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Outcome of locking compression plating for proximal humeral fractures: a prospective study

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ABSTRACT

Purpose. To evaluate the outcome of open reduction and internal fixation using locking compression plates for proximal humeral fractures.
Methods. 54 men and 16 women aged 28 to 79 (mean, 54) years underwent open reduction and internal fixation using a locking compression plate for closed 2-part (n=22), 3-part (n=38), and 4-part (n=10) proximal humeral fractures. 10 of the patients also had dislocation of the humeral head; 4 had fractures extending to the shaft. Wound condition, functional outcome, bone union, amount of collapse, and malalignment were assessed. Functional outcome was assessed using the Constant-Murley score.
Results. The mean follow-up period was 15 (range, 6–24) months. All fractures achieved union after a mean of 9 (range, 6–12) weeks. The mean Constant-Murley scores for the injured and normal shoulders were 72 and 82, respectively (88% of normal). The final outcome was excellent in 14 patients, good in 28, moderate in 22, and poor in 6. In the latter 6 patients, 2 had screw penetration, 2 had plate impingement, one had a mal-reduced greater tuberosity, and one had adhesive capsulitis. All were preventable. In all, 18 patients had 20 complications: subacromial impingement of the plate (n=6), mal-reduction of the greater tuberosity (n=6), screw penetration (n=2), adhesive capsulitis (n=2), superficial infection (n=2), and haematoma (n=2); 12 of these complications were technique-related.
Conclusion. Locking proximal humeral plates enabled stable fixation in all Neer-type proximal humeral fractures. Most complications were technique-related.

Key words: *bone plates; fracture fixation, internal; humeral fractures; shoulder fractures*

INTRODUCTION

Proximal humeral fractures account for approximately 5% of all fractures.[1] It is the third most common fracture among the elderly (after hip and distal radial fractures).[2] More than 70% of the patients

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are aged >60 years, and 75% are women.[3] In the elderly, the risk factors are osteoporosis and frequent falls. Treatments for proximal humeral fractures include Kirschner wire fixation (percutaneous pinning), suture fixation, external fixation, wire loops, intramedullary nailing (rush nails, Polarus nails), plating, and prosthetic replacement. The treatment goals are anatomic reduction, mechanical stability, and early recovery of the range of motion, while preserving the blood supply of the humeral head.

In the 1970s, the AO/ASIF popularised plate-and-screw fixation and redesigned the humeral head prosthesis, but these techniques are associated with implant failure, loss of reduction, nonunion or malunion, impingement, and osteonecrosis of the humeral head.[4–6]

The poor central cancellous bone stock in the humeral head, particularly in the elderly, leads to a high risk of fixation failure after plate-and-screw fixation.[4,7,8] Blade plate fixation may overcome this limitation with the advantage of a fixed-angle device, but only affords a single primary fixation point and can be difficult to insert correctly.[9] Both techniques require soft-tissue stripping and may affect the tenuous vascular supply of the humeral head. There is no consensus on optimal treatment for displaced 3- and 4-segment fractures.[6,10] Outcomes following blade plate fixation or plate-and-screw fixation are usually poor, owing to reduced humeral head blood supply and non-anatomic reduction. Secondary loss of reduction frequently occurs. Joint replacement also leads to disappointing results.[11] Angular stable plates broaden the spectrum of indications and enable anatomic fixation even for severely displaced 3- and 4-part fractures.[12]

Concerns of damage to the blood supply leading to avascular necrosis may be overstated. The best predictors of humeral head perfusion are the length of medial metaphyseal fragment and the intact medial soft-tissue hinge, and the fracture pattern.[13,14] Fractures that devitalise the humeral head articular fragments are at risk of avascular necrosis and therefore less suitable for open reduction and internal fixation. It was thought that detachment of the arcuate artery supply to the humeral head (a branch of the anterior circumflex artery) would lead to avascular necrosis.15 However, either a medial metaphyseal extension of the humeral head fragment or an intact medial capsule is sufficient to maintain humeral head blood supply in most patients.[13,14]

Locking compression plates enable significantly more stability in simulated osteoporotic bone.[16] Angular stable plates provide stability in proximal humeral fractures with firm anchorage in osteoporotic bone and enable early functional exercise even in elderly patients, and therefore achieve favourable clinical results.[17] This study aimed to evaluate the outcome of open reduction and internal fixation using locking compression plates for proximal humeral fractures.

MATERIALS AND METHODS

Between June 2009 and May 2011, 54 men and 16 women aged 28 to 79 (mean, 54) years underwent open reduction and internal fixation using a locking compression plate for closed 2-part (n=22), 3-part (n=38), and 4-part (n=10) proximal humeral fractures (Fig.). Among them, 10 also had dislocation of the humeral head, and 4 had fractures extending to the shaft. 36 patients injured the right side; none had bilateral injuries. The injury mechanisms were road traffic accident (n=40), fall from a height (n=14), and trivial trauma (n=16). Patients with pathologic fractures, immature skeleton, or associated polytrauma were excluded. The time from injury to operation was within 6 hours in 10 patients, 6 to 24 hours in 26, and 1 to 3 days in 34. The PHILOS plate (n=28) and the locking proximal humeral plate (n=42) were used. 17 patients had additional fixation with lag screws (n=7) and sutures (n=10). The fracture patterns were classified by a senior consultant using the Neer classification.

