Minimally invasive plate osteosynthesis in the treatment of proximal humeral shaft fractures

Abed A. El-Negery, Yaser Y. Abed

Department of Orthopedic Surgery, Mansoura University, Mansoura, Egypt

Correspondence to Abed A. El-Negery, MD, Lecturer of Orthopedic, Orthopedic Surgery Department, Mansoura University;
Tel: 00201066699908;
e-mail: abedalnegery@yahoo.com

Received 15 February 2013
Accepted 15 March 2013

The Egyptian Orthopaedic Journal
2016, 51:199–204

Introduction
The treatment for proximal humeral shaft fracture is still controversial, attributed to the multiplicity of treatment options. The aim of this study was to evaluate the results of minimally invasive plate osteosynthesis (MIPO) in the treatment of proximal humeral shaft fractures.
Patients and methods
Between February 2007 and November 2011, 20 patients with displaced fracture of the proximal one-third shaft of the humerus were treated using the MIPO technique. The average age of the patients was 45.3 years, and there were 13 male and seven female patients. Eleven (55%) patients had AO (AO Foundation is a medically guided, not-for-profit organization led by an international group of surgeons specialized in the treatment of trauma and disorders of the musculoskeletal system) type 12C fractures. The right humerus was fractured in 11 (55%) patients. Falls were the most common cause of fracture in eight (40%) patients. Follow-up was carried out regularly with radiography and measurement of range of movement of the elbow.
Results
All fractures healed in an average time of 10.35 weeks within an average follow-up of 23.46 months. Surgery was performed on average 1.75 days after injury. Fractures were fixed using dynamic compression plating in 12 cases and locked plating in eight cases. The average range of elbow range of motion was 123 degrees; 12 (60%) patients were able to achieve full elbow extension at last follow-up. The average extension lag was 5.25°. The average range of elbow flexion was 128.25°. Six complications occurred in our cases. There were two cases of shoulder impingement. One patient developed deep infection. Three (15%) patients had postoperative radial nerve injuries. All of them recovered spontaneously.
Conclusion
Although MIPO is technically demanding, it is a safe and efficient procedure for the treatment of humeral shaft fracture. Adequate healing and low complication rate can be obtained if the appropriate surgical technique is used. Elbow flexion contracture can be regarded as a possible complication that can be avoided by the use of early adequate elbow rehabilitation protocol.

Keywords:
humeral shaft fracture, minimally invasive plate osteosynthesis, plate osteosynthesis

Egypt Orthop J 51:199–204

1110-1148

Introduction

Management of fracture of the proximal shaft of the humerus is not an easy orthopedic problem to handle. Successful conservative treatments using a U-shaped slab or hanging cast has been reported [1–4].

However, conservative method requires a lot of patient compliance and proper selection of patients. Obese patients and those with poor and fragile skin conservative treatment will easily fail [2].

Intramedullary fixation is another option in the management of proximal humeral shaft fracture [3–5]. However, a higher rate of nonunion or failed fixation was reported in these patients fixed with nails [4,5]. Ender nailing was also described for treating simple humeral shaft fractures in special situations as in multiple trauma or unstable patients with less blood loss and short surgical time [6–12].

Fixation with plates and screws remains the gold standard for surgical treatment of humeral fractures due to its lower complication rate and shorter time to union compared with intramedullary nailing [6–8].

To avoid the extensive soft tissue dissection required for open reduction and internal fixation (ORIF), a less invasive technique that allows indirect reduction and percutaneous plating of the humerus has been developed.

 DOI: 10.4103/1110-1148.208921

Various reports have shown excellent healing rates and alignment, and infrequent complications [6–8,13–15].

The aim of this study was to evaluate the results of minimally invasive plate osteosynthesis (MIPO) of humeral fractures in the Orthopedic Department, Mansoura University Hospitals in Mansoura, Egypt.

Patients and methods

Between February 2007 and November 2011, 20 patients with displaced fracture of the proximal one-third shaft of the humerus were treated using the MIPO technique. All patients with open injury, pre-existing nerve injury, multiple injury patients, or pathological fractures were excluded. Only cases with follow-up more than 6 months were included. This study approved by the Ethical committee of Mansoura University, Mansoura, Egypt.

The mean age was 45.3 years (range: 36–72 years). There were 13 (65%) male and seven female patients. Eleven (55%) patients had AO type 12C fractures. The right humerus was fractured in 11 (55%) patients. Falls were the most common cause of fracture in eight (40%) patients (Table 1).

