Original Article

Analysis of the clinical effect of the concept of "shoulder preservation" in the treatment of proximal humeral fractures: a retrospective cohort study of 66 patients

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Background: The three- and four-part fractures of the proximal humerus are often combined with rotator cuff injury, and shoulder joint replacement is often selected clinically. The concept of "shoulder preservation" can greatly restore the function of the shoulder joint through internal fixation of the proximal humerus fracture and rotator cuff suture. This study investigated the clinical effect of the concept of "shoulder preservation" in the treatment of three- and four-part fractures of the proximal humerus.

Methods: We conducted a retrospective analysis of 66 patients with proximal humeral fractures (PHFs) who were treated at the Affiliated Hospital of Qinghai University between 2016 and 2019. The patients were divided into 3 groups according to the Neer fracture classification system, and the fracture healing time of the 3 groups was compared. A visual analog scale (VAS) was used to evaluate the pain, and the Neer score was used to evaluate shoulder joint function.

Results: The operations were successfully completed and the 3 groups of patients were compared in pairs. All incisions healed by first intention after operation, and no early complications occurred. The average follow-up time was 18 months. All fractures had healed. The VAS score of the 3 groups of patients was 1.5±0.5 at 1 month after operation and 1.0±0.5 at the final follow-up, which was significantly improved compared with preoperative scores, although the difference was not statistically significant ($P>0.05$). The Neer scores of the first group of patients at 1, 3, and 9 months postsurgery were higher than those of the second and third groups, and the difference was statistically significant ($P<0.05$). There was no significant difference among the 3 groups in Neer score 12 months after the operation ($P>0.05$).

Conclusions: Proximal humeral internal locking osteosynthesis system (PHILOS) fixation + rotator cuff suture is a reliable treatment method involving a simple operation, firm fixation, and good postoperative recovery. It can restore shoulder joint function to the greatest extent, but it also has some shortcomings, including slow recovery time.

Keywords: Proximal humeral fractures (PHFs); rotator cuff; proximal humeral internal locking osteosynthesis system (PHILOS); internal fixation; shoulder preservation

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Introduction

Proximal humeral fractures (PHFs) account for 6% of all body fractures (1) and is the third most common osteoporotic fracture after the distal radius and vertebrae. PHF is common in elderly patients with osteoporosis (2), and the incidence rate increases with age (3). The Neer (4) classification system divides PHF into one-, two-, three-, and four-part fractures. Three- and four-part fractures often involve rotator cuff injuries. For such patients, proximal humeral plate internal fixation, interlocking intramedullary nailing, and reverse shoulder arthroplasty are often used clinically (5). Internal fixation of proximal humerus plate for the treatment of proximal humeral fractures is commonly used clinically, but it has many complications, such as shoulder stiffness, humeral head necrosis, and malunion. Interlocking intramedullary nailing in the treatment of proximal humerus fractures requires less stripping of soft tissue and faster fracture healing, but it is easy to damage the rotator cuff during the operation, which is not conducive to postoperative functional exercise. The reverse shoulder arthroplasty is traumatic and has a high surgical risk. For patients with three- and four-part proximal humerus fractures, the surgical method of plate internal fixation + rotator cuff suture can effectively avoid the complications of internal plate fixation alone, and the effect is similar to that of patients with proximal two-part fractures of the humerus. This can effectively avoid reverse shoulder arthroplasty and protect the shoulder joint as much as possible. In this retrospective study, patients were divided into 3 groups: the first group underwent proximal humeral internal locking osteosynthesis system (PHILOS) fixation, and the second and third groups underwent PHILOS fixation + rotator cuff suture. We believe that the recovery of patients in the second and third groups is not significantly different from the first group. We present the following article in accordance with the STROBE reporting checklist (available at https://apm.amegroups.com/article/view/10.21037/apm-22-195/rc).

Methods

General information

We used a cohort study. A total of 66 patients with PHFs who underwent surgical treatment at the Affiliated Hospital of Qinghai University between January 2016 and June 2019 were selected. The patients included 25 males and 41 females, aged 32–87 years, with an average age of 72.3 years. The operation interval after injury was 1 to 9 days, with an average of 3.5 days. The injuries were caused by car accident (3 cases), falling from a height (5 cases), falling (54 cases), and crushing (4 cases). The patients were divided into 3 groups based on the Neer classification system, including 11 cases of two-part fractures (group 1), 31 cases of three-part fractures (group 2), and 24 cases of four-part fractures (group 3). The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). Ethical approval was waived by ethics committee of Affiliated Hospital of Qinghai University. All patients were aware of the contents of this study and signed an informed consent form voluntarily.

Inclusion and exclusion criteria

The inclusion criteria were: (I) patients who were diagnosed with PHFs after imaging examinations and required surgical treatment; (II) patients with normal nerve function and able to communicate without barriers; (III) patients without history of other serious diseases; and (IV) patients who were conscious.

