Long contoured locking plate fixation of traumatic proximal humeral fractures with distal extension

Joby J George Malal, Alistair I W Mayne, Faten Arouri, Ali M Noorani, Matthew Kent, Matt Smith, Inigo Guisasola and Peter Brownson

Abstract

Background: There is a paucity of data available with respect to outcome on long contoured locking plate fixation for proximal humerus fractures with distal fracture extension.

Methods: Thirty-four patients with traumatic proximal humerus fractures with distal extension underwent fixation with long contoured locking plates. Twenty-five patients (74%) were included in the study: one patient died, two patients had unrelated illnesses resulting in them being unable to complete follow-up assessment and six were lost to follow-up. Patients' case notes and radiographs were retrospectively reviewed, and patients were contacted to assess functional outcome using the Visual Analogue Scale (VAS) for pain, Disabilities of the Arm, Shoulder and Hand (DASH) score, Oxford Shoulder Score (OSS) and Stanmore Percentage of Normal Shoulder Assessment (SPONSA).

Results: Mean follow-up was 27 months (range 11 months to 60 months). Mean pain at final follow-up was 3.6 [95% confidence interval (CI) = 2.5 to 4.8] with only four patients having residual pain greater than 5 on the VAS scale. Mean DASH score was 41.2 (95% CI = 32.0 to 50.4), mean OSS was 29.1 (95% CI = 24.3 to 33.9) and mean SPONSA was 63.9% (95% CI = 50.8 to 77.2). There was one wound infection. Three patients had non-unions that required bone grafting and revision internal fixation.

Conclusions: We feel long contoured locking plates represent a useful treatment option for complex proximal humerus fractures

Keywords

Long contoured locking plates, proximal humerus fractures, PHILOS plate

Date received: 21st February 2014; accepted: 25th May 2014

Introduction

Proximal humeral fractures account for 4% to 5% of fractures and are increasingly common among the elderly age group with osteoporotic bone stock.¹ Many of these fractures are displaced fractures involving the tuberosities or are associated with dislocations. A smaller proportion of these fractures are further complicated by extension of the fracture line towards the diaphysis of the humerus. This includes segmental fractures. A range of treatment options are available for these fractures, ranging from non-operative management to external fixation to internal fixation techniques, including intramedullary nailing and plate fixation.²

It is well recognized that the functional outcome of proximal humerus fractures is best when the tuberosity fragments are well reduced and aligned with the shaft.³ A relatively recent advance in the treatment of proximal humerus fractures has been the introduction and wide spread adoption of contoured locking plates.^{3,4} Although much has been written in the published

Department of Trauma and Orthopaedics, Royal Liverpool & Broadgreen University Hospitals, Liverpool, UK

Corresponding author:

Alistair Mayne, Department of Trauma and Orthopaedics, Royal Liverpool & Broadgreen University Hospitals, Liverpool, UK.
Email: alistairmayne@hotmail.co.uk

literature about the experience with these locking plates for the more common proximal humeral fractures, there is a paucity of data available with respect to outcome for their use in proximal humerus fractures with distal extension of the fracture line. The one English language paper on the subject is a mixed series involving traumatic, pathological and peri-prosthetic fractures.⁵

The present study aimed to assess the medium-term results of traumatic proximal humerus fractures with distal metaphyseal or diaphyseal extension treated with long contoured proximal humerus internal locking system (PHILOS) plates (Synthes, Stratec Medical, Oberdorf, Switzerland).

Materials and methods

A retrospective review was performed on all patients treated with the long PHILOS plate for traumatic proximal humerus fractures with distal fracture extension between July 2007 and January 2011. Procedures carried out for pathological and peri-prosthetic fractures were excluded.

Surgical technique

All procedures were performed by consultant shoulder surgeons or senior trainees under direct consultant supervision. A beach chair position was used in all cases. The delto-pectoral approach was employed to expose the proximal humerus. The incision was started from the tip of the coracoid process proximally and extended distally as appropriate depending on fracture morphology. The cephalic vein was identified and preserved. The bicipital groove was used as the landmark for approaching the tuberosities. All attempts were made to preserve the long head of biceps, particularly in younger patients. If the biceps tendon was damaged, a tenodesis was performed in the distal part of the bicipital groove and the proximal tendon was excised. The anterior one-third of the deltoid insertion was elevated sub-periosteally to allow for the positioning of the plate lateral to the bicipital groove. If the fracture line extended into the tuberosities, control of the tuberosities was established early in the procedure with modified Mason Allen stitches through the rotator cuff tendons using number five Ethibond (Ethicon, Somerville, NJ, USA) suture. An image intensifier was used throughout the procedure to help aid with the reduction as well as to ensure accurate implant positioning and adequate fixation. The proximal humerus anatomy was reconstructed first using a combination of direct and indirect reduction manoeuvres and provisionally held with K-wires and the anchoring stitches. In fractures without metaphyseal comminution, the