Follow-up was carried out regularly with radiography and measurement of range of movement of the elbow. Solid union was confirmed by the evidence of callus formation on three cortices on radiographic study.

Table 1 Preoperative data

Case nos	Sex	Age	Side	AO classification	Mechanism of trauma
1	Female	47	Right	12C3	RTA
2	Female	55	Left	12B2	MCA
3	Male	56	Right	12B3	RTA
4	Male	40	Right	12C1	MCA
5	Female	60	Left	12C3	Fall
6	Male	67	Right	12B1	Fall
7	Male	50	Right	12C3	MCA
8	Male	42	Left	12B3	RTA
9	Male	70	Left	12C1	Fall
10	Male	66	Left	12B2	Fall
11	Male	44	Right	12B1	MCA
12	Female	60	Left	12C3	Fall
13	Male	72	Right	12C1	Fall
14	Female	45	Right	12B3	RTA
15	Female	47	Right	12C1	RTA
16	Male	36	Left	12C3	MCA
17	Female	48	Right	12B3	MCA
18	Male	60	Left	12B1	Fall
19	Male	62	Left	12C1	Fall
20	Male	59	Right	12C3	RTA
Average		45.3			

MCA, middle cerebral artery; RTA, road traffic accident

Surgical technique

After general or regional anesthesia, the patient was made to lie in a supine position. A 5 proximal incision was made at the anteromedial border of the deltoid muscle. Careful dissection was performed to avoid injury of the cephalic vein in the deltopectoral groove.

The incision should be about 5 cm distal to the acromion to avoid injury of the axillary nerve. The submuscular plane was developed laterally underneath the deltoid muscle.

Another 5 cm distal incision was made over the lateral side of the distal shaft of the humerus guided by the image intensifier below the distal end of the fracture. The brachialis muscle was split using blunt dissection. The anatomical course of the radial nerve should always be kept in mind during the distal dissection. The nerve was not routinely explored, and retraction was performed gently.

Careful blunt dissection was performed until the periosteum was reached, to avoid trapping the nerve between the distal end of the plate and the bone.

The proximal fragment was usually displaced in an abducted and internally rotated position. Therefore, reduction of the fracture was performed through abduction and internal rotation of the distal fragment to obtain a reasonable alignment.

Thereafter, a submuscular tunnel can be developed with the plate itself or using a coup elevator of the spine. We insured that the tunnel is submuscular and that the radial nerve was superficial to the tunnel to avoid its entrapment by the plate.

Osteosynthesis was performed using the available plates of adequate length to provide a secure fixation proximal and distal to the fracture. Usually three to four screws engaging six to seven cortices proximal and distal to the fracture were used. Locked plates were used whenever possible, especially in osteoporotic fractures.

Precontouring and twisting of the plates were performed to allow fixation to the lateral cortex proximally and to the anterolateral surface of the distal humerus. Precontouring was checked using the image intensifier before final fixation.

The fracture reduction was confirmed with an image intensifier using both the anteroposterior and lateral views. Proximal fixation of the plate was performed

first to the lateral cortex; the distal fragment was indirectly reduced using the plate. Image intensifier was regularly used to check each step of the reduction.

Preliminary fixation was performed proximal and distal to the fracture after adequate alignment of the fracture and checked with an image intensifier. Thereafter, final fixation was performed. The final alignment of the fracture and the implant was checked under an image intensifier.

Free active range of motion (ROM) of the shoulder and the elbow was allowed on the second day after the operation. A simple arm sling was used to immobilize the limb in the first 2 weeks after surgery. Physiotherapy was started 3 weeks after the operation (Fig. 1).

Results

All fractures healed after an average follow-up of 23.46 months (range: 7–36 months). The average time for union was 10.35 weeks (range: 8–16 weeks). Surgery was performed on average 1.75 days (range: 0–5 days) after injury. Fractures were fixed using dynamic compression plating in 12 (60%) cases and locked plating in eight cases.

The average range of elbow ROM was 123° (range: 100–140°); 12 (60%) patients were able to achieve full elbow extension at last follow-up. The average extension lag was 5.25° (range: 0–20°). The average range of elbow flexion was 128.25° (range: 110–140°).

