduction. The incision of MIPO is made at a sufficiently remote area away from the fracture site to preserve the periosteum around the fracture area for indirect bone healing, thereby obtaining higher rates of union, a lower infection risk, and a decreased need for bone graft.[8] Although MIPO has been applied for the purpose of fixation of lower extremity fractures,[11,12] the application of the MIPO technique has recently been extended to proximal humeral fractures as an alternative to open reduction and internal fixation.[10,18-21] Furthermore, the MIPO technique has also improved with the development of the angular stable plate.

Overall functional outcomes after open locking plate fixation are dependent on the type of proximal humeral fracture. Whereas satisfactory outcomes can be achieved in displaced 2- or 3-part fractures, outcomes are less satisfactory in 4-part fractures on the basis of the Neer classification.[24] Although several studies have reported excellent clinical results after the MIPO technique in the treatment of proximal humeral fractures,[10,18-21] few studies have analyzed the clinical and radiologic outcomes according to the fracture pattern in patients with proximal humeral fractures treated with the MIPO technique.[21]

The purpose of this study was to evaluate functional results and to analyze the clinical and radiologic outcomes according to the type of fracture in patients with proximal humeral fractures treated with the MIPO technique.

Materials and methods

This is a retrospective case series of patients with proximal humeral fractures treated with the MIPO technique from March 2009 to July 2011. Of 85 consecutive patients with displaced proximal humeral fractures, 23 were lost to follow-up within 2 years after operation because of relocation, death, severe medical conditions, or refusal to be included in the study. Finally, 62 patients were evaluated (follow-up rate of 73%). The mean follow-up period was 37 months (range, 24-53 months).

The inclusion criteria of this study were 2-part surgical neck fractures with more than 1 cm of displacement or more than 45° of angulation and displaced 3- and 4-part proximal humeral fractures. Minimally displaced fractures of the proximal humerus, combined peripheral nerve injury, pathologic fractures, and open fractures were excluded from this study. There were 23 men and 39 women with an average age of 57 years (range, 29-85 years). The dominant shoulder was involved in 25 patients. All patients underwent surgery within 2 weeks of injury, with a mean time from injury to operation of 2 days (range, 1-8 days). Five patients had associated injuries: 1 with an olecranon fracture, 1 with a femoral shaft fracture, and 3 with multiple rib fractures. All the fractures were classified according to the Neer classification: 27 patients had 2-part fractures (44%), 24 had 3-part fractures (39%), and 11 had 4-part fractures (17%). In all patients, the 3.5-mm proximal humerus anatomic locking plate (PHILOS; Synthes, Paoli, PA, USA) was used.

Clinical outcomes were assessed at the final follow-up visit by the active range of motion of the shoulder joint and the Constant score.[6] Shoulder stiffness was considered as limitation of both active and passive motions in at least 2 directions (forward flexion <120° or 50% restriction of contralateral external rotation and internal rotation).[22] Patient satisfaction of the operation was evaluated by a visual analog scale.

Radiographic evaluations were performed routinely at 2 weeks, 1 month, and 2 months postoperatively and every 2 months thereafter until union was obtained. Nonunion was defined as no progression of radiographic healing during the 3-month period. The neck-shaft angle was measured on an anteroposterior radiograph with 20° of external rotation immediately after operation and at final follow-up to obtain the exact value.[16] Varus collapse, defined as the neck-shaft angle measured on the postoperative radiograph, was decreased to <120° on follow-up radiographs. Malreduction was defined as the neck-shaft angle <120° measured on immediate postoperative radiographs. Operating time was defined as the time from the skin incision to closure.

The outcomes of this study were recorded and evaluated with the statistical software SPSS version 17.0 (SPSS Inc, Chicago, IL, USA). Descriptive evaluation was performed on the basis of the mean and standard error as well as percentage. Age, interval to operation, operation time, and Constant scores were reported as median and range because numbers were shown on a rank sum scale. The Kruskal-Wallis test was used to compare non-normally distributed data among the 3 groups. The Mann-Whitney U test for parametric data and Fisher exact test for nonparametric pair comparisons were used to identify significant differences. P values of <.05 were considered significant.

Surgical techniques

The supine position was preferred with the injured extremity draped free, as posterior angulation or sagging could occur without support underneath the injured arm during the surgery in the beach chair position. Under an image intensifier, closed reduction was attempted with a longitudinal and a varus or valgus (varus force was necessary in most cases) force to the humeral shaft. The proximal skin incision started from the anterolateral corner of the acromion and extended approximately 4 cm distally. After the skin incision, the fiber of the deltoid muscle was split along the anterior raphe. The subdeltoid bursa was also dissected and used to create a protection sleeve for the axillary nerve. In the case of a fragmentation of the greater tuberosity, a nonabsorbable suture was sutured on the bone and rotator cuff tendon junction for mobilization and reduction. A 2.4-mm Kirschner wire was inserted into the humeral head to manipulate the proximal part of the humerus for anatomic reduction. After reduction of the greater tuberosity fragment, two or three 1.6-mm Kirschner wires were inserted for temporary fixation. Kirschner wires were placed so as not to disturb the plate position.

The axillary nerve, which traverses in the posterior to anterior direction under the deltoid muscle, could be palpated blindly by the index finger approximately 2 to 3 cm below the inferior