REVIEWING OUR INSTITUTIONAL EXPERIENCE OF PERCUTANEOUS VERSUS OPEN PLATING OF PROXIMAL HUMERAL FRACTURES

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ABSTRACT

Background: Fractures of the proximal humeral are a common referral to orthopaedic centres. While undisplaced fractures can be managed conservatively with a plaster U-slab, the Neer criteria define the requirements for operative intervention. Pre-countoured titanium locking plates are the mainstay of operative intervention in these patients however several studies report the advantages of percutaneous humeral plating in 2-part proximal humeral fractures.

Objectives: To compare the operative parameters, and post-operative outcome, of 23 patients who underwent open plating of their 2-part proximal humerus fractures, to those of 26 patients with the same fracture site and configuration, who underwent percutaneous plating.

Methods: We performed a retrospective chart review of 49 patients who presented to our unit with proximal 2-part humeral fractures over a 6-year period from the 1st January 2014 to 29th November 2019, 23 of which underwent open plating and 26 of which underwent percutaneous plating. The data captured and analysed in this study included patient's age; gender; mechanism of injury; fracture pattern; indication for surgery; whether an open plating or minimally invasive percutaneous plating was performed; time from injury to operative intervention; length of operative procedure; volume of intra-operative blood loss; complications; amount of early post-operative surgical site pain assessed by the Visual Analogue Pain Scale score; range of shoulder movement at the 3-week follow-up appointment; length of hospital stay; and patient satisfaction at a 1-year follow-up end point.

Results: The findings were that when comparing open humeral plating versus percutaneous humeral plating, in the management of 2-part humeral fractures, a significant reduction was demonstrated in; length of surgery; volume of intra-operative blood loss; length of hospital stay; three-week functional recovery; one-year patient satisfaction, all of which favoured the percutaneous humeral plating group**.**

Conclusion: Percutaneous humeral plating offers significant advantages over open plating in 2-part proximal humeral fractures. We recommend that this should be the primary operative procedure considered by orthopaedic surgeons who manage this form of fracture configuration.

Key words: Percutaneous plating proximal 2-part humeral fractures, Open plating proximal 2-part humeral fractures

INTRODUCTION

Proximal humeral fractures are common accounting for 5% of all skeletal fractures. Considering humeral fractures alone, 45% of these involve the proximal humerus, aptly referred to as fractures of the surgical neck of the humerus. Epidemiological clustering is seen in elderly females with a peak incidence being seen in those with co-morbid osteoporosis (1). Various surgical options for the treatment of these fractures include extramedullary plating, intramedullary nailing, and in select cases primary hemiarthroplasty (2,3). Considering humeral head conservation techniques, the two important surgical aims are firstly to restore anatomical alignment between the humeral head and shaft and secondly to achieve sufficient immediate post-operative stability to allow restoration of a functional range of motion of the glenohumeral joint facilitating early rehabilitation. Osteoporotic bone makes fixation challenging and failure of fixation is a commonly encountered post-operative complication (5-7).

Patients with displaced fractures of the proximal humerus are considered surgical candidates. The Neer criteria, commonly employed to assess these fractures, recommend operative intervention for; (i) A fracture gap greater than 1cm, or 0.5cm for the greater humeral tuberosity, (ii) Humeral shaft displacement of greater than 10mm, (iii) Humeral shaft angulation of greater than 45 degrees, (iv) Comminution of the medial metaphyseal column and (v) An intra-articular step of greater than 2mm (8).

Fixed-angle pre-contoured titanium plates have an established role in the surgical management of proximal humeral fractures allowing superior anatomical reconstruction (9). These plates can be inserted either by an open surgical technique or minimally invasively (Figures 1-2). Screw insertion is achieved by affording a 30-degree radius (polyaxial) which allows the plate to be compressed against the bone and thereby fracture reduction is achieved. Angular stability is achieved by subsequent locking cap insertion (10).