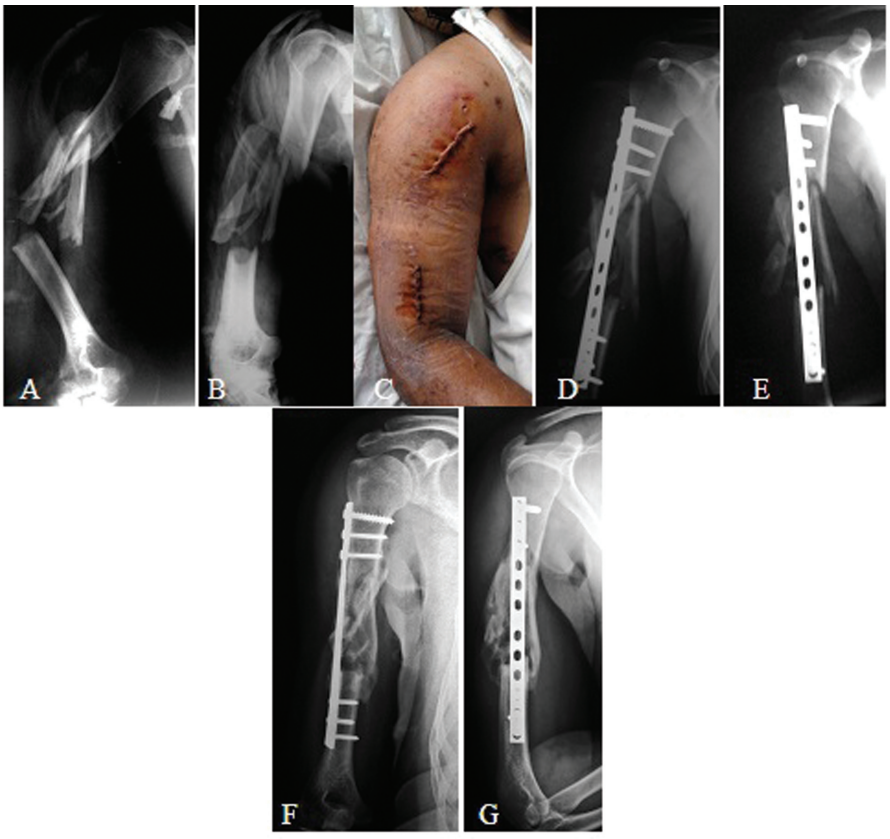
Six complications occurred in our cases. There were two cases (case 12 and case 19) of shoulder impingement causing restriction of abduction. Full range of movement was achieved after the implants were removed. These two cases were the only two cases that had implants removed.

One patient developed a deep infection that responded to debridement and irrigation with culture-specific antibiotics. Three (15%) patients (case 1, case 9, and case 16) had postoperative radial nerve injuries. All of them recovered 6, 8, and 3 months after surgery, respectively. Postoperative results are summarized in Table 2 and Fig. 2.

Discussion

Although conservative treatment continues to be one of the most commonly used methods for the management of humeral shaft fracture, conservative management of

Figure 1



Case 20: (a and b) Preoperative radiography. (c) Skin incisions. (d and e) Immediate postoperative radiography. (f and g) 6-month follow-up radiography

Table 2 Operative and postoperative data

Case nos	Union time (weeks)	Follow-up (months)	Time to surgery (days)	Implant type	Elbow ROM			Complications	Additional procedure
					Extension lag	Flexion	Range		
1	12	36	2	4.5 DCP	0	120	120	Radial nerve	
2	8	36	1	4.5 DCP	10	135	125		
3	8	34	0	4.5 DCP	0	110	110		
4	10	32	0	LCP	0	130	130		
5	16	30	1	4.5 DCP	10	135	125		
6	10	29	3	LCP	0	135	135		
7	8	28	1	4.5 DCP	0	120	120		
8	9	28	1	4.5 DCP	0	140	140		
9	12	27	5	LCP	20	135	115	Radial nerve	
10	11	25	4	LCP	15	125	110		
11	9	24	1	4.5 DCP	0	140	140		
12	8	24	0	LCP	5	130	125	Shoulder impingement	Plate removal
13	14	23	5	LCP	15	125	100	Infection	Debridement
14	13	20	0	4.5 DCP	20	120	100		
15	10	18	1	4.5 DCP	0	140	140		
16	9	15	0	4.5 DCP	0	140	140	Radial nerve	
17	8	12	1	4.5 DCP	0	135	135		
18	12	12	3	LCP	10	120	110		
19	11	8	2	LCP	0	110	110	Shoulder impingement	Plate removal
20	9	7	1	4.5 DCP	0	130	130		
Average	10.35	23.4	1.75		5.25	128.25	123		

DCP, dynamic compression plate; LCP, locking compression plates; ROM, range of motion.

the proximal part of the shaft of the humerus is usually cumbersome to both patients and treating physician. This is because the unbalanced deltoid muscle tends to displace the proximal fragment in abduction, which makes reduction difficult using U-slab or a hanging cast. Cast or slab sometimes causes skin complications such as irritations or pressure sores around the axilla and chest region, especially in hot humid weather. Prolonged immobilization can lead to stiffness in the shoulder and elbow, especially in older patients [9,16].

