Minimally invasive plate osteosynthesis for proximal humeral fractures

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ABSTRACT

Purpose. To report the outcome after minimally invasive plate osteosynthesis (MIPO) through the deltoid-splitting approach for proximal humeral fractures.

Methods. 10 men and 30 women aged 37 to 88 years underwent MIPO through the deltoid-splitting approach using the Proximal Humerus Internal Locking System or the Locking Proximal Humerus Plate for 2-part (n=18), 3-part (n=20), and 4-part (n=2) proximal humeral fractures. The rehabilitation protocol was standardised.

Results. All 40 patients were followed up at 3 months, 34 (85%) at 6 months, 30 (75%) at one year, and 13 (33%) at 2 years. Two patients had malunion. No patient had avascular necrosis, infection, nerve palsy, or nonunion. The mean Constant score at one year and 2 years was 75 and 87.5, respectively. The Constant score at 6 months correlated to that at one year ($r=0.926$, $p<0.0001$) and at 2 years ($r=0.874$, $p=0.0001$). In younger patients, improvement in the range of motion was faster. The early plateau group (those with no further improvement after 6 months) and the late plateau group (those with no further improvement after one year) did not differ significantly in age, fracture grade, or hand dominance.

Conclusion. MIPO for fixation of proximal humeral fractures using a locking plate is safe and effective in enabling an early return of shoulder function.

Key words: humeral fractures; treatment outcome

INTRODUCTION

Proximal humeral fractures account for 5% to 9% of all fractures and 45% of all humeral fractures.1 Non-operative treatment is preferred for elderly patients, patients with major comorbidities, and for minimally displaced fractures. Open reduction and internal fixation is indicated when the greater tuberosity fragment displacement is >5 mm, the shaft fragment displacement is >20 mm, or the head-fragment angulation is >45°. Fixation implants
include conventional plates, intramedullary nails, Kirschner wires, and screws. Minimally invasive plate osteosynthesis (MIPO) through the deltoid-splitting approach requires less soft tissue retraction and periosteal stripping, and enables better preservation of the blood supply and more direct visualisation of the greater tuberosity fragment. This study reports the outcome after MIPO through the deltoid-splitting approach for proximal humeral fractures.

MATERIALS AND METHODS

Between January 2009 to December 2011, 10 men and 30 women aged 37 to 88 (mean, 63; standard deviation [SD], 13.2) years underwent MIPO through the deltoid-splitting approach using the Proximal Humerus Internal Locking System (PHILOS) or the Locking Proximal Humerus Plate from Synthes for 2-part (n=18), 3-part (n=20), and 4-part (n=2) proximal humeral fractures. Of the patients, 4 were manual workers, 24 were clerical workers, and 12 were unemployed or retired. Three patients sustained their injury while at work. 25 patients injured the dominant side. Patients with minimally displaced fractures, pathological fractures, multiple fractures, pre-existing neuromuscular disorders, or concomitant neurological injury were excluded.

Surgery was undertaken with the patients placed in a beach chair position. An incision was made through the deltoid-splitting approach not extending beyond 5 cm distal from the anterolateral corner of the acromion, to avoid injury to the traversing axillary nerve. All fractures were reduced using a C-arm image intensifier. Fractures were held temporarily with Kirschner wires and then fixed with the PHILOS or the Locking Proximal Humerus Plate. Distal screws were locked using the MIPO technique through additional stab wounds. The greater and lesser tuberosity fragments were reduced with heavy braided sutures placed through the rotator cuff insertion and tied to anchor holes on the locking plate. The chief surgeon decided the length of the plate, and whether additional compression screws were required. All wounds were closed in layers over a deep drain with vicryl sutures and monocryl subcuticular sutures. A shoulder immobiliser was given until discharge.

Postoperatively, patients were discharged after 3 days unless there were complications. Immediate pendulum exercises and gentle passive and assisted active range of motion exercise under supervision were allowed. More strenuous exercises were allowed after fracture union.