Figure 1

Intra-operative photograph showing the typical 15cm skin incision size used in open humeral plating. The figure also illustrates the extensive deltoid muscle dissection in the open humeral plating which completely avoided the humeral splitting technique employed in the percutaneous humeral plating below

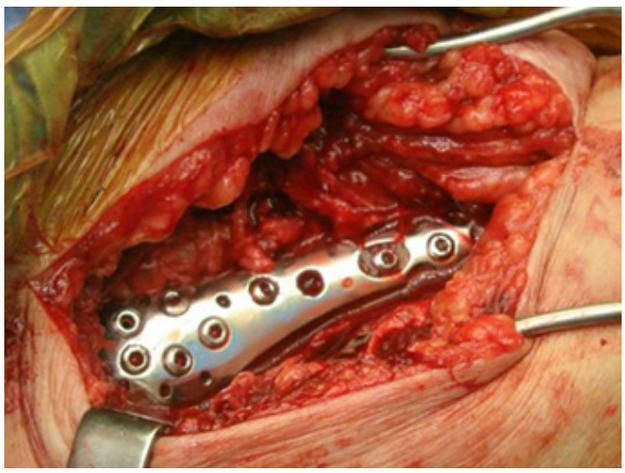


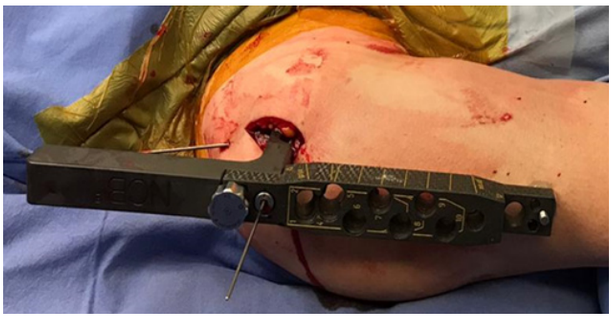
Figure 2

Intra-operative photograph of the incision sizes in the percutaneous humeral plating procedure

Several studies confirm the superiority of the minimally invasive technique in 2-part proximal humeral fractures which utilises a 3-5cm deltoid split surgical corridor starting at the anterolateral acromion rather than the 15-20cm incision utilised in the open deltopectoral approach. This translates directly into shortened operative time, less intra-operative blood loss, less muscle dissection and importantly by patients incurring less post-operative pain. Several studies report an earlier functional recovery (10,11). Whilst the plate itself is a standard fixed angle titanium implant in both the open and minimally invasive procedures fundamental differences between the open and minimally invasive techniques are firstly that in the minimally invasive technique a radiolucent jig is utilized which attaches to a handle allowing it to be inserted through the much smaller incision the deltoid muscle (Figure 3).

Figure 3

Intra-operative photograph of the jig used to perform the percutaneous humeral plating procedure



The distal plate tip is subsequently advanced against the humerus under fluoroscopic guidance to prevent axillary nerve injury (Figures 4-5).

Figure 4

Intra-operative X-ray image illustrating the percutaneously inserted plate and the jig in place through which the locking screws are inserted reducing the fracture

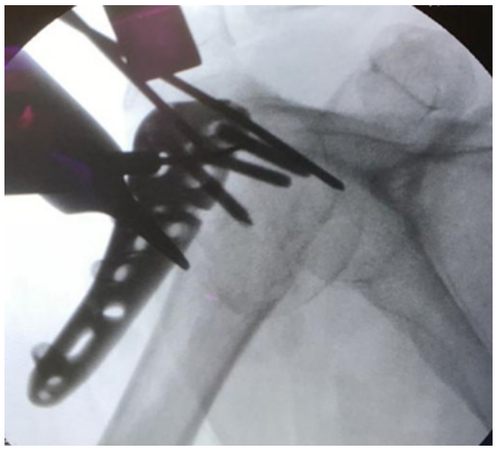


Figure 5

Intra-operative X-ray showing the completed percutaneous humeral plating procedure with the fracture reduced

Additional surgical considerations in the minimally invasive technique are that the screws are inserted through the jig which aligns them with

the holes in the plate through an intermediary stab incision in the skin. A drill guide and a screw sleeve are additional measures utilized to protect the deltoid muscle being transversed. A further difference is that, unlike in the open technique where a stand drill is utilized, in the minimally invasive technique an oscillating drill is routinely used (10).