Intramedullary nailing is one of the treatment options in proximal humeral shaft fractures. However, it had been shown that this treatment carries a slightly higher risk for failed fixation, especially in comminuted and osteoporotic patients. Moreover, in fractures that extend into the tuberosity of the proximal humerus, antegrade nailing is technically not feasible because of the fixation problem. Shoulder pain related to the insertion of the nail is also a common complication that is still unsolved. Nonunion or delayed union was also relatively common and required revision with bone grafting [6].

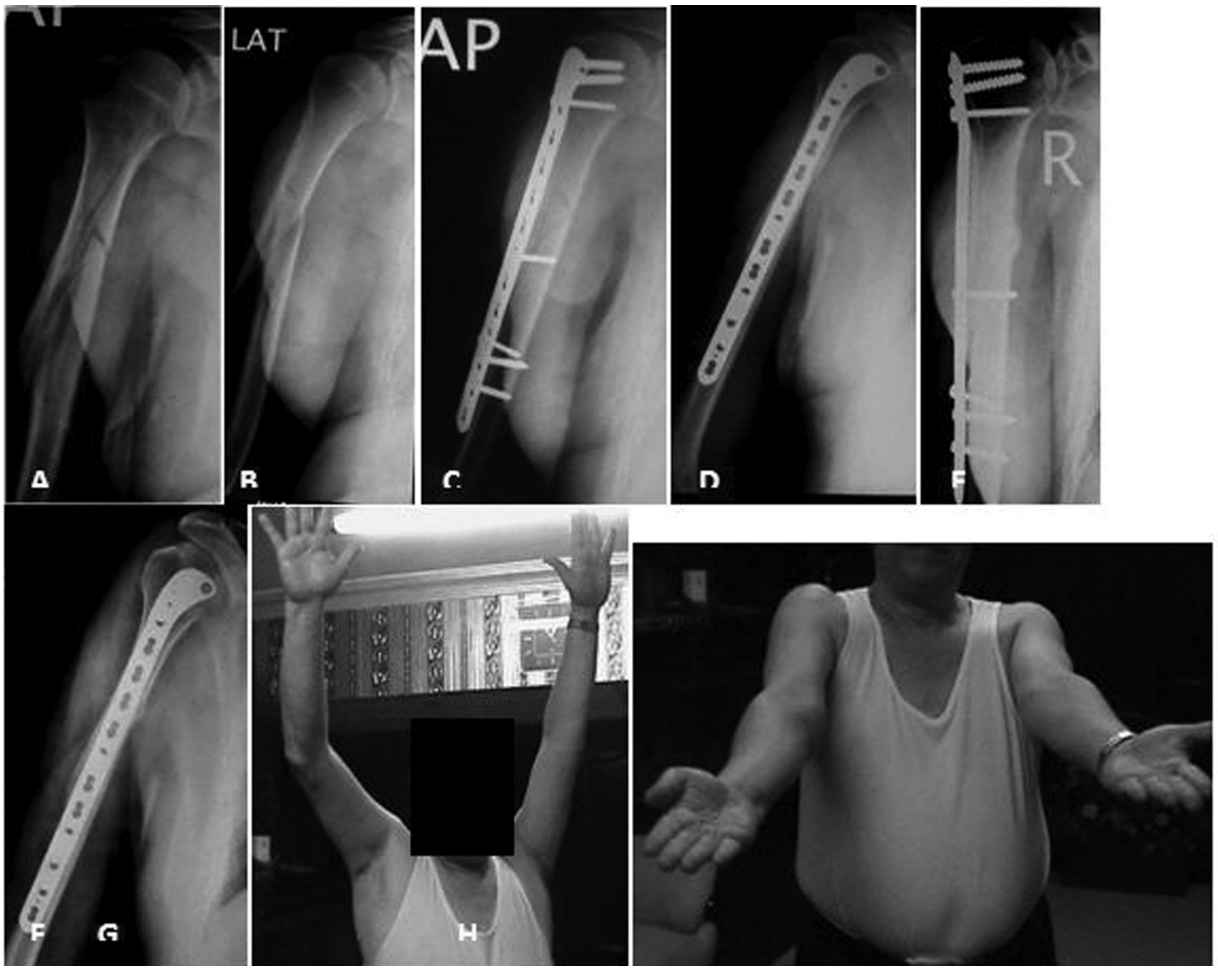
Several published studies considered ORIF of humerus shaft fractures the standard operative treatment of humeral shaft fractures due to the favorable outcome. Union rates were reported to be more than 88% [9–21]. Iatrogenic radial nerve injuries have been reported to occur in up to 31% of cases [6,10,11,17,18] and infections in less than 7% [6,11,16,18]. Extensive soft tissue dissection and radial nerve exposure associated with ORIF may have been possible risk factors for these complications. However, conservative casting or minimal less invasive fixation such as Ender's nails or interlocking nails still has its own weaknesses that have not been resolved [6].