Patients were placed in a supine position and operated on through the deltopectoral approach. The articular surface was reduced anatomically without stripping the periosteum. Kirschner wires, clamps, or towel clips were used to hold the fragments temporarily. Locking screws were inserted using a torque-limiting screwdriver. The plate span ratio,

Figure Fixation of a 3-part proximal humeral fracture using a locking compression plate.

number of screws, and working length were based on the protocol. The proximal screws were inserted under image intensification. Upper locking screws were inserted bicortically. To accurately measure the screw length in osteopenic bone, a depth gauge was used to feel the resistance of the subchondral bone after drilling the lateral half of the track. The final screw length had to be 2 to 3 mm shorter than the measured length.[18] The proximal fragment was fixed with 4 to 9 locking screws into the head for better stabilisation. In 6 patients with medial communition of the proximal fragment, the inferomedial region was reconstructed with an inferomedial screw.[19]

Table 1
Injury mechanism of the patients

Age group (years)	No. of patients		
	Road traffic accident	Fall from a height	Trivial trauma
20–30	8	-	-
31–40	10	-	-
41–50	12	4	-
51–60	8	6	6
61–70	2	4	4
71–80	-	-	6

Table 2
Neer classification of the patients

Parameter	Neer classification of proximal humeral fractures (No. of patients)		
	2-part (n=22)	3-part (n=38)	4-part (n=10)
Associated injury			
Dislocation of the humeral head	0	6	4
Fracture extension to the shaft	0	2	2
Constant-Murley scoring system			
Excellent	8	6	-
Good	10	16	2
Moderate	4	14	4
Poor	-	2	4

Reduction was acceptable if there was <1 cm of displacement and <45° of angulation for any fragment. Good cortical continuity on both cortices and absence of varus or valgus angulation were confirmed intra-operatively.

Postoperatively, radiographs were taken to assess fracture reduction and implant position. On day 1, active finger and wrist movements as well as passive range of motion of shoulder and active-assisted forward flexion, backward flexion, and abduction were allowed. After 6 weeks, active internal and external shoulder rotation as well as power building exercises were allowed. Patients were followed up at week 6, months 3 and 6, and years 1 and 2. The wound condition, functional outcome, bone union, amount of collapse, and malalignment were assessed. Functional outcome was assessed using the Constant-Murley score. A score of 0 to 55 was considered poor, 56 to 70 moderate, 71 to 85 good, and 86 to 100 excellent.

RESULTS

51% of the patients were aged 40 to 60 years, and all the females were aged ≥50 years and had osteoporosis (Table 1). The mean follow-up period was 15 (range, 6–24) months. All the fractures achieved union after a mean of 9 (range, 6–12) weeks. The mean Constant-Murley scores for the injured and normal shoulders were 72 (standard deviation [SD], 13) and 82 (SD, 10), respectively (88% of normal). The final outcome was excellent in 14 patients, good in 28, moderate in 22, and poor in 6 (Table 2). In the latter 6 patients, 2 had screw penetration, 2 had plate impingement, one had a mal-reduced greater tuberosity, and one had adhesive capsulitis. All were preventable.

18 patients had 20 complications: subacromial impingement of the plate (plate placed too far cranially) [n=6], mal-reduction of the greater tuberosity (n=6), screw penetration (n=2), adhesive capsulitis (n=2), superficial infection (n=2), and

Table 3
Comparison studies for proximal humeral fractures

Study	No. of patients	Mean follow-up (months)	Mean time to union (weeks)	Mean Constant-Murley scores	Complication rate (%)
Plecko and Kraus,[20] 2005	36	31	-	81	-
Chidambaram et al.,[22] 2005	126	-	14	78	-
Moonot et al.,[21] 2007	32	11	10	67	28
Thyagarajan et al.,[23] 2009	30	9	12	58	10
Fazal and Haddad,[24] 2009	27	13	6	70	-
Present study	70	15	10	72	25

haematoma (n=2); 12 of these complications were technique-related.

DISCUSSION

The mean Constant-Murley score of the injured shoulders in our patients was 72, which was similar mean scores of 58 to 81 reported in other studies (Table 3).[20–24] 12 of the 20 complications in our series were technique-related. Therefore, intra-operative confirmation of plate placement and absence of breaching of the articular surface during screw insertion is essential. Mal-reduction of the greater tuberosity resulted in poor functional outcome in 2 of our patients. This may have been avoided if reduction was proper. The infection rate was low because the plate had a low profile and required less soft-tissue dissection, thus enabling stable fixation. Satisfactory reduction of the fracture and optimal positioning of the plate under image control was paramount for obtaining good results. In medial comminuted fractures of the proximal humerus, additional fixation with inferomedial locking screws is necessary. Proper reduction of the greater tuberosity and other fragments before plate positioning could have prevented impingement. Early rehabilitation in the postoperative period is essential for achieving optimal outcome.

Avascular necrosis can be prevented by careful surgical dissection to avoid damage to the arcuate branch of the anterior humeral circumflex artery, as well as by minimising dissection near the bicipital groove. Dissection of the posteromedial aspect of the humeral neck, where the posteromedial vessels pass, should be avoided. To prevent avascular necrosis, the medial periosteal hinge was maintained in all the patients.

One limitation of this study was the small number of patients. Besides, the mean follow-up was too short (minimum being 6 months) to determine long-term complications like osteonecrosis. There was no control group for comparison. Larger studies with longer follow-up are warranted. The use of locking plates is challenging and associated with a steep learning curve; surgeons must be aware of the indications and technical tricks, as well as the advantages and limitations of resorting to locking compression plates.

DISCLOSURE

No conflicts of interest were declared by the authors.

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