MJMR, Vol. 35, No. 4, 2024, pages (1-8).

Open Access
ISSN: 2682-4558

Research Article

Reversed proximal humeral internal locking system (PHILOS) plate for distal humeral shaft fractures through an Anterolateral Approach

Ahmed Omar Youssef[1], Mohamed Yahia Hassan[1], Ahmad Alaa Mohamed Rabea Mohamed[1] and Mohamed Sayed khamies[1]

[1] Department of Orthopedic Surgery and Traumatology, Faculty of Medicine, Minia University

DOI: 10.21608/MJMR.2024.279180.1693

Abstract

Background: We described the application of a PHILOS plate in a reversed manner for the treatment of extra-articular distal third humeral fractures through an anterolateral approach. **Methods:** For the treatment of distal humerus fractures, sixteen patients underwent internal fixation procedures using the reversed (PHILOS) plate between August 2022 and August 2023. Data was collected regarding clinical results, radiological results, and surgical complications. The Mayo and Oxford elbow scores, as well as the elbow's range of motion, were all part of the clinical evaluation. **Results:** The mean follow-up time was 8 months(range, 6 to 12 months).The average Mayo elbow and Oxford elbow scores were 95.31 (of a total of 100) and 45.31 (of a total of 48), respectively. The mean range of elbow motion was 134.37° (range 130–140). Fracture union was noted in all patients, with an average period of 15.13 weeks. One patient had a superficial wound infection, and another patient post operatively developed radial nerve palsy which completely recovered within 3 months.

Conclusion: In extra-articular distal third diaphyseal humeral fractures, a modified anterior application of the PHILOS plate could be a practical choice in fractures within 3 cm from coronoid fossa.

Key Words: Reversed PHILOS - Distal humeral shaft fracture

Introduction

Extra-articular distal humerus fracture accounts for approximately 16% of humerus fractures, 30% of periarticular elbow fractures, and 3% of all fractures in adults.[1, 2]

There is a bimodal distribution in terms of age and gender, with peaks of incidence in males aged 12-30 years and females aged 60 years and older.[1] Treatment of distal-third diaphyseal humerus fractures is difficult and often debatable.[3]

Because it is difficult to control the rotation of the little distal fragment, conservative management with a hanging cast or functional bracing is not usually practicable.[4]

When treating extra-articular distal third diaphyseal humeral fractures, surgeons often have difficulties due to the small distal fragment, which prevents them from using enough screws through the plate holes to secure the fracture.[1], there is still some debate over which implant is best for surgical treatment. Additionally, due to the relatively weak bone structure in this meta-diaphyseal junctional area, early mobilization of the elbow—one of the joints susceptible to contracture—and rigid, stable fixation are necessary for fracture union with adequate alignment and functional outcome.[2, 5].

Every implant option has its pros and cons; some examples include intramedullary nails, lambda plates, locking compression plates of

3.5 and 4.5 mm, metaphyseal plate fixation, reversed PHILOS plates, and extra-articular distal humerus lateral column plates.[5]

The proximal humeral internal locking system, or PHILOS plate, was designed to treat proximal humerus fractures by conforming to the specific anatomy of the bone. A range of screw trajectory angles can be achieved using the nine holes in the proximal area of the plate that are designed for locking head screws. Surprisingly, the flaring distal humeral fragment can be stabilized by simply using the proximal section of the PHILOS plate. This is because the shape and angle of the distal humerus are perfectly suited to the plate.[6]

The purpose of this study was to assess the clinical and radiological results of treating distal humeral shaft fractures using an anterolateral approach with the reversed proximal humeral internal locking system (PHILOS) plate.

Patients and Methods

Internal fixation procedures using the PHILOS plate were carried out on sixteen patients suffering from distal humeral shaft fractures in the orthopedic surgery and traumatology department at Minia University Hospital from August 2022 to August 2023. These procedures were authorized by the local human ethical committee (no: 392/08/2022), and the patients were required to sign an informed consent form.

The study only included participants who met the following criteria: they had to be at least 16 years old, have a fracture site that was more than 3 cm from the coronoid fossa, and have had a recent displaced extra-articular distal-third diaphyseal humeral fracture (within 2 weeks). Floating elbow injury, intraarticular fracture, extraarticular distal humeral fracture classified as 13A (AO), history of any prior surgery on the same humerus, open fracture, pathologic fracture, and age less than 16 years were all factors that were not considered.

