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Evolving trends in surgically managed patients with proximal humerus fracture: are we different after ten years?

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INTRODUCTION New knowledge, and improved surgical hardware and fixation techniques have changed surgical management. We review the evolving trends of surgically managed proximal humerus fractures.

METHODS Patients who underwent surgery for proximal humerus fractures from 1 January 2001 to 31 December 2010 were identified from the hospital's electronic diagnosis and operative coding database. Data extracted from the database included patient demographics, comorbidities, clinical and radiological findings, operative techniques, and complications.

RESULTS In total, 95 patients with 97 surgically managed proximal humerus fractures were identified. The median age of the patients was 50 (range 12–85) years, and the male to female ratio was 1.2:1.0. Male patients tended to present at a younger age than female patients (peak age 30–39 years vs. 70–79 years, $p < 0.001$). Two-part surgical neck fracture was the most common type of fracture (n = 33, 34.0%). Plate osteosynthesis was predominantly used for two- and three-part surgical neck fractures involving the greater tuberosity ($p = 0.03$, $p = 0.0002$, respectively). Hemiarthroplasty was commonly performed for four-part fractures ($p < 0.001$). Wound infections, implant failure, avascular necrosis of the humeral head and nonunion were seen in 8 (8.3%) cases. Minimally invasive plate osteosynthesis (MIPO) had been in use since 2007 ($p < 0.001$).

CONCLUSION Surgically managed proximal humerus fractures predominantly involved young men following high velocity injury and elderly women following osteoporotic fractures. Open plating was most commonly used for two- and three-part fractures, and hemiarthroplasty for four-part fractures. MIPO techniques have been practised in our institution since 2007.

Keywords: complication, epidemiology, minimally invasive plate osteosynthesis, Neer's classification, proximal humerus fracture

INTRODUCTION

Proximal humerus fractures account for 5% of all fractures and 10% of all upper limb fractures.[1-3] Surgical treatment, which has acceptable risks, aims to avoid potential complications such as nonunion, malunion and prolonged immobilisation.[4-11] With advancement in knowledge regarding these fractures and improvements in hardware designs and fixation techniques, fractures are now increasingly being treated surgically. In fact, many different fixation methods have surfaced in the literature over the past ten years, with no large randomised study supporting the use of one method over another.[12-20] Thus, the primary objective of the present study is to describe the clinical parameters of patients with surgically managed proximal humerus fractures and to identify any evolving trends in such surgeries over the past decade. Any observable predilection for a particular surgery or surgical approach may be used to drive future trials toward studying the indications and outcomes of these surgical techniques and approaches.

METHODS

We identified all the patients who had undergone surgery for proximal humerus fractures in our institution over a ten-year period (from January 2001 to December 2010). The list of patients was generated electronically from the hospital's diagnosis and operative coding database, and manually checked to confirm the diagnosis of all the patients on the list. A proximal humerus fracture was defined as a fracture that occurred proximal to the surgical neck of the humerus.

The case notes, electronic records and radiographs of all the identified patients with proximal humerus fractures were reviewed. The parameters recorded were patient demographics (e.g. age, gender), comorbidities, clinical findings (e.g. mechanism of injury, presence of open fracture and neurovascular deficits), radiological findings (e.g. fracture configuration), operative techniques (e.g. surgical approaches, type of implants) and operative complications. Altogether, 26 patients were excluded from the study – 15 patients were inappropriately coded, 4 polytrauma patients did not undergo surgery, and 7 patients with pathological fractures (due to local infection or tumours) were undergoing revision surgeries.

During the review process, we paid particular attention to the presence of pre- and postoperative injuries of the axillary nerve, radial nerve and/or blood vessels.[21-23] Based on our retrospective search, indications for surgery included open fractures, angulation of the articular surface > 45°, displacement between the major fracture fragments > 1 cm, fracture-dislocation, and fractures with varus or valgus impaction.[5] Fractures were classified according to Neer's classification system using two standard orthogonal shoulder radiographs (anteroposterior and Y-scapula views), which were reviewed by two consultants not involved in the

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management of the patient.[4] In the event of differing opinions, a third independent reviewer was consulted. A differentiation was made between anatomical and surgical neck fractures, as we took into consideration the possible lack of proximal bony purchase during fixation and the disruption of blood supply to the humeral head, which may predispose patients to replacement surgery.