Outcome measures included abduction and flexion, the Constant score, the shortened Disabilities of the Arm, Shoulder and Hand (QuickDASH) score, and the Shoulder Pain and Disability Index (SPADI). Scores between and within groups were compared using the independent \( t \) test and paired \( t \) test, respectively. Fracture classification and occupations were compared using one-way ANOVA. Scores at early and later rehabilitation were compared using Pearson correlations to determine the predictive power of early outcome to final outcome.

RESULTS

All 40 patients were followed up at 3 months, 34 (85%) at 6 months, 30 (75%) at one year, and 13 (33%) at 2 years (Table 1). Two patients had malunion: one had loss of fixation with screw perforation at 6 weeks, and another had loss of fixation and varus collapse at the fracture site (Fig.). Both declined revision surgery. No patient had avascular necrosis, infection, nerve palsy, or nonunion.

Using the paired \( t \) test, all outcome measures improved from 6 months to one year: mean abduction from 117.5º to 132.7º (\( p=0.0012 \)), mean flexion from

<table>
<thead>
<tr>
<th>Mean±SD (range)</th>
<th>3 months (n=40)</th>
<th>6 months (n=34)</th>
<th>12 months (n=30)</th>
<th>24 months (n=13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abduction</td>
<td>92.5±29.1º (5º–150º)</td>
<td>117.5º±32.4º (30º–170º)</td>
<td>132.7º±29.7º (55º–180º)</td>
<td>143.5º±31.3º (60º–180º)</td>
</tr>
<tr>
<td>Flexion</td>
<td>98.2±23.9º (5º–145º)</td>
<td>114.9º±24.4º (40º–155º)</td>
<td>126.1º±24.4º (60º–160º)</td>
<td>139.2º±30.0º (60º–160º)</td>
</tr>
<tr>
<td>Constant score</td>
<td>51.9±14.5 (20–83)</td>
<td>69.9±15.7 (26–98)</td>
<td>75.0±14.6 (33.5–91)</td>
<td>87.5±8.0 (74.6–95)</td>
</tr>
<tr>
<td>Shortened Disabilities of the Arm, Shoulder and Hand score</td>
<td>28.0±20.2 (0–70)</td>
<td>16.1±15.9 (0–67.5)</td>
<td>11.7±16.4 (0–77.3)</td>
<td>8.1±18.7 (0–54.5)</td>
</tr>
<tr>
<td>Shoulder Pain and Disability Index</td>
<td>30.8±23.7 (1.5–73)</td>
<td>21.7±23.3 (0–80.7)</td>
<td>12.6±19.0 (0–59)</td>
<td>8.8±15.8 (0–40.8)</td>
</tr>
</tbody>
</table>
114.9° to 126.1° (p=0.0002), mean Constant score from 69.9 to 75.0 (p=0.003), mean QuickDASH score from 16.1 to 11.7 (p=0.0198), and mean SPADI from 21.7 vs. 12.6 (p=0.146). Comparisons of scores between 3 months and 6 months were not made, because scores before 6 months were uniformly low.

Using the Pearson correlation, the Constant score at 6 months correlated to that at one year (r=0.926, p<0.0001) and at 2 years (r=0.874, p=0.0001), indicating high correlation between 6-month and one-year scores.

Using the independent t-test, the Constant score at one year was not associated with age (cut-off at 65 years), sex, or injury at work. Using one-way ANOVA, the Constant score was not associated with fracture classification or type of occupation. In younger patients, improvement in the range of motion was faster. In terms of the Constant score, the early plateau group (those with no further improvement after 6 months) and the late plateau group (those with no further improvement after one year) did not differ significantly in age, fracture grade, or hand dominance.