fracture was reduced under image intensifier guidance and held with a provisional K-wire inserted medial to the bicipital groove in a medial distal to proximal lateral direction. A plate reduction technique was used for fracture patterns with significant metaphyseal or distal comminution, with the plate being affixed to the reconstituted head fragment ensuring correct anterior-posterior alignment of the plate first and then the distal fragment was reduced on to the plate. A minimum of five locking screws were used in the proximal plate, often augmented with stitches through the rotator cuff tendons. Distal fixation was performed using a mix of locking and nonlocking screws. At the end of the procedure, the wound was thoroughly washed out. The elevated anterior part of the deltoid insertion was reattached and the wound was closed in layers with subcuticular stitches for skin approximation. Figure 1 shows the pre- and post-operative radiographs of two patients with proximal humerus fractures with distal extension treated with long contoured locking plates.

Postoperative rehabilitation

Patients would start active mobilization out of the sling on the ward. Initially, sliding and gym ball rolling exercises would be used. After discharge, patients would generally be reviewed at 2 weeks in the physiotherapy department where manual techniques such as mobilisations, stretching and soft tissue work may be added to a home exercise programme. Strengthening exercises including the use of therabands are started when a functional range of movement is achieved, usually at 6 weeks. Patients also have access to a hydrotherapy pool.

Follow-up and outcome scores

All patients had check radiographs postoperatively and had physiotherapist supervised rehabilitation. Patients were initially seen at 2 weeks postoperatively for wound review. Follow-up clinical evaluation and radiographs were performed at 6 weeks and then at 6-weekly intervals until radiological union.

Final function was measured using the Oxford Shoulder Score (OSS, 0 to 48), Disabilities of the Arm, Shoulder and Hand (DASH) score, Stanmore Percentage of Normal Shoulder Assessment (SPONSA) and Visual Analogue Scale (VAS) for pain.⁶⁻⁸

Results

Thirty-four patients were treated with the long PHILOS plate for complex proximal humerus fractures during the study period. Mean patient age was 55.3 years (range 25 years to 83 years). Eighteen patients

Figure 1. Pre- and postoperative radiographs of proximal humerus fractures with distal extension treated with long contoured locking plates.

(53%) were female. The most common mechanism of injury was a low energy fall onto the arm. Out of this initial cohort of 34 patients, one patient died of an unrelated cause, two patients had unrelated illnesses resulting in them being unable to complete the follow-up assessment and six patients were lost to follow-up, leaving 25 patients (74%) for analysis. Nine of these fractures involved the humeral head or tuberosities, whereas the remainder were at or below the level of the surgical neck of the humerus (Table 1). There were three segmental fractures. One patient had the procedure for non-union following initial treatment with an intramedullary nail. The length of plate used varied from five to 12 holes for the shaft region. The mean follow-up period was 27 months (range 11 months to 60 years) from the time of the index operation.

Functional outcomes are summarised in Table 2. At final follow-up, the mean residual pain, as assessed on a

standard 10-cm VAS was 3.6, with a 95% confidence interval (CI) of 2.5 to 4.8. Only four patients among the 25 had residual pain more than 5 on the VAS scale. However, nineteen of the twenty-five patients (76%) had some amount of residual pain from the shoulder. The mean DASH score was 41.2 (95% CI = 32.0 to 50.4), mean OSS was 29.1 (95% CI = 24.3 to 33.9) and mean SPONSA was 63.9% (95% CI = 50.8 to 77.2).

One patient developed a superficial wound infection that was treated with antibiotics. Another patient had a wound haematoma that did not require any surgical intervention. Three patients (12%) had a non-union of the fracture requiring bone grafting along with revision of the internal fixation to a double-plate construct. Table 3 summarises the characteristics of the three non-unions. On final review, only one patient was unhappy with the result of the operation. None of the cases where the fracture had united required further surgery to remove the implant.

Table 1. Summary of fracture type.

Fracture type	Number of patients
Comminuted fracture surgical neck, no head involvement	5
Comminuted fracture of surgical neck with GT involvement	3
Surgical neck fracture with distal extension	3
Surgical neck fracture with distal extension and GT involvement	3
Comminuted fracture prox to middle 1/3 rd ; no head involvement	9
Long spiral fractures revised from previous failed fixation	2

GT, greater tuberosity.

Table 2. Summary of outcome measures on final assessment.

Outcome measure	Mean	95% Confidence interval
VAS	3.6	2.5 to 4.8
DASH	41.2	32.0 to 50.4
OSS (0 to 48)	29.1	24.3 to 33.9
SPONSA	63.9	50.8 to 77.2

VAS, Visual Analogue Scale; DASH, Disabilities of the Arm, Shoulder and Hand; OSS, Oxford Shoulder Score; SPONSA, Stanmore Percentage of Normal Shoulder Assessment.