Surgical approaches were classified as percutaneous, minimally invasive, or open. The open approach was further subdivided into deltopectoral or deltoid splitting. The type of fixations used were Kirschner wires, bone suture, plate osteosynthesis, cancellous screw fixation, hemiarthroplasty, and a combination of surgical implants. All surgeries were performed by surgeons of at least a registrar grade, under the charge of a fellowship-trained consultant orthopaedic surgeon. Complications were grouped into the following categories: (a) problems with union (e.g. delayed union, nonunion); (b) implant-related problems (e.g. fracture propagation, loosening, implant breakage); (c) wound infection (e.g. superficial, deep infections); and (d) avascular necrosis. This retrospective study was approved by our local ethics committee board, with a waiver of consent.

Statistical analysis was performed using the Statistical Package for the Social Sciences version 16 (SPSS Inc, Chicago, IL, USA). Categorical variables were presented as proportions, while continuous variables were presented as median, where appropriate. Univariate analyses were performed using Chi-square test for categorical variables, and Mann-Whitney *U* test for continuous variables. Correlation between fracture configuration, approach and fixation method was considered statistically significant if the p-value was ≤ 0.005 based on Bonferroni correction. Statistical significance was set at p-value ≤ 0.05.

RESULTS

A total of 95 patients with 97 surgically managed proximal humerus fractures were included in the data analysis. Two patients had bilateral proximal humerus fractures. The median age of the patients was 50 (range 12–85) years, and the male to female ratio was 1.2:1.0. The average follow-up duration was 4.1 (range 2–10) years. There was a predominance of male patients aged < 40 years and female patients aged > 70 years (p < 0.001). A total of 47 (48.5%) fractures were high velocity injuries, of which 74.5% were due to road traffic accidents. Of the 97 fractures, 3 (3.1%) were open fractures – puncture wound in the axilla, Gustilo grade 2 fractures, and Gustilo grade 3A fractures. Neurological deficits were observed in 2 (2.1%) patients; preoperatively, both patients had sensory loss over the regimental badge area (axillary nerve distribution). None of the patients had radial nerve or vascular injuries. There were no surgically-treated valgus impacted fractures in our study cohort. Based on Neer's classification, two-part surgical neck fractures (33/97, 34.0%) and three-part greater tuberosity fractures (22/97, 22.7%) were the two most common types of fracture encountered. Of the 97 fractures, 16 (16.5%) were four-part fractures and 17 (17.5%) were fractures cum dislocations. Other types of fractures were two-part greater tuberosity fractures (7/97, 7.2%) and two-part anatomical neck fractures (2/97, 2.1%). Table I summarises the baseline characteristics of our patients.

Table I. Baseline characteristics of the patients (n = 95).

Characteristic	No. (%)
Mean age* (yrs)	49.7 (12–85)
Male gender	52 (54.7)
Mechanism of injury (n = 97)	
High-velocity trauma	47 (48.5)
Road traffic accident	35 (74.5)
Fall from height	12 (25.5)
Low-velocity trauma	50 (51.5)
Direct impact to shoulder	42 (84.0)
Fall on outstretched hand	8 (16.0)
Open fracture	3 (3.1)
Neurological deficits	2 (2.1)
Fracture configuration (n = 97)	
Two-part surgical neck	33 (34.0)
Three-part greater tuberosity	22 (22.7)
Four or more parts	16 (16.5)
Fracture–dislocation	17 (17.5)
Others†	9 (9.3)

Note: There were 97 fractures, as 2 of the 95 patients had bilateral proximal humerus fractures. *Data is presented as mean (range). †Comprises two-part greater tuberosity and two-part anatomical neck fractures.