The exclusion criteria were: (I) patients with an old fracture of the proximal humerus; (II) pregnant or lactating women; (III) patients <20 years old; (IV) patients with severe cardiac, liver, or renal insufficiency; (V) patients who had contraindications to the treatment methods involved in the study; and (VI) subject suspension or withdrawal.

Surgical methods

The surgical procedure used in the first group was PHILOS fixation. Under brachial plexus block anesthesia, the patient was placed in the supine position, routinely sterilized with iodophor, and covered with a sterile sheet before an incision of about 12 cm was made along the pectoralis major deltoid approach. The skin and subcutaneous tissue were cut, and the pectoralis major and deltoid muscles were bluntly separated from the proximal humerus. During the separation process, the cephalic vein and axillary nerve were protected while the fractured end was fully exposed and blood crust and incarcerated soft tissue were removed. Under direct vision, the fracture was reduced and temporarily fixed with Kirschner wires. The proximal humerus locking plate was then placed 0.5–0.8 cm below the lateral greater tubercle and 0.4–0.6 cm behind the intertubular groove. The "C" arm fluoroscopy confirmed good fracture reduction. Holes were then drilled and fixed with locking screws (4–9 at the

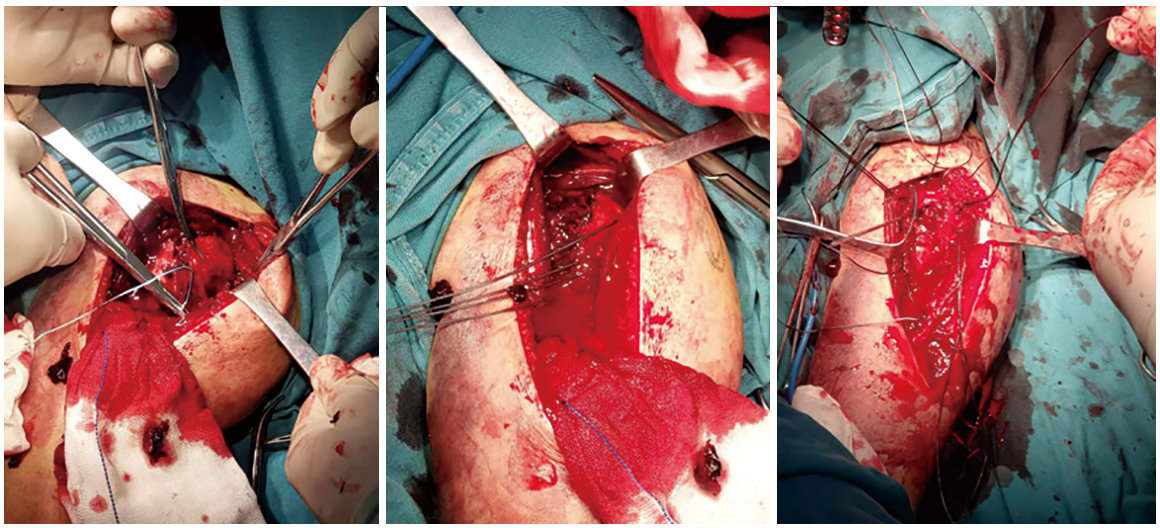

Figure 1 ETHIBOND No. 5 nonabsorbable suture was used to pass through the teres minor tendon, infraspinatus tendon, supraspinatus tendon, and subscapularis tendon.

proximal end and 2–4 at the distal end). The "C" arm was used again to confirm that the reduction was sufficient and the internal fixation firm. Finally, a drainage tube was placed, the surgical port flushed, the incision closed layer by layer, and the operation completed.

The surgical technique used in the second and third groups was PHILOS fixation + rotator cuff suture. Under brachial plexus block anesthesia, the patient was placed in the supine position, routinely sterilized with iodophor, and covered with a sterile sheet before an incision was made of about 12 cm along the pectoralis major deltoid approach. The skin and subcutaneous tissue were cut, and the pectoralis major and deltoid muscles were bluntly separated from the proximal humerus. During the separation process, the cephalic vein and axillary nerve were protected while the fractured end was fully exposed and blood crust and incarcerated soft tissue were removed. Next, ETHIBOND No. 5 nonabsorbable suture was passed through the teres minor tendon, the needle of the suture was cut, and the thread set aside. In the same way, ETHIBOND No. 5 nonabsorbable suture was passed through the infraspinatus tendon, supraspinatus tendon, and subscapularis tendon (*Figure 1*). Under direct vision, the fracture was reduced and temporarily fixed with Kirschner wires. Afterwards, the proximal humerus locking plate was placed 0.5–0.8 cm below the lateral greater tubercle and 0.4–0.6 cm behind the intertubular groove. The ETHIBOND No. 5 thread that passed through the rotator cuff was passed through the outer hole through the steel plate (*Figure 2*), and the fracture reduction was confirmed through "C" arm fluoroscopy. Holes were drilled and fixed with locking screws (4–9 at the proximal end and 2–4 at the distal end). The ETHIBOND No. 5 suture was then knotted in turn, the rotator cuff fixed, and the fractured end reinforced and fixed (*Figure 3*). The "C" arm was used again to confirm that the reduction was sufficient and the internal fixation firm. Finally, a drainage tube was placed, the surgical port flushed, the incision closed layer by layer, and the operation completed.