All patients had AP and lateral radiographs taken of the full humerus, which includes the elbow and shoulder joints. In order to exclude out intraarticular extension, CT elbow was performed in certain patients.

Age, sex, body mass index (BMI), injury mechanism, related injuries, fracture configuration according to AO/OTA classification, and time-to-operate were all documented.

Surgical technique

Under general anesthesia, every single patient had their procedures done. Each patient had their afflicted arm laid on a radiolucent table, and the surgeon was positioned beside the arm's lateral side.

The surgical intervention commenced by making a distal skin incision of 5 cm, positioned 2.5 cm superior to the antecubital crease. Once the lateral border of the biceps muscle was identified, it was subsequently withdrawn in a medial direction to expose the brachialis muscle (Figure 1a). The musculocutaneous nerve was situated alongside the brachialis muscle on the anteromedial surface. Subsequently, the muscle was longitudinally split, therefore revealing the distal humerus (Fig. 1b).

Dissection was carried out directly to the anterior crest of the proximal humerus after a proximal skin incision was made between the biceps and deltoid muscles (Fig. 1c).

A periosteal elevator was used to establish a submuscular tunnel beneath the brachialis muscle, which connected the proximal and distal windows. The two skin incisions were connected in certain instances of multifragmentary fractures. The radial nerve, situated anatomically between the brachialis and brachioradialis muscles, is safeguarded by the lateral portion of the brachialis muscle. As a result, regular nerve exploration had not been performed.

After the plate was positioned just above the coronoid fossa and parallel to the humeral shaft to prevent restricting elbow range of motion, a fluoroscope was used to confirm the location and length of the plate (Fig. 2). At final fixation, four screws were inserted into the proximal fragment and at least five screws into the distal fragment.

The patient's arm was supported in a sling for the weeks following surgery. As the patient felt comfortable, they began to engage in exercises that required different ranges of motion. Regular radiographic evaluations of the humerus anteroposterior (AP) and lateral views were carried done at 2 weeks, 1 month, and monthly thereafter to ensure bone union (Fig. 3,4).

At the last follow-up, the clinical outcomes were evaluated by looking at elements such as the Oxford elbow score, the Mayo Elbow Performance Score (MEPS) range of motion of the elbow joint and postoperative complications.

Statistical Analysis:

The statistical analysis was performed using IBM SPSS Statistics version 22. Continuous (quantitative) variables were presented as the mean ± standard deviation. Categorical (qualitative) variables were presented as percentages.

Results

Eight months was the mean follow-up time (range, six to twelve months).

The study's demographic data is displayed in table 1.

The distal humeral fragment had a median of six screw fixations, with a range of five to seven. The average extent of elbow motion was found to be 134.37°, with a range of 130° to 140°. The MEP score, on average, was 95.31 ± 6.45 out of a total of 100. Among the patients, 81.2% exhibited excellent outcomes, 18.8% demonstrated good outcomes, and no instances displayed fair or poor outcomes. The average score for the Oxford elbow was 45.25 ± 2.33 out of a total of 48 patients. Among these patients, 93.8% exhibited outstanding outcomes, while 6.3% had good outcomes. No instances shown fair or poor outcomes. All patients achieved fracture union with an average duration of 15.13 ± 3.5 weeks, with a range of 12 to 24 weeks.

A case of superficial infection in one patient was successfully treated with intravenous antibiotics for seven days and multiple dressing changes. The radial nerve palsy that one patient experienced after surgery resolved entirely after three months.