Discussion

Proximal humerus fractures are the most common fracture type after hip and distal radius fractures, especially in the elderly.⁹ The use of contoured locking plate fixation devices for the treatment of these fractures is becoming increasingly popular.^{3,10,11} Locking plate devices are particularly suited for metaphyseal fractures where there is comminution and loss of bone as the fixed angle nature of the construct resists cantilever bending stresses.^{10,12} It is also proposed that the decreased plate to bone compression reduces the interference with local microvascular circulation. Locking plates may also produce a fixation construct stable enough to allow early range of motion exercises.³ Even in fractures of the humeral shaft region, a recent Cochrane review found higher rates of sub-acromial impingement and the need for implant removal with locked nails compared to compression plates, although both fixation techniques had similar early complication rates and functional outcomes.¹³

A study of 18 long PHILOS plate fixations for a mixture of pathologies by Pimple et al. reported no non-unions, with a mean residual pain of 0.8 as assessed by the VAS.⁵ The results of this series, which looked purely at nonpathological fractures and excluded peri-prosthetic fractures, compare unfavourably with a non-union rate of 12% and a mean residual pain of 3.6 on the VAS scale. On analysis of the non-unions, we could not identify any specific predisposing factors to predict non-union but are limited in analysis by the small sample size. However, given that this series looked at proximal humeral fractures complicated with distal metaphyseal and diaphyseal extension, the results

Table 3. Summary of non-union fracture characteristics.

Age	Sex	Fracture description	PHILOS plate length
70	Female	Spiral fracture of proximal humerus extending into neck and greater tuberosity	Eight hole
42	Male	Comminuted spiral fracture of mid-shaft with medial angulation of distal segment and almost complete displacement	Twelve hole
76	Male	Short segmental spiral fracture of proximal humerus	Nine hole

PHILOS, proximal humerus internal locking system.

are comparable to the American Academy of Orthopaedic Surgeons technology overview of locking plate stabilization of simple proximal humerus fractures that used systematic review methodology to investigate eight published studies.¹² A recent large series review investigating the risk factors for complications and revision surgery following PHILOS plating for proximal humerus fractures identified the non-impacted metaphyseal proximal humerus fracture (AO type 11-A3) as a significant predictor for poor outcome.¹⁴ This series contained a high proportion of these extra-articular metaphyseal fractures complicated with diaphyseal extension of the fracture line. An excellent outcome for the treatment of a proximal humerus fracture is when a patient has evidence of radiological union across the fracture site within a reasonable time frame (not exceeding 6 months to 9 months) with no wound or neurovascular complications, no residual pain and no functional limitations from the shoulder or clinical need for implant removal. A high proportion of patients in this series had some amount of residual long-term pain from the shoulder. However, these results compare well with larger studies looking at the functional outcome of proximal humerus fractures.^{10,15,16} The incidence of neurological or wound complications was also low in this present series.^{10,12,15} There were no cases of avascular necrosis of the humeral head, the incidence of which is quoted at between 0% to 10% for larger series looking at simple proximal humerus fractures.^{10,11,15}

Given the wide variation in treatment preferences for proximal humerus fractures,¹⁷ some surgeons may feel these injuries should be treated with nailing. The variety and complexity of the fracture type that we examined in the present study makes direct comparison with other studies difficult. Many studies specifically exclude fractures extending into the humeral shaft, whereas others contain a heterogeneous group containing some fractures with shaft extension. Adedapo and Jkpeme included data on seven patients with three- or four-part

proximal humerus fractures with distal extension treated with the Polarus nail.¹⁸ They reported a mean constant score of 69 (range 40 to 94) at 1 year, and that four patients had complete pain relief at final follow-up.¹⁸ Complications were not detailed for this subgroup. Gradl et al. included five patients with proximal humerus fractures with shaft extension treated with the Targon PH nail.¹⁹ All five had backing out of screws and the mean Constant score at 1 year was 79.4.¹⁹ Popescu et al. included seven proximal humerus fractures with shaft involvement treated with the T2 proximal humerus nail.²⁰ At a minimum 12-month follow-up, OSS was available for five of these patients and was 22.4 (range 16 to 44). Complications were not reported for this sub-group.²⁰

There are advantages and disadvantages of both plating and nailing techniques, with reasonable results reported for both. Ultimately, treatment choice in the management of these difficult fractures will be strongly influenced by surgeon preference and experience. The present study has found long contoured locking plates to be useful in the treatment of proximal humerus fractures with distal extension. These plates provide an opportunity to align and stabilize the tuberosities appropriately with the shaft fragment. The stability of fixation provided by these plates allow early mobilization. In fractures not involving the tuberosities, there is a lower risk of cuff damage and impingement with locking plate fixation compared to intramedullary nailing. Nonetheless, it is important to note the limitations including the risk of non-union and the high incidence of residual pain.