Postoperative treatment

The drainage tube was removed 24 hours postsurgery, antibiotics were routinely used for 48 hours after the operation, and the upper limb was suspended and fixed with a wrist band for 2 weeks. Patients were encouraged to start active wrist and elbow joint exercises on the first day after surgery and to start shoulder joint exercises on the second day, including active and passive flexion, abduction, external rotation, and lifting, gradually strengthening active activities. There was no weight-bearing exercise until the fracture was fully healed.

Curative effect evaluation index

The fracture healing time of the 3 groups was compared. A visual analog scale (VAS) (6) was used to evaluate the pain

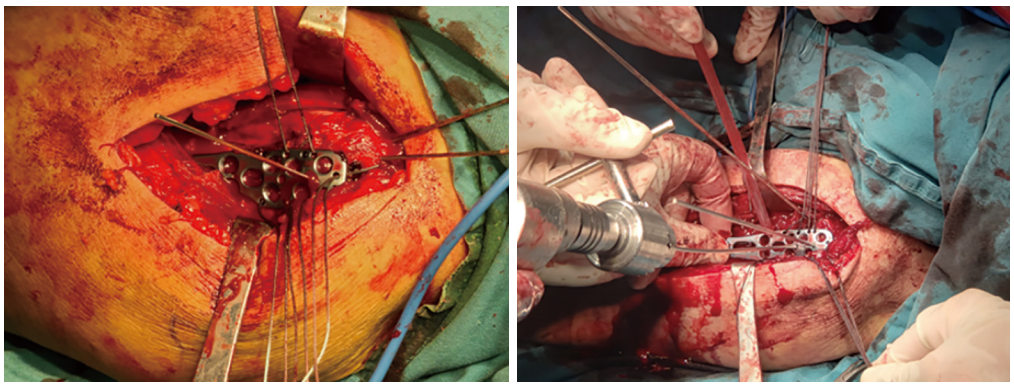

Figure 2 The ETHIBOND No. 5 thread that passed through the rotator cuff was passed through the outer hole through the steel plate.

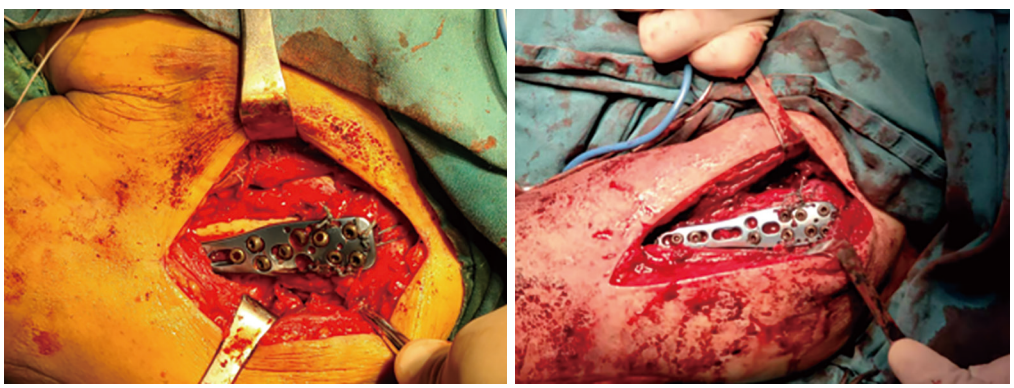

Figure 3 ETHIBOND No. 5 suture was knotted in turn, and the rotator cuff was fixed.

1 month after the operation, and the Neer scoring system was used to evaluate shoulder joint function at 1, 3, 9, and 12 months postoperation. The total score was 100 points.

Statistical methods

SPSS 25.0 software was used to process the experimental data. Pairwise comparisons were made between the experimental data. The measurement data conformed to a normal distribution and was expressed as mean ± standard deviation ($\bar{x}\pm s$). Analysis of variance (ANOVA) was used, with α=0.05 considered significant.