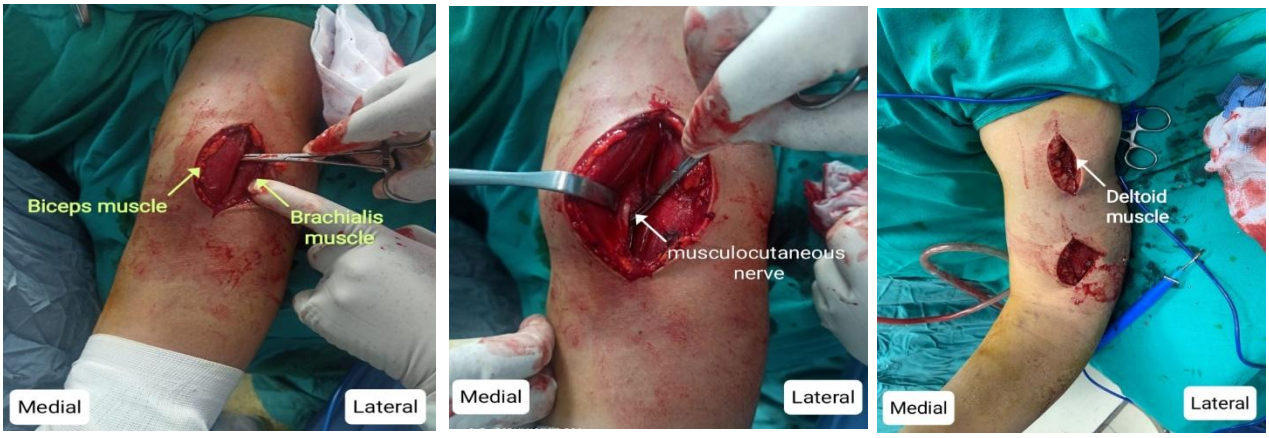

Fig. (1 a): The biceps muscle's lateral border was seen in the distal window before it was drawn back medially to reveal the brachialis muscle. b musculocutaneus nerve was identified. c showing proximal window.

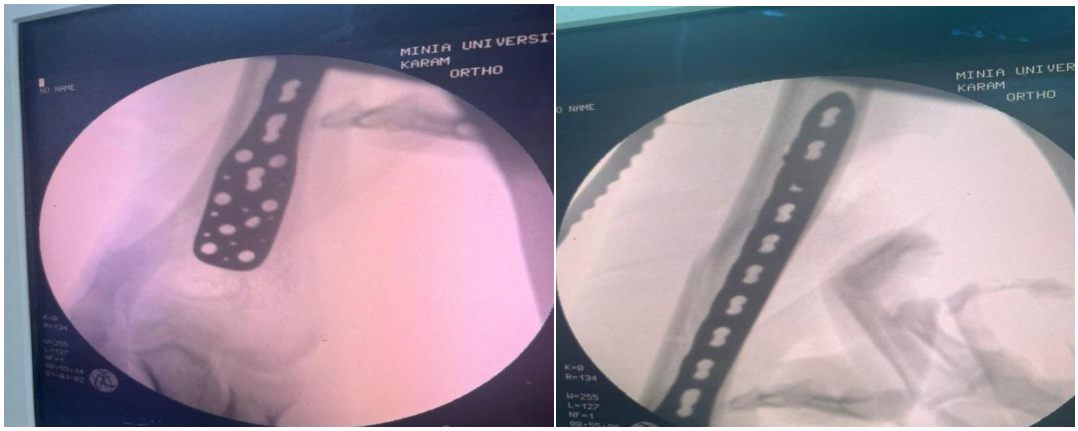

Fig. 1: fluoroscopic images of position and length of the plate.

Table (1): Demographic data of the studied patients

Variable	Studied patients (n=16)	
	Mean ± SD	**Range**
Age (years)	34.56 ± 13.53	18 – 56
BMI (kg/m^2)	24.5 ± 3.27	19 – 31
Normal	9	56.3%
Overweight	6	37.5%
Obese	1	6.3%
Sex	**N**	**%**
Male	9	56.2%
Female	7	43.8%
Comorbidity	**N**	**%**
Asthmatic	1	(6.3%)
DM	1	(6.3%)
HTN	2	(12.5%)
Mechanism of injury	**N**	**%**
Motorcycle accident	6	37.5%
Direct trauma	3	18.8%
Fall from height	2	12.5%
Simple fall	4	25%
Sports injury	1	6.3%
Involved side	**N**	**%**
Right	9	56.2%
Left	7	43.8%
AO/OTA classification	**N**	**%**
12-A1	3	18.8%
12-A2	2	12.5%
12-A3	2	12.5%
12-B1	6	37.5%
12-B2	3	18.8%
Associated injury	**N**	**%**
Fracture ribs	1	6.3%
Fracture shaft ulna	1	6.3%
Head trauma	1	6.3%
Pleural effusion	1	6.3%
Time to operation (days)	2.94 ± 2.46	0 - 8