**DISCUSSION**

Studies of MIPO through the deltoid-splitting approach using a locking plate for proximal humeral fractures have been reported (Table 2).2-5 The locking

**Table 2**

<table>
<thead>
<tr>
<th>Study</th>
<th>No. of patients</th>
<th>One-year follow-up rate (%)</th>
<th>Safe zone used (cm)</th>
<th>Implant used</th>
<th>Avascular necrosis rate (%)</th>
<th>Implant-related complication rate (%)</th>
<th>Nerve injury</th>
<th>Mean Constant score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lau et al.,2 2007</td>
<td>17</td>
<td>59</td>
<td>5</td>
<td>Metaphyseal locking compression plate</td>
<td>0</td>
<td>5.9</td>
<td>0</td>
<td>76.8 (6 months)</td>
</tr>
<tr>
<td>Laflamme et al.,3 2008</td>
<td>34</td>
<td>79</td>
<td>4</td>
<td>Proximal humerus internal locking system</td>
<td>0</td>
<td>5.9</td>
<td>0</td>
<td>79.0 (12 months)</td>
</tr>
<tr>
<td>Roderer et al.,4 2010</td>
<td>54</td>
<td>100</td>
<td>-</td>
<td>Non-contact bridging</td>
<td>5.6</td>
<td>17.0</td>
<td>0</td>
<td>66.8 (17 months)</td>
</tr>
<tr>
<td>Acklin et al.,5 2013</td>
<td>124</td>
<td>78</td>
<td>6</td>
<td>Proximal humerus internal locking system</td>
<td>8.2</td>
<td>7.2</td>
<td>0</td>
<td>75.0 (18 months)</td>
</tr>
</tbody>
</table>

**Figure** Radiographs showing (a) suboptimal fracture reduction after surgery, (b) loss of fixation and secondary screw perforation at 6 weeks, and (c) early varus collapse but eventually healed fracture at 3 months without screw cut-out.
plate enables rigid fixation, even in osteoporotic bone, to allow early mobilisation and results in a low mechanical failure rate. It increases torsional stiffness and fatigue resistance, and stability. The traditional deltopectoral approach requires extensive soft tissue retraction and stripping of the anterior circumflex humeral artery (which is the primary blood supply to the humeral head), and does not facilitate exposure of the greater tuberosity. Distraction forces of the retractor may result in malalignment in reduction. MIPO eliminates the need for extensive periosteal stripping and preserves the blood supply for fracture healing. The deltoid-splitting approach enables a more direct visualisation of the greater tuberosity fragment for easier reduction and fixation and results in a shorter operating time (compared with the deltopectoral approach). The most common complication of MIPO using the locking plate is screw perforation; constant awareness and the use of intra-operative fluoroscopy help to reduce this complication.

To prevent axillary nerve injury, a 5-cm safe zone was strictly observed, and no nerve complication was encountered. The nerve can at times be palpable and thus avoided. The mean acromion-axillary nerve distance is about 6 cm and strongly correlates with upper arm length. Abduction brings the nerve closer by approximately 1.5 cm. Nonetheless, in nearly 20% of cadavers, the nerve along its course around the humerus in the deltoid muscle was <5 cm at some point from the palpable edge of the acromion (particularly in female cadavers with short arm spans).

Limitations of this study included that the number of patients was not sufficient to calculate the incidence of complications. Only one-third of the patients were followed up at 2 years. The number of 4-part fractures was low. Clinical assessment of palsy in the anterior branch of the axillary nerve is difficult; there is a subtle difference between the power of the anterior deltoid and that of its mid-posterior portion. This may have led to under-reporting of nerve complications. In addition, not all patients underwent computed tomography prior to surgery. Classification based on computed tomography may be more informative than that based on the Neer classification.

**CONCLUSION**

MIPO through the deltoid-splitting approach for fixation of proximal humeral fractures using a locking plate is safe and effective in enabling an early return of shoulder function.

**DISCLOSURE**

No conflicts of interest were declared by the authors.

**REFERENCES**