Trend analysis showed that our institution started practising minimally invasive plate osteosynthesis (MIPO) surgery of the proximal humerus in 2007 (p < 0.001). MIPO constitutes about 20% of all cases managed per year (Fig. 1). No other surgical fixation methods or approaches showed statistical significance over the ten-year period. The MIPO technique was used to treat 9 proximal humerus fractures, of which 6 (66.7%) were two-part surgical neck fractures and 3 (33.3%) were three-part greater tuberosity fractures. For open surgery, the deltoid splitting approach was used in 14 patients, and the deltopectoral approach, in 69 patients.

In terms of the fixation method, plate osteosynthesis was the most common, with a total of 49 out of 97 (50.5%) proximal humerus fractures treated using this method. This was followed by hemiarthroplasty of the shoulder and fixations with cancellous screw. Conversely, Kirschner wires, bone anchors and intramedullary nails were infrequently used during this period (Fig. 2). None of the patients required any form of combined fixation in our series. Plate osteosynthesis was the predominant choice for fixation of two-part and three-part proximal humerus fractures involving the greater tuberosity (p = 0.03 and p = 0.0002, respectively). Hemiarthroplasty was performed in 26 out of 97 (26.8%) proximal humerus fractures, consisting of mostly four-part surgical neck fractures (p < 0.001). No correlation between surgical/anatomical neck fractures and the type of surgery was noted.

Over the ten-year study period, there were 8 (8.3%) instances of postoperative complications – 3 (3.1%) wound infections, 2 (2.1%) implant failures due to loss of fixation, 2 (2.1%) nonunion and 1 (1.0%) avascular necrosis of the humeral head (Table II). Among the three patients with wound infection, one patient had Kirschner wire pin site infection and two had superficial wound site infection from hemiarthroplasty. These patients were successfully treated with short-term antibiotics. Of the two