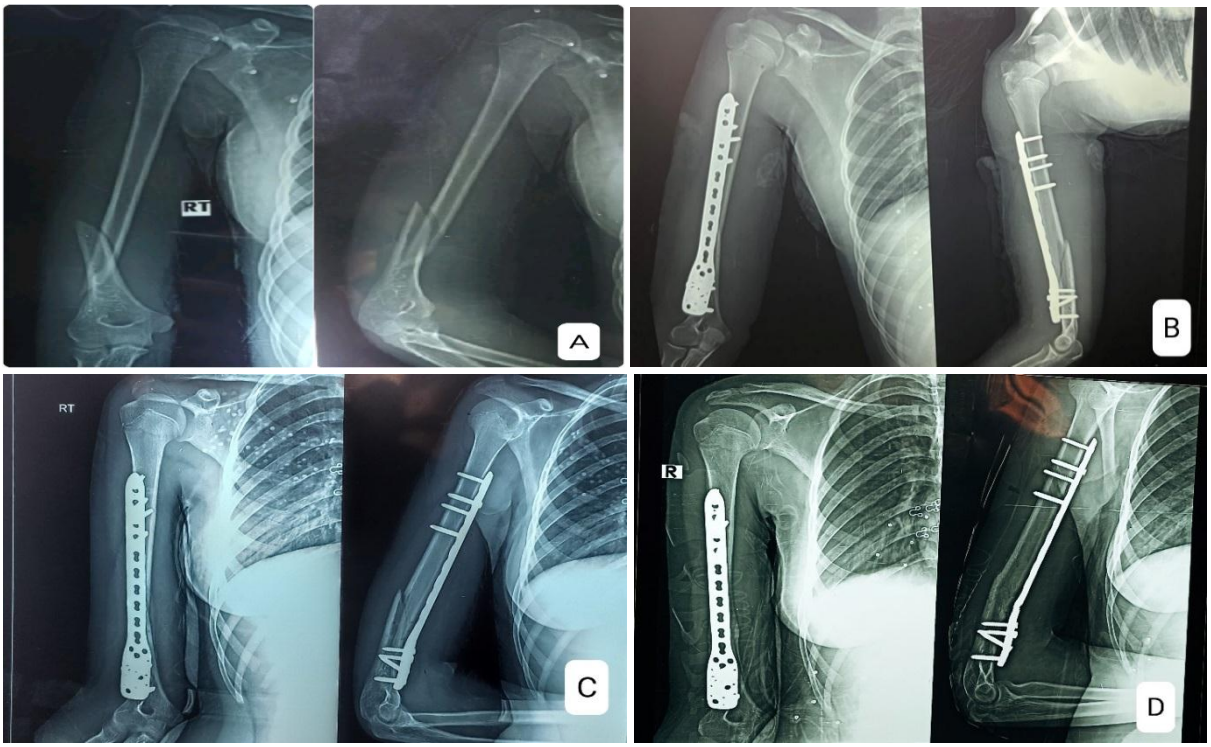

Fig. (4): Pcase of a 18-year-old female came to our emergency department following a fall from height (A) The initial plain radiograph showed a simple spiral fracture (AO/OTA 12-A!). (B) Immediate postoperative radiographs. (C) Radiographs 6 weeks after surgery. (D) Radiographs 3 months after surgery.