In addition, bone grafting is frequently required as an adjunct measure to obtain the high reported union rates [11,16,20,22].

MIPO of the humeral shaft has been developed to allow plate and screw fixation with less soft tissue disruption, thereby improving union rates and reducing complications such as infection and iatrogenic radial nerve palsy [11].

Most articles on MIPO of humerus shaft fractures report healing rates of 100% for closed fractures [13,15,17,23] and healing rates between 90 and 100% for open fractures [12,23]. Infection rates after MIPO of the humerus range from 0 to 17% in closed fractures and from 0 to 7% in studies that include open fractures [13,17,23,24].

Figure 2



Case 4 12C1 fracture (a and b) Preoperative radiography. (c and d) Immediate postoperative radiography. (e and f) Radiography at last follow-up. (g and h) Clinical outcome

The union rate in our study with no open fractures included was 100%, which supports that MIPO is an effective treatment option for humeral shaft fractures when surgery is indicated. Therefore, we excluded open fractures from our study to accurately evaluate the biological effect of MIPO. Furthermore, only one deep infection occurred, which represents 5% infection rate and is consistent with that reported in the literature.

Furthermore, in this study three (15%) patients had postoperative iatrogenic radial nerve injury; all patients had spontaneous recovery 3, 6, and 8 months postoperatively. In our study, cases with preoperative radial nerve injury were excluded to evaluate the true incidence of postoperative radial nerve injury. Most published MIPO series did not report postoperative radial nerve injury. One study reported three (17.6%) cases of radial nerve injury that spontaneously recovered in a maximum of 8 months [17].

An average elbow ROM of 123° was found in our study, which is similar to the results of Ziran and colleagues, who obtained an average 128° and 129°, respectively, after MIPO of humerus shaft fractures [13,18].

Furthermore, elbow ROM after MIPO is consistently reported to be above 100° [13,17,23,25], a minimum value that has been shown to be required for normal elbow function [18]. In our study, all our patients had final elbow ROM more than 100°.

Only two patients had final elbow ROM of 100°; one of them had postoperative infection. The average extension lag of 5.25° that was present in these cases may be due to scarring of the brachialis muscle incised during the MIPO technique. Full extension was achieved in 12 (60%) patients.

MIPO provides the benefits of both conservative and operative treatment and at the same time avoids complications of both. The preserved biology as in conservative treatment allows early healing, low infection rates, and low incidence of radial nerve

injury. The stability provided by plate fixation allows early mobilization and reduces the incidence of elbow stiffness.

The repeated reproducible successful results of MIPO of humeral fractures encouraged the use of this technique in the management of certain cases of humeral fracture nonunion [13].

Conclusion

MIPO is technically demanding, but it is a safe and efficient procedure for the treatment of humeral shaft fracture. Adequate healing and low complication rates can be obtained if the appropriate surgical technique is used. Elbow flexion contracture can be regarded as a possible complication using this approach and can be avoided with the use of early adequate elbow rehabilitation protocol.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Ekholm R, Tidermark J, Törnkvist H, Adami J, Ponzer S. Outcome after closed functional treatment of humeral shaft fractures. J Orthop Trauma 2006 20:591–596.