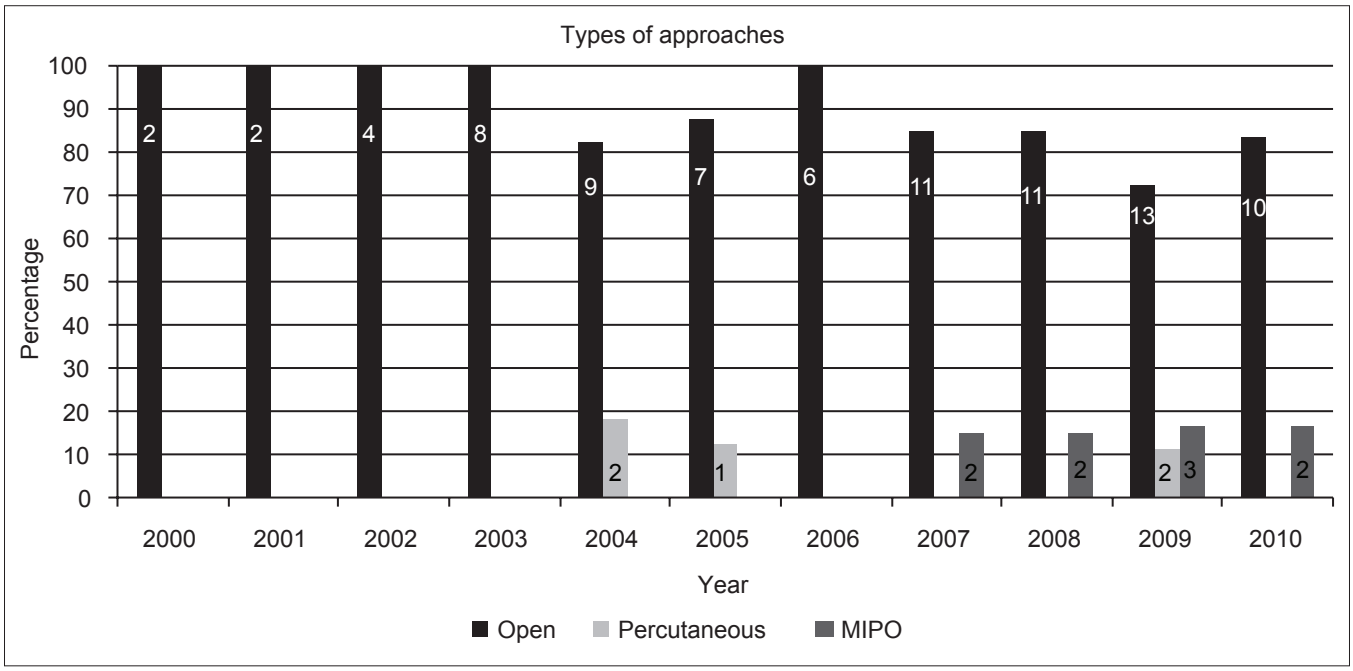

Fig. 1 Graph shows the types of surgical approaches used to treat proximal humerus fractures over a ten-year period. MIPO: minimally invasive plate osteosynthesis

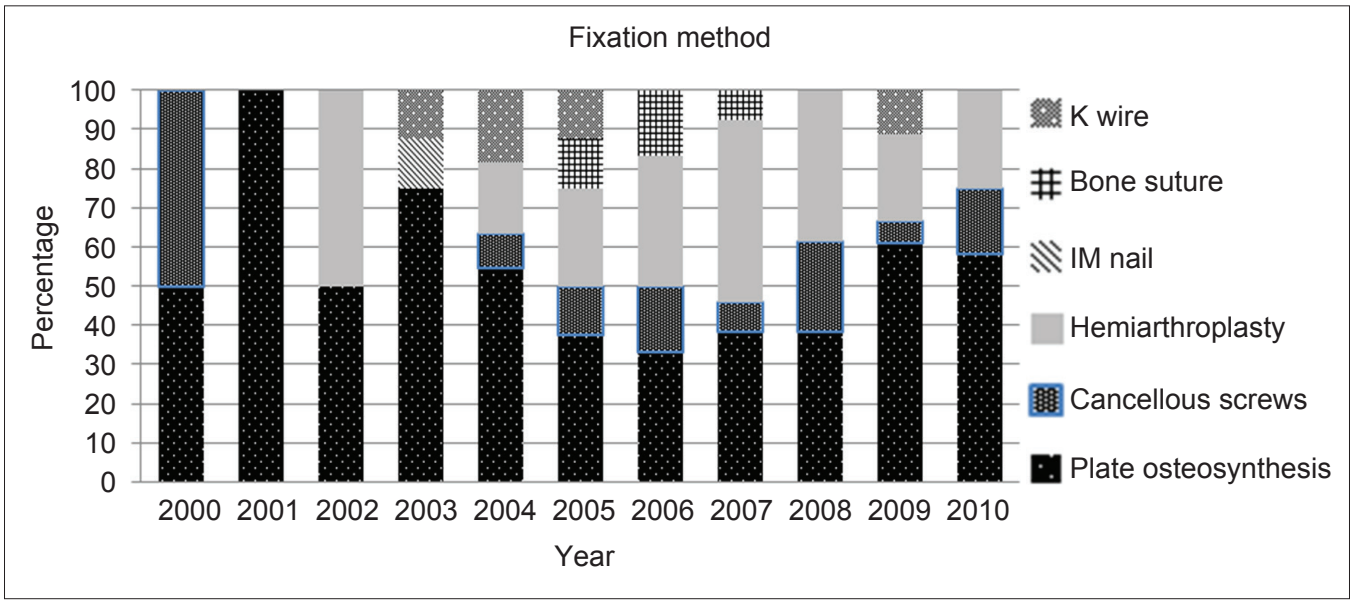

Fig. 2 Graph shows the proportion of fixation methods used to treat proximal humerus fractures over a ten-year period. IM: intramedullary; K: Kirschner

Table II. Complications encountered in surgically managed patients with proximal humerus fractures.