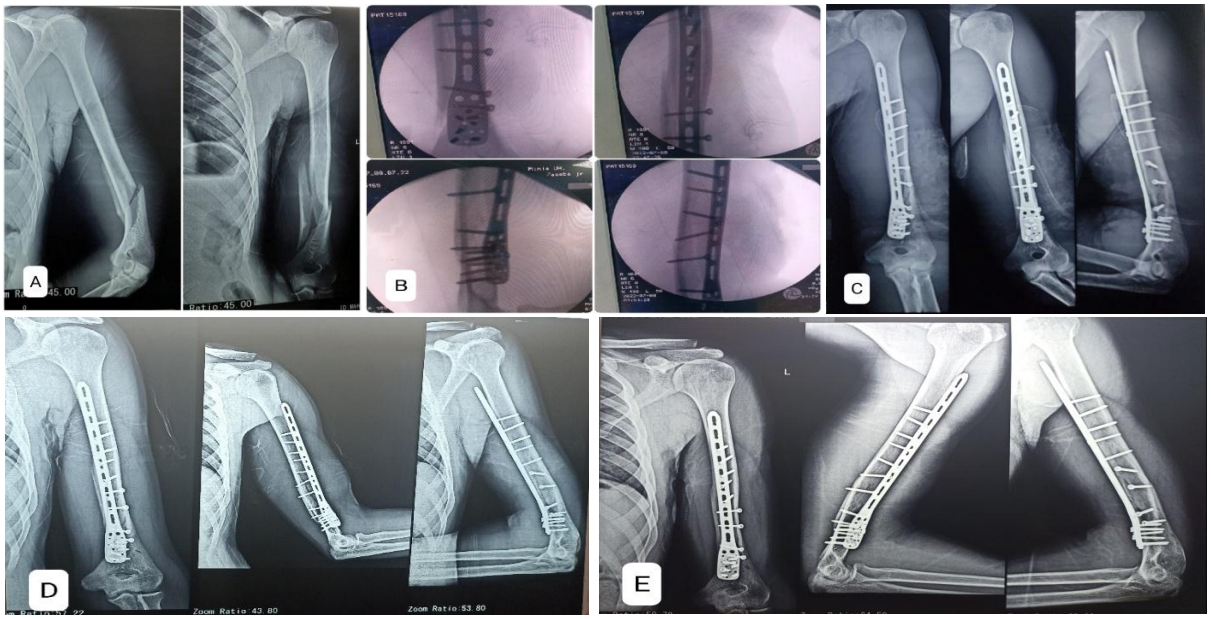

Fig. (3):. case of a 22-year-old male who sustained a fracture duo to sports injury. (A) The initial plain radiograph showed a spiral wedge fracture (AO/OTA 12-B1). (B) fluoroscopic intraoperative images. (C) Immediate postoperative radiographs. (D) Radiographs 8 weeks after surgery. (E) Radiographs 6 months after surgery showed solid bony union.

Discussion

Extraarticular fractures of the distal humerus occur at an anatomical watershed between the humerus shaft and the intercondylar region. Management of these injuries takes a cue from the treatment options for both humeral shafts as well as intercondylar fractures.[1]
Compared to other joints, the elbow requires the highest level of anatomical alignment, complete stabilization, and early mobilization.[1]

Operative fixation has become the preferred method of treating distal humerus fractures, with 75% of patients experiencing excellent to good outcomes. These fractures can be treated and mobilized early with open reduction and plating.[7]

Because the distal diaphyseal fragment (the part of the bone just in front of the olecranon fossa) is usually somewhat small, a long, straight dorsal plate cannot be used for distal fixation. No matter the surgical technique, the radial nerve is at danger, the fragments are usually quite dislocated, and the fracture can be multifocal or contain a third big fragment. Dissection of the medial column of the distal humerus may encase the ulnar nerve.[8]

When it comes to double plating, the complication rate was 31.25% in patients treated with it compared to 4.44% in patients treated with single plating, according to Meloy et al., Mao, Jui-Ting, et al.,, who advocated for single plating rather than double plating, reached the same conclusion: that the former adequately achieved rigid fixation, yielded better early functional outcomes, was associated with a shorter surgical duration, lower blood loss, and fewer complications; and that the latter was associated with a high incidence of implant-related complications such as painful hardware, ulnar neuritis, elbow stiffness, and iatrogenic radial nerve palsy. (9, 10)

Hoon-Sang Sohn et al., reviewed the effectiveness of anterior and posterior plating systems in treating extraarticular distal third diaphyseal humeral fractures. The results showed that, although posterior plating produced satisfactory clinical results and radiological findings in terms of elbow joint union, range of motion, and functional restoration, the posterior plating group experienced more plate-related symptoms, more plate removal procedures, and longer operation times than the anterior plating group. In the posterior plating group, 77% of the patients complained of plate-related problems, such as pain when the elbow struck a hard surface, discomfort during everyday activities, and cosmetic problems because of the prominence of the plate.[6]

This study was conducted on sixteen patients; 56.2% of the patients were males and 43.8% were females. The patient age in this study varied from 18 years to 56 years. Most of the patients were either between 21- 30 years old (25%), or between 45-56 years old (31%).

This came in accordance with Jitprapaikulsarn et al.,[11] and Shin et al.,[12], studies that were conducted on (12 and 18 cases, respectively) while Park et al.,[2] had a relatively small number of cases (9 cases).

Males were more prevalent than females in all studies. The age of cases did not exceed 60 years in all studies, including this study, except Shin et al.,[12] which included elderly patients with an age up to 69 years old.