Complications of proximal humeral plating are common and several studies report complication rates between 32 and 50% (12-14). Complications can be categorized as; (i) Implant related which includes intra-articular perforation, proximal screw toggling, distal screw pull-out and implant fracturing and (ii) General complications which include secondary fracture displacement, avascular necrosis of the humeral head, surgical site infection, frozen shoulder, acromial impingement, fracture non-union and fracture delayed-union (15).

MATERIALS AND METHODS

This study was approved by the University of the Witwatersrand Research and Ethics Committee with Ethics certificate number M191113.

This was a retrospective chart review of 49 patients who presented to the Department of Orthopaedics, Helen Joseph Hospital, University of the Witwatersrand, Johannesburg, South Africa, with proximal 2-part humeral fractures that were surgically stabilized. The study period was from 1st January 2014 to 29th November 2019 which included 1-year follow-up. Twenty-three subjects had open plating of their proximal 2-part humeral fractures and 27 subjects underwent minimally invasive percutaneous plating of their proximal 2-part humeral fractures. All patients were reviewed at a 1-year follow-up appointment which was the study end point.

The data captured and analysed in this study included patient age; gender; mechanism of injury; fracture pattern; indication for surgery; whether an open plating or minimally invasive percutaneous plating was performed; time from injury to operative intervention; length of operative procedure; volume of intra-operative blood loss; complications; amount of early post-operative surgical site pain assessed by the Visual Analogue Pain Scale score; range of shoulder movement at the 3-week follow-up appointment; length of hospital stay; and patient satisfaction at a 1-year follow-up end point. Regarding patient satisfaction, at 1-year follow-up as our outcome measure, we utilized the grading scale of: not satisfied; partially satisfied; satisfied; very satisfied; and extremely satisfied.

All statistical tests were two-sided and p-values less than or equal to 0.05 were considered significant. All statistical procedures were done on SAS (SAS Institute Inc, NC, USA), Release 9.4 or higher, running under Microsoft Windows.

RESULTS

Sixty seven subjects enrolled for the study. However, only 49 subjects fulfilled the study requirements by having arrived or being able to be contacted telephonically, 1-year post-operatively. Hence 18 subjects were automatically excluded from the study. Regarding the 49 subjects who fulfilled the study requirements 23/49 (47%) subjects had an open plating of their proximal 2-part humeral fractures performed and 26/49 (53%) subjects had a minimally invasive percutaneous plating of their proximal 2-part humeral fractures performed. The mean age of the 49 subjects was 49.1 (±16.7) years and the youngest subject was 19 years old and the oldest subject was 88 years old. Thirty seven (76%) of the subjects were between the age of 20 and 60 years. No significance was demonstrated between patient age and whether an open or percutaneous plating was performed (p=0.93). A clinical trend was however demonstrated where in the open group 16/23 (70%) subjects were below the age of 50 years, while in the percutaneous group only 14/26 (54%) subjects were below the age of 50 years.

Regarding gender 22/49 (45%) subjects were male and 27/49 (55%) subjects were female. In our study being of female gender demonstrated a significantly increased chance that a percutaneous plating would be performed (p=0.05). We propose that the reason for our finding was due to combination of surgeon preference.

In terms of mechanism of injury 21/49 (43%) subjects had been involved in a motor vehicle accident, 26/49 (53%) subjects gave a history of a fall, and 2/49 (4%) subjects had been assaulted. No significance was demonstrated between mechanism of injury and whether a percutaneous or open humeral plating was performed (p=0.22). Considering the fracture pattern 31/49 (63%) subjects presented with a transverse 2-part proximal humeral fracture, 13/49 (27%) presented with a comminuted 2-part proximal humeral fracture, 3/49 (6%) presented with a spiral 2-part proximal humeral fracture, and 2/49 (4%) presented with a proximal 2-part humeral fracture that had a butterfly fragment. Significance was demonstrated between having a transverse 2-part fracture pattern which in our study significantly increased a subjects' chance of having a percutaneous plating performed (p=0.03). Considering indication for surgery 17/49 (35%) subjects had a fracture gap >10mm and shaft displacement >10mm without shaft angulation >45 degrees. Eighteen (37%) had a fracture gap >10mm and shaft displacement >10mm and shaft angulation >45 degrees. The indication for surgery in the remaining 14/49 (29%) subjects was evenly spread between a fracture gap >10mm, shaft displacement >10mm, shaft angulation >45 degrees, comminution