Complication	No. of fractures (%)
Wound infection	
Superficial	3 (3.1)
Deep	0 (0)
Implant-related problems	
Implant failure	2 (2.1)
Implant loosening	0 (0)
Union problems	
Delayed union	0 (0)
Nonunion	2 (2.1)
Avascular necrosis of the humeral head	1 (1.0)

Note: There were 97 fractures, as 2 of the 95 patients had bilateral proximal humerus fractures.

patients with loss of fixation, the first patient had undergone open plating for a three-part greater tuberosity fracture; however further displacement of the greater tuberosity in this patient led to the need for revision plating. The second patient had undergone open plating for a comminuted fracture-dislocation of the proximal humerus; as further displacement of the fragments was observed on follow-up, this patient underwent revision surgery to hemiarthroplasty. Both of these patients had no further sequelae following revision surgery. Two patients with four-part proximal humerus fracture had aseptic atrophic nonunion after open plating and required bone grafting 5–6 months later. The fractures healed well after subsequent bone grafting surgery. As both of these patients had open plate osteosynthesis following high-velocity injuries, extensive soft tissue and periosteal stripping

Table III. Fracture configurations and management.

Parameter	Two-part surgical neck		Three-part greater tuberosity		Four or more parts	
	No. (odds)	p-value	No. (odds)	p-value	No. (odds)	p-value
Fixation method						
Plate	22 (2.00)	0.0300	19 (6.33)	0.0002	4 (0.33)	0.0300
Hemiarthroplasty	3 (0.10)	0.0700	3 (0.16)	0.1700	12 (3.00)	0.0001
Cancellous screw	1 (0.03)	0.0600	0 (0)	0.0400	0 (0)	0.1200
Kirschner wire	6 (0.22)	0.0600	0 (0)	0.3500	0 (0)	0.6000
Bone suture	0 (0)	1.0000	0 (0)	1.0000	0 (0)	1.0000
Intramedullary nail	1 (0.03)	0.3400	0 (0)	1.0000	0 (0)	1.0000
Approach						
Open	29 (7.25)	0.7700	18 (4.50)	0.7300	15 (15.00)	0.4500
MIPO	3 (0.10)	1.0000	2 (0.10)	1.0000	1 (0.07)	1.0000
Percutaneous	1 (0.03)	0.6600	2 (0.10)	0.3200	0 (0)	0.5900

MIPO: minimally invasive plate osteosynthesis

at the time of injury or surgery could have compromised the vascular supply to the humerus, thus affecting bony union.[13,14] None of the complications documented in the present study were from patients who had undergone surgery using the MIPO technique. All MIPO surgeries were performed by four consultant orthopaedic surgeons and were followed up for an average duration of 3.6 (range 2–5) years.

DISCUSSION

New knowledge, together with improved surgical hardware and fixation techniques, can potentially change surgical management. To the best of our knowledge, the present study is the first to evaluate the evolving trends of surgically managed proximal humerus fractures over a ten-year period. Similar to most other fracture presentations,[1-3] patients who present with such injuries often fall under one of the following two categories – elderly female patients who have osteoporosis and young male patients who sustained a high-velocity injury.[6-11] This trend is reflected in the present study, as male patients presenting with fractures were at a peak age of 30–39 years, and female patients, at a peak age of 70–79 years ($p < 0.001$, Fig. 3). Furthermore, male patients aged below 65 years were found to be associated with high-velocity injuries ($p = 0.046$). Given the fast-ageing population in Singapore (9% of the population is aged above 65 years according to the 2010 population census), osteoporotic fractures involving the elderly is likely to rise.[12]

The trends in the operative management of proximal humerus fractures have changed over the last decade. Since 2007, the MIPO technique has been practised in our institution in conjunction with courses conducted by AOTrauma, a clinical division within the AO Foundation. MIPO surgery is unique in that it uses two incisions (i.e. one proximal and one distal) to allow gliding of the plate across the fracture site along the submuscular plane.[17-20] This technique minimises further soft tissue injury from dissection following the initial trauma, and preserves the periosteum with the intention of promoting bony union.[17-20] With the expected rise of osteoporotic fractures in the elderly, MIPO surgery will continue to gain popularity, as it gives the added advantage of minimising soft tissue injury in patients who have reduced healing potential. Numerous studies have demonstrated