Motor cycle accident (MCA) was the major cause of injury in this study group, contributing 37.5% (n=6) of the mode of injury. 75% of them were in the age group between (20 – 30 years). Simple falls were the second leading cause of injury in 25% of patients. (n=4) all of them in the age group between 45- 56 years. Three patients were injured from direct trauma, two fell from height, and one patient duo to sports injury. So, it seems that high energy trauma was the common cause of injury in young adults. and low energy trauma was the cause of injury in old patients.

Park et al.,[2] reported that the causes of injury were missteps in five patients, traffic accidents in three patients, and falls in one patient, while Jitprapaikulsarn et al.,[11] reported that eleven patients were injured in motor vehicle accidents and one from a simple fall.
In this study, associated injuries were observed in 25% of cases (n = 4). Three cases involved high-energy trauma (2 cases from a motorcycle accident and one case from falling from height). One patient had an associated fracture of the

distal shaft ulna due to direct trauma (assaulted from others), and this came in accordance with Jitprapaikulsarn et al.,[11], who reported that three patients (25%) had associated injuries. while other studies didn't evaluate it. This series, Park et al.,[2], Jitprapaikulsarn et al.,[11], and Shin et al.,[12] studies exhibited intact radial nerve at the time of surgical intervention in all patients.

According to the AO classification, the most common fracture type in this study was 12-B1, representing 37.5% of patients. Followed by 12-A1 and 12-B2 (18.8%), then 12-A2 and 12-A3 (12.5%). while 13-A was one of the exclusion criteria in this study.

According to Jitprapaikulsarn et al.,[11], out of a total of 12 patients, 6 were classified as 12B and 6 as 12C according to the AO/OTA system.
12A (n = 9), 12B (n=12), and 12C (n = 2) were the three fracture types reported by Shin et al.,[12] based on the AO/OTA classification.
Park et al.,[2] reported that 13-A was the most common fracture type, followed by 12-A and 12-B.

In this study, the mean time to operation was 2.9 days and ranged between (0-8 days). Associated injuries and comorbid medical disorders were the main factors contributing to delayed surgery for up to 8 days. This came in accordance with Shin et al.,[12] study that reported the mean time-to-surgery was 3.5 days. On the other hand, Jitprapaikulsarn et al.,[11] had the shortest time between injury and surgery (26.5 h).

As regards approach and implant of choice, in this study, 12 patients were operated on through the MIPO technique, and in four patients (25%), the proximal and distal incisions had been connected and converted to the conventional anterolateral approach. Three patients had multifragmentary fractures. The fourth patient was obese. So, application of the plate through the tunnel was difficult. (PHILOS) plate was applied in all cases and allowed sufficient screw fixation in the distal fragment, ranging from (5–7) with an average of 5.5.

In the study done by Shin et al.,[12], 15 patients were operated on through a conventional anterolateral approach, and the MIPO technique was used in 10 patients. The average number of screw fixations in the distal humeral fragment was 5.6 (range, 4 - 7).

Park et al.,[2] used the conventional anterolateral approach in all patients, while the MIPO technique was used in all patients in the study done by Jitprapaikulsarn et al.,[11]

Regarding perioperative outcomes, intra-operative blood loss was more elevated in cases of conventional anterolateral approach than in cases of MIPO technique, with averages of 350 mL and 137.5 mL, respectively, while other studies didn't evaluate operative blood loss.

The follow-up period in this study was convergent with Park et al.,[2], with an average of 8 and 9.1 months, respectively. While Jitprapaikulsarn et al.,[11] and Shin et al.,[12] had long follow-up periods with averages of 19.3 and 18.13 months, respectively.

In the current study, all cases were united by 24 weeks; the mean duration of fracture union was 15.13 weeks, which is relatively compatible with Park et al.,[2], Jitprapaikulsarn et al.,[11] and Shin et al.,[12] studies, which found that the mean duration of union was 12.4, 14.8 and 20.8 weeks, respectively.

In this study, the mean range of elbow motion of the elbow was 134.37° (range 130–140). This came in accordance with Shin et al.,[12], Park et al.,[2] and Jitprapaikulsarn et al.,[11] studies that reported that the mean ROM of the elbow was 130.4°, 132.2° and , respectively

In the current study, the mean MEPS was 95.31 (of a total of 100), with 81.2% excellent results and 18.8% good results, and all patients returned to pre-injury daily activities.

This came in accordance with Park et al.,[2], Shin et al.,[12], and Jitprapaikulsarn et al.,[11], studies that reported that the mean MEP score was 87.2, 97.6, and 98, respectively.