Declaration of conflicting interests

None declared.

Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Note

This research was previously presented at: (i) British Trauma Society Annual Scientific Meeting, Leeds. 16 to 18 May 2012 (oral presentation); (ii) British Orthopaedic Trainees Association (BOTA) annual conference. 15 to 17 June 2012 (poster presentation); and (iii) 33rd SICOT & 17th PAOA Orthopaedic World Conference. Dubai, 28 to 30 November 2012 (e-poster).

References

1. Court-Brown CM, Garg A and McQueen MM. The epidemiology of proximal humeral fractures. *Acta Orthop Scand* 2001; 72: 365–71.
2. Helmy N and Hintermann B. New trends in the treatment of proximal humerus fractures. *Clin Orthop* 2006; 442: 100–8.
3. Ricchetti ET, DeMola PM, Roman D and Abboud JA. The use of precontoured humeral locking plates in the management of displaced proximal humerus fracture. *J Am Acad Orthop Surg* 2009; 17: 582–90.
4. Moonot P, Ashwood N and Hamlet M. Early results for treatment of three and four part fractures of the proximal humerus using the PHILOS plate system. *J Bone Joint Surg (Br)* 2007; 89B: 1206–9.
5. Pimple M, Chidambaram R and Mok D. Long Philos plate fixation for complex humeral fractures. *Shoulder and Elbow* 2010; 2: 255–8.
6. Dawson J, Fitzpatrick R and Carr A. Questionnaire on the perceptions of patients about shoulder surgery. *J Bone Joint Surg (Br)* 1996; 78: 593–600.
7. Hudak P, Amadio PC and Bombardier C for the Upper Extremity Collaborative Group. Development of an upper extremity outcome measure: The DASH (Disabilities of the Arm, Shoulder and Hand). *Am J Ind Med* 1996; 29: 602–8.
8. Noorani AM, Roberts DJ, Malone AA, et al. Validation of the Stanmore percentage of normal shoulder assessment. *Int J Shoulder Surg* 2012; 6: 9–14.
9. Baron JA, Barrett JA and Karagas MR. The epidemiology of peripheral fractures. *Bone* 1996; 18(Suppl 3): 209–13.
10. Sproul RC, Iyengar JJ, Devic Z and Feeley BT. A systematic review of locking plate fixation of proximal humerus fractures. *Injury* 2011; 42: 408–13.
11. Thanasis C, Kontakis G, Angoules A, Limb D and Giannoudis P. Treatment of proximal humerus fractures with locking plates: a systematic review. *J Shoulder Elbow Surg* 2009; 18: 837–44.
12. Anglen J, Kyle RF, Marsh JL, et al. Locking plates for extremity fractures. *J Am Acad Orthop Surg* 2009; 17: 465–72.
13. Kurup H, Hossain M and Andrew JG. Dynamic compression plating versus locked intra medullary nailing for humeral shaft fractures in adults. *Cochrane Database Syst Rev* 2011; 6: CD005959.
14. Spross C, Platz A, Rufibach K, et al. The PHILOS plate for proximal humerus fracture – risk factors for complications at one year. *J Trauma Acute Care Surg* 2012; 72: 783–92.
15. Faraj D, Kooistra BW, Stappen WAH and Werre AJ. Results of 131 consecutive operated patients with a displaced proximal humerus fracture: an analysis with more than two years follow up. *Eur J Orthop Surg Traumatol* 2011; 21: 7–12.
16. Geiger EV, Maier M, Kelm A, Wetzler S, Seebach C and Marzi I. Functional outcome and complications following PHILOS plate fixation in proximal humeral fractures. *Acta Orthop Traumatol Turc* 2010; 44: 1–6.
17. Petit CJ, Millett PJ, Endres NK, Diller D, Harris MB and Warner JJP. Management of proximal humerus fractures: Surgeons don't agree. *J Shoulder Elbow Surg* 2010; 19: 446–51.
18. Adedapo AO and Jkpeme JO. The results of internal fixation of three- and four-part proximal humeral fractures with the Polarus nail. *Injury* 2001; 32: 115–21.
19. Gradl G, Dietze A, Arndt D, et al. Angular and sliding stable antegrade nailing (Targon PH) for the treatment of proximal humeral fractures. *Arch Orthop Trauma Surg* 2007; 127: 937–44.
20. Popescu D, Jenaro A, Fernandez-Valencia, et al. Fixation of proximal humerus fractures using the T2-proximal humeral nail. *Arch Orthop Trauma* 2009; 129: 1239–44.