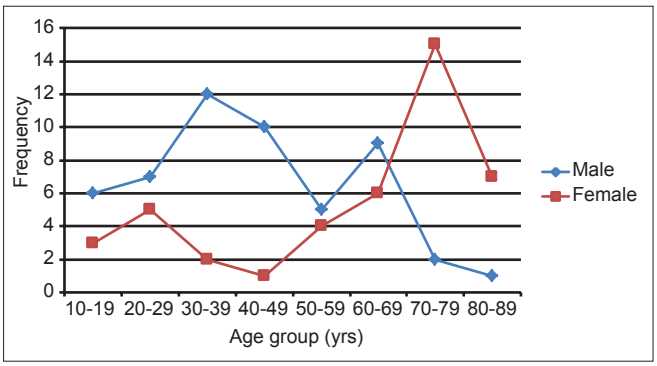

Fig. 3 Graph shows the frequency of proximal humeral fractures according to age group.

good results following MIPO surgery.[17-20] Although the present study did not review the outcomes of patients who underwent MIPO surgery, given the promising results reported by other studies,[17-20] we opine that more patients will likely undergo this procedure in the future.

No other surgical fixation method or approach showed statistical significance over the ten-year study period. However, findings from the last decade showed that patients with two-part surgical neck fractures (odds 2.00, $p = 0.003$) and those with three-part greater tuberosity fractures (odds 6.33, $p = 0.002$) were more likely to undergo plate osteosynthesis, while those with four-part fractures were more likely to undergo hemiarthroplasty (odds 3.00 $p < 0.001$) (Table III). Although such strategies appear to be intuitive, no strict rules governing the choice of fixation exists. Moreover, the results of these surgeries are variable, thus highlighting the need for future studies reviewing patients' functional outcomes following the various surgical treatment modalities.The trend toward primary reverse shoulder arthroplasty for elderly patients, especially those with concomitant cuff tears, has also been suggested in the literature.[24-26] However, this is beyond the scope of the present study.

On analysis of the complication rates following surgery, eight cases of complications were noted. Of these eight cases, only three were superficial wound infections, which were successfully resolved using a short course of oral antibiotics. Such low rates of

wound infections are consistent with that reported in the existing literature.[27] Fracture union was achieved in 97.9% of our patients following operative fixation. No complication from MIPO cases was noted. Considering the possibility that MIPO surgery may result in a better chance of bony union due to reduced soft tissue stripping, we approached the primary surgeons who performed the MIPO surgeries for their opinion regarding the feasibility of using the MIPO technique in the treatment of four-part fractures, in order to avoid complications of devascularisation and nonunion (both of our patients who developed nonunion had four-part fractures that were treated with open reduction and fixation). The consensus of the surgeons was that the MIPO technique is not the choice of surgery for four-part fractures, as surgical procedures for proximal humerus fractures greater than three parts are more technically challenging.

The present study reviewed only surgically managed proximal humerus fractures. It is not meant to provide information on the prevalence of surgical management in patients with proximal humerus fractures. We recognise several limitations to the present study. First, although this study was a ten-year analysis of surgically managed proximal humerus fractures, the number of patients in each subgroup was small and may not have been powered to detect significant changes in trends after Bonferroni correction. Second, as our hospital is situated along major expressways and is a catchment for patients from industrial estates in the western part of Singapore, it is likely that the number of cases due to high-velocity injury is overestimated in the present study compared to other hospitals. Finally, as this is a retrospective study, it had the inherent challenge of missing data and poor documentation. Where possible and appropriate, more information regarding the management of the patients was obtained from the attending doctors.

In conclusion, open plate osteosynthesis was the most common method of fixation in the present study. It was primarily used for the treatment of two-part and three-part proximal humerus fractures, while hemiarthroplasty was the most common method used for treating four-part fractures. MIPO of the proximal humerus, which has been practiced in our institution since 2007, was the method of treatment for about 20% of all cases managed per year. Further developments in MIPO techniques may change the way proximal humerus fractures are managed in the future. Therefore, further studies should be conducted on surgically managed proximal humeral fractures, either for the subsequent ten years of follow-up, or as part of a larger multicentre study.

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