The Oxford elbow score in this study was convergent with Park et al.,[2] with a mean of 45.31 and 43.3 (a total of 48), respectively, while other studies didn't utilise it.

Regarding postoperative complications, this study showed that one patient had postoperative radial nerve palsy and another suffered from superficial wound infection. No other complications occurred, such as implant failure or elbow stiffness.

The first patient completely recovered within 3 months. The case of the superficial wound infection was diabetic, and the infection resolved with 7 days of intravenous antibiotics and repeated dressings; therefore, she did not need any surgical debridement.

Neither Park et al.,[2] nor Jitprapaikulsarn et al.,[11] nor Shin et al.,[12] found any postoperative problems that necessitated a second operation, including infection, screw pullout, neurovascular impairment, or plate breaking.

No patient complained of discomfort due to plate irritation in studies using the (PHILOS) plate, including this study, and no patient underwent plate removal during the follow-up period except 3 patients (13%) in the study done by Shin et al.,[12], who performed removal upon patient request.

Conclusion

Clinical and radiological results were good when a modified anterior application of the PHILOS plate was used to treat extra-articular distal-third diaphyseal humeral fractures. It may be a reasonable option for a distal humeral shaft fracture with a short distal fragment. Alternative methods and implants may be more appropriate in cases where the fracture-to-coronoid distance (FCD) is less than 3 cm.

References

1. Sharma B, Shakunt RK, Kumar A, Patel J, Gahlot S, Pal CP. To evaluate the outcome of posterolateral plate in distal humerus fracture. Journal of Bone and Joint Diseases. 2023 Sep 1;38(3):225-31.
2. Park JH, Kim JW, Oh CH, Choi KS, Hong JY, Kim JG. PHILOS plate osteosynthesis in metaphyseal fractures of the distal humerus through an anterolateral approach. Clinics in Shoulder and Elbow. 2015 Sep;18(3):128-32.
3. Kar R, Kumar S, Garg AK. Distal humerus extraarticular fractures with large butterfly fragment: How we deal with it. International Journal of Orthopaedic Surgery. 2022 Jan 1;30(1):3-7.
4. Orapiriyakul W, Apivatthakakul V, Theppariyapol B, Apivatthakakul T., Humerus shaft fractures, approaches and management. Journal of Clinical Orthopaedics and Trauma, 2023: p. 102230.
5. Thorat B, Singh A, Vohra R, Arshad M, Mavani R. Modified application of distal medial tibial locking plate as an alternative for fixation of an extraarticular distal-third diaphyseal humerus fracture. Trauma Case Reports. 2021 Aug 1;34:100420.
6. S Shin SJ, Kwak JW, Sohn HS. Comparison between anterior and posterior plating systems in extra-articular distal-third diaphyseal humeral fractures. International Orthopaedics. 2022 Sep;46(9):2119-26.
7. El Mahboub N, Arafat W. Open reduction and internal fixation of extra-articular comminuted distal humerus fractures by double-plating osteosynthesis. The Egyptian Orthopaedic Journal. 2012 Dec 1;47(4):393-8.
8. Druel T, Burnier M, Herzberg G. Long dorsal “Y-shaped” plate for distal diaphyseal humeral fractures. International Orthopaedics. 2021 May;45:1309-14.
9. Mao JT, Chang HW, Lin TL, Lin IH, Lin CY, Hsu CJ. Clinical outcomes of single versus double plating in distal-third humeral fractures caused by arm wrestling: A retrospective analysis. Medicina. 2022 Nov 15;58(11):1654.
10. Meloy GM, Mormino MA, Siska PA, Tarkin IS. A paradigm shift in the surgical reconstruction of extra-articular distal humeral fractures: single-column plating. Injury. 2013 Nov 1;44(11):1620-4.
11. Jitprapaikulsarn S, Neti N, Thremthakanpon W, Gromprasit A. Anterior minimally invasive plating osteosynthesis using reversed proximal humeral internal locking system plate for distal humeral shaft fractures. European Journal of Orthopaedic Surgery & Traumatology. 2020 Dec;30:1515-21.
12. Sohn HS, Shin SJ. Modified use of a proximal humeral internal locking system (PHILOS) plate in extra-articular distal-third diaphyseal humeral fractures. Injury. 2019 Jul 1;50(7):1300-5.