of the medial diaphyseal column, and an intra-articular step > 2mm with no significant clustering being seen. Considering time from injury to operative intervention 32/49 (65%) subjects were operated within 3 days, 43/49 (88%) were operated within 5 days, and 100% of subjects were operated within 8 days of injury.

In terms of length of surgery in 14/23 (61%) subjects who underwent open plating this was 90-120 minutes and in 6/23 (26%) this was 120-150 minutes. Hence in 20/23 (87%) subjects who underwent open plating surgery was completed in 90-150 minutes. In the percutaneous plating group 13/26 (50%) subjects had their surgery performed in 30-90 minutes and 10/26 (38%) subjects had their percutaneous plating performed in 90-120 minutes. Hence in the percutaneous plating group 23/26 (88%) subjects had their surgery completed within 120 minutes. Significance was demonstrated between operative time and the surgical procedure performed with the percutaneous plating demonstrating a significantly shorter operative time (p=0.03). The intra-operative blood loss in the percutaneous plating group in all 26 (100%) subjects was 20-100mls. The intra-operative blood loss in 21/23 (91%) subjects in the open plating group was 100-400mls. A high significance was demonstrated when comparing the blood loss between the two groups with the percutaneous plating group demonstrating significantly less blood loss than the open plating group (p<0.001).

Considering early post-operative pain utilizing the Visual Analogue Pain Scale score as our outcome measure, 9/23 (39%) subjects who had undergone open humeral plating gave scores ranging from 3/10-5/10 and 14/23 (61%) gave score ranging from 6/10-8/10. In the percutaneous humeral plating group 8/26 (30%) gave scores ranging from 4/10-5/10 and 18/26 (69%) gave scores ranging from 6/10- 8/10. In the open humeral plating group, all 27/27 (100%) subjects gave scores ranging from 2/10-5/10. No significance was demonstrated between whether an open or percutaneous plating procedure was performed and early post-operative pain in our study (p=0.49). Considering length of hospital stay the mean length of post-operative hospital stay in the open humeral plating group was 7.0 (±2.76) days with a median stay of 7 days. The mean length of hospital stay in the percutaneous humeral plating group was 3.27 (±0.83) days with a median stay of 3 days. A significant difference was demonstrated whereby having a percutaneous humeral plating procedure performed shortened the mean in-patient hospital stay by 3.73 days.

Considering range of shoulder movement at the 3-week follow-up appointment we independently evaluated shoulder abduction, shoulder flexion and shoulder extension.

In the open humeral plating group, the mean range of shoulder abduction was 19.3 (± 9.8) degrees, with a median range of 20 degrees, and the minimum range seen was 5 degrees and a maximum range seen was 40 degrees. In the percutaneous humeral plating group, the mean range of abduction was 79.6 (±14.76) degrees, the median range was 80 degrees, and the minimum range was 40 degrees and the maximum range was 100 degrees.

Considering shoulder flexion in the open humeral plating group, the mean range of shoulder flexion was 19.3 (±9.3) degrees, with a median range of 20 degrees, and the minimum range seen was 10 degrees and a maximum range seen was 50 degrees. In the percutaneous humeral plating group, the mean range of flexion was 75.2 (±11.87) degrees, the median range was 70 degrees, and the minimum range was 60 degrees and the maximum range was 100 degrees.

Considering shoulder extension in the open humeral plating group, the mean range of shoulder extension was 11.2 (±5.17) degrees, with a median range of 10 degrees, and the minimum range seen was 15 degrees and a maximum range seen was 20 degrees. In the percutaneous humeral plating group, the mean range of extension was 24.8 (±5.74) degrees, the median range was 28 degrees, and the minimum range was 10 degrees and the maximum range was 30 degrees.