2 Hunter SG. The closed treatment of fractures of the humeral shaft. Clin Orthop Relat Res 1982; 164:192–198.

3 Koch PP, Gross DF, Gerber C. The results of functional (Sarmiento) bracing of humeral shaft fractures. J Shoulder Elbow Surg 2002; 11:143–150.

4 Sarmiento A, Kinman PB, Galvin EG, Schmitt RH, Phillips JG. Functional bracing of fractures of the shaft of the humerus. J Bone Joint Surg Am 1977; 59:596–601.

5 Ruedi T, Moshfegh A, Pfeiffer KM, Allgower M. Fresh fractures of the shaft of the humerus. Conservative or operative treatment? Reconstr Surg Traumatol 1974; 14:65–74.

6 Chao TC, Chou WY, Chung JC, Hsu CJ. Humeral shaft fractures treated by dynamic compression plates, Ender nails and interlocking nails. Int Orthop 2005; 29:88–91.

7 Crates J, Whittle AP. Antegrade interlocking nailing of acute humeral shaft fractures. Clin Orthop Relat Res 1998; 350:40–50.

8 Lin J, Hou SM. Antegrade locked nailing for humeral shaft fractures. Clin Orthop Relat Res 1999; 365:201–210.

9 Ajmal M, O'Sullivan M, McCabe J, Curtin W. Antegrade locked intramedullary nailing in humeral shaft fractures. Injury 2001; 32: 692–694.

10 Petsatodes G, Karataglis D, Papadopoulos P, Christoforides J, Gigis J, Pournaras J. Antegrade interlocking nailing of humeral shaft fractures. J Orthop Sci 2004; 9:247–252.

11 Singisetti K, Ambedkar M. Nailing versus plating in humerus shaft fractures: a prospective comparative study. Int Orthop 2010; 34: 571–576.

12 Bhandari M, Devereaux PJ, McKee MD, Schemitsch EH. Compression plating versus intramedullary nailing of humeral shaft fractures – a meta-analysis. Acta Orthop 2006; 77:279–284.

13 Apivatthakakul T, Arpornchayanon O, Bavornratanavech S. Minimally invasive plate osteosynthesis (MIPO) of the humeral shaft fracture. Is it possible? A cadaveric study and preliminary report. Injury 2005; 36: 530–538.

14 Jiang R, Luo CF, Zeng BF, Mei GH. Minimally invasive plating for complex humeral shaft fractures. Arch Orthop Trauma Surg 2007; 127:531–535.

15 Ziran BH, Belangero W, Livani B, Pesantez R. Percutaneous plating of the humerus with locked plating: technique and case report. J Trauma 2007; 63:205–210.

16 Rutgers M, Ring D. Treatment of diaphyseal fractures of the humerus using a functional brace. J Orthop Trauma 2006; 20:597–601.

17 McCormack RG, Brien D, Buckley RE, McKee MD, Powell J, Schemitsch EH. Fixation of fractures of the shaft of the humerus by dynamic compression plate or intramedullary nail. A prospective, randomised trial. J Bone Joint Surg Br 2000; 82:336–339.

18 Chapman JR, Henley MB, Agel J, Benca PJ. Randomized prospective study of humeral shaft fracture fixation: intramedullary nails versus plates. J Orthop Trauma 2000; 14:162–166.

19 An Z, Zeng B, He X, Chen Q, Hu S. Plating osteosynthesis of mid-distal humeral shaft fractures: minimally invasive versus conventional open reduction technique. Int Orthop 2009; 34:131–135.

20 Changulani M, Jain UK, Keswani T. Comparison of the use of the humerus intramedullary nail and dynamic compression plate for the management of diaphyseal fractures of the humerus. A randomised controlled study. Int Orthop 2007; 31:391–395.

21 Niall DM, O'Mahony J, McElwain JP. Plating of humeral shaft fractures – has the pendulum swung back? Injury 2004; 35:580–586.

22 Lin J. Treatment of humeral shaft fractures with humeral locked nail and comparison with plate fixation. J Trauma 1998; 44:859–864.

23 Chiu FY, Chen CM, Lin CF, Lo WH, Huang YL, Chen TH. Closed humeral shaft fractures: a prospective evaluation of surgical treatment. J Trauma 1997; 43:947–951.

24 Livani B, Belangero WD. Bridging plate osteosynthesis of humeral shaft fractures. Injury 2004; 35:587–595.

25 Lau TW, Leung F, Chan CF, Chow SP. Minimally invasive plate osteosynthesis in the treatment of proximal humeral fracture. Int Orthop 2007; 31:657–664.