From the above values it can hence be seen that the percutaneous humeral plating group demonstrated clearly significantly increased ranges of motion, in all planes, compared to the ranges seen in the open humeral plating group.

In terms of complications 46/49 (94%) subjects had no complications and 3/49 (6%) subjects developed a complication. Looking more closely at these 1/23 (4%) subject in the open humeral plating group developed a frozen shoulder that was managed with physiotherapy and 2/26 (8%) subjects in the percutaneous humeral plating group developed delayed fracture union that was managed conservatively. No significance was demonstrated between whether a complication occurred and whether an open or percutaneous plating had been performed (p=1.00).

At 1-year follow-up considering the open humeral plating group 1/23 (4%) subject reported being not satisfied, 7/23 (30%) subjects reported being partially satisfied, 11/23 (48%) reported being satisfied, 4/23 (17%) subjects reported being very satisfied, and none (0%) of the subjects reported being extremely satisfied with the procedure. In the percutaneous humeral plating group 2/26 (8%) reported being partially satisfied, 6/26 (23%) reported being satisfied, 14/26 (54%) reported being very satisfied and 4/26 (15%) reported being extremely satisfied. Hence in the open surgery group 15/23 (65%) subjects reported a favourable outcome, and in the percutaneous surgery group 24/26 (92%) reported a favourable outcome, which we interpreted to be a score from satisfied to extremely satisfied. A significant difference was

demonstrated between 1-year patient satisfaction and open humeral plating versus percutaneous humeral plating with the percutaneous humeral plating group demonstrating a significantly increased chance of reporting a favourable outcome (p=0.0008).

DISCUSSION

In this study the percutaneous humeral plating group demonstrated a significantly shorter operative time (p=0.03), as well as significantly less intra-operative blood loss (p<0.001), than the operative time and intra-operative blood loss recorded in the open humeral plating group. Several studies report similar decreased operating times and blood loss in percutaneously plated humeral fractures compared to open plated fractures and our study finding supports the findings from other studies (10,11,26,27). In our study there was no significant difference demonstrated between the amount of early post-operative pain in the percutaneous humeral plating group compared to the open humeral plating group (p=0.49), which is not in keeping with the finding in similar studies, which report this as an additional significant difference (10,11,27). In our study undergoing a percutaneous humeral plating versus an open humeral plating shortened the mean length of in-hospital patient stay by 3.73 days. This is not in keeping with one of the above studies that comprised a meta-analysis of 1050 patients in which 464 underwent percutaneous plating and 586 underwent open plating, in which it is reported that no significant difference in in-patient hospital stay was demonstrated (26).

In our study, at 3-week follow up, the mean range of abduction in the percutaneous plating group was 79.6 ±14.76 degrees, the mean range of flexion was 75.2 ±11.87 degrees, and the mean range of extension was 24.8 ±5.74 degrees. Another study which considered 24 patients who underwent minimally invasive percutaneous plating of proximal humeral fractures noted, at 12-months follow-up, a mean range of abduction of 129 ±31 degrees and a median range of flexion of 141 ±39 degrees (27). In our study the mean ranges of abduction and flexion demonstrated were less than those reported in this study. In the authors opinion this is due to the difference in the follow-up period.

Considering functional outcome our study demonstrated, at the 3-week out-patient follow-up appointment, a significantly increased range of motion in all planes between our percutaneous humeral plating group and our open humeral plating group. One study, which compared functional outcome in 30 patients managed by open plating to 30 patients managed by percutaneous plating, reported significantly decreased abduction (109.7 degrees versus 133.7 degrees; p<0.01) and flexion (128.3° degrees vs 145.7°degrees; p<0.01) in the open plating group compared to the percutaneously plated group (28). Our study finding is similar to the findings by a study done by Ortmaier *et al* (28).

CONCLUSIONS

Our study findings are that when comparing open humeral plating versus percutaneous humeral plating for 2-part proximal humeral fractures a significant reduction was demonstrated in (i) Length of surgery; (ii) Volume of intra-operative blood loss; (iii) Length of hospital stay; (iv) Three-week functional recovery, and (v) One-year patient satisfaction, all of which favoured the percutaneous humeral plating group.

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