Results

The operations were successfully completed and the 3 groups of patients were compared in pairs. Patient hospital stay was 6–11 days, with an average stay of 8 days. All incisions healed by first intention after operation, and no early complications, such as infection, occurred. Follow-up time was 12–22 months, with an average of 18 months. X-ray reexamination showed that all fractures had healed. The healing time of the 3 groups was between 3–6 months, and the difference was not statistically significant (P>0.05; *Tables 1*,*2*). The VAS score of the 3 groups of patients was 1.5±0.5 at 1 month postoperation and 1.0±0.5 at the last follow-up, which was significantly improved compared with preoperative scores, although the difference was not statistically significant (P>0.05, *Tables 1*,*2*). The Neer scores of the first group of patients for shoulder joint function at 1, 3, and 9 months postsurgery were higher than those of the second and third groups, and the difference was statistically significant (P<0.05, *Tables 1*,*2*). There was no significant difference among the 3 groups in Neer score for shoulder joint function at 12 months postoperation (P>0.05, *Tables 1*,*2*).

Typical cases

Typical case 1: a 56-year-old female patient with a

Table 1 Patient data for the first group and second group

Group	n	VAS score (postoperation)		Neer score (postoperation)			
		Healing time (month)	1 month (points)	1 month (points)	3 months (points)	9 months (points)	12 months (points)
Group 1	11	2.90±0.82	1.50±0.50	79.73±1.85	83.09±1.51	91.27±2.69	96.45±1.51
Group 2	31	3.20±0.89	1.50±0.50	75.97±2.36	80.84±2.10	89.55±1.55	95.06±2.17
t value		0.979	0	4.777	3.259	2.591	1.953
P value		>0.05	>0.05	<0.05	<0.05	<0.05	>0.05

This table compares healing time, VAS score, and Neer scores in the first group and second group of patients. VAS, visual analog scale.

Table 2 Patient data for the first group and third group

Group	n	VAS score (postoperation)		Neer score (postoperation)			
		Healing time (month)	1 month (points)	1 month (points)	3 months (points)	9 months (points)	12 months (points)
Group 1	11	2.90±0.82	1.50±0.50	79.73±1.85	83.09±1.51	91.27±2.69	96.45±1.51
Group 3	24	3.52±0.93	1.50±0.50	70.79±1.69	77.88±2.13	88.13±2.29	94.58±3.43
t value		1.896	0	14088	7.287	3.577	1.722
P value		>0.05	>0.05	<0.05	<0.05	<0.05	>0.05

This table compares healing time, VAS score, and Neer scores in the first group and third group of patients. VAS, visual analog scale.

fracture of the proximal right humerus caused by a fall and dislocation of the shoulder joint underwent PHILOS fixation + rotator cuff suture. The fracture healed 3 months after the operation. The preoperative VAS score was 9 points and the Neer score was 12 points. The VAS score 1 month postsurgery was 1.0, the Neer score 3 months postsurgery was 65, and the NEER score 12 months after surgery was 80 (*Figure 4*).

Typical case 2: a 36-year-old male patient with a comminuted fracture of the proximal left humerus caused by a car accident underwent PHILOS fixation + rotator cuff suture operation. The fracture healed 5.5 months after the operation. The preoperative VAS score was 9 points, and the Neer score was 15 points. The VAS score was 1.5 in the first month, and the Neer score was 81 twelve months after the operation (*Figure 5*).

Discussion

For three- and four-part fractures, it is often difficult to obtain stable fixation due to comminution and poor bone quality (7), with extramedullary fixation, intramedullary fixation, and humeral head replacement as possible treatment options (8). The locking plate of the proximal humerus has the characteristics of stable angulation, reliable fixation, protection of the blood supply of the fractured end, and low incidence of avascular necrosis of the humeral head, but its postoperative complications are high. Humeral head and reverse shoulder joint replacement is an effective method for the treatment of three- and four-part fractures, but it involves significant trauma and high surgical risk.

A retrospective study of 294 patients by Spross *et al.* (9) showed that the complication rate of PHFs treated with locking plates was 28.2%, the reoperation rate was 24.5%, and 6.8% of patients had bacterial necrosis of the humeral head. Oldrini *et al.* (10) raised proximal humerus synthesis with a PHILOS plate has high complications and reintervention rates. The most frequent complication was screw cut-out, followed by humeral head AVN and subacromial impingement. Gardner *et al.* (11) raised the issue of medial support after reduction during surgery for the treatment of PHFs. After surgical reduction, a locking plate (Synthes, Paoli, PA, USA) was placed and the rotator cuff was fixed with nonabsorbable sutures to the hole in the steel plate. In a further study, Gardner *et al.* (12) devised a technique for using a segment of fibula allograft, placed endosteally and incorporated into the locking construct, to aid in the reduction and restoration of the mechanical integrity of the medial column of the proximal humerus. Cha *et al.* (13) reported that fixation using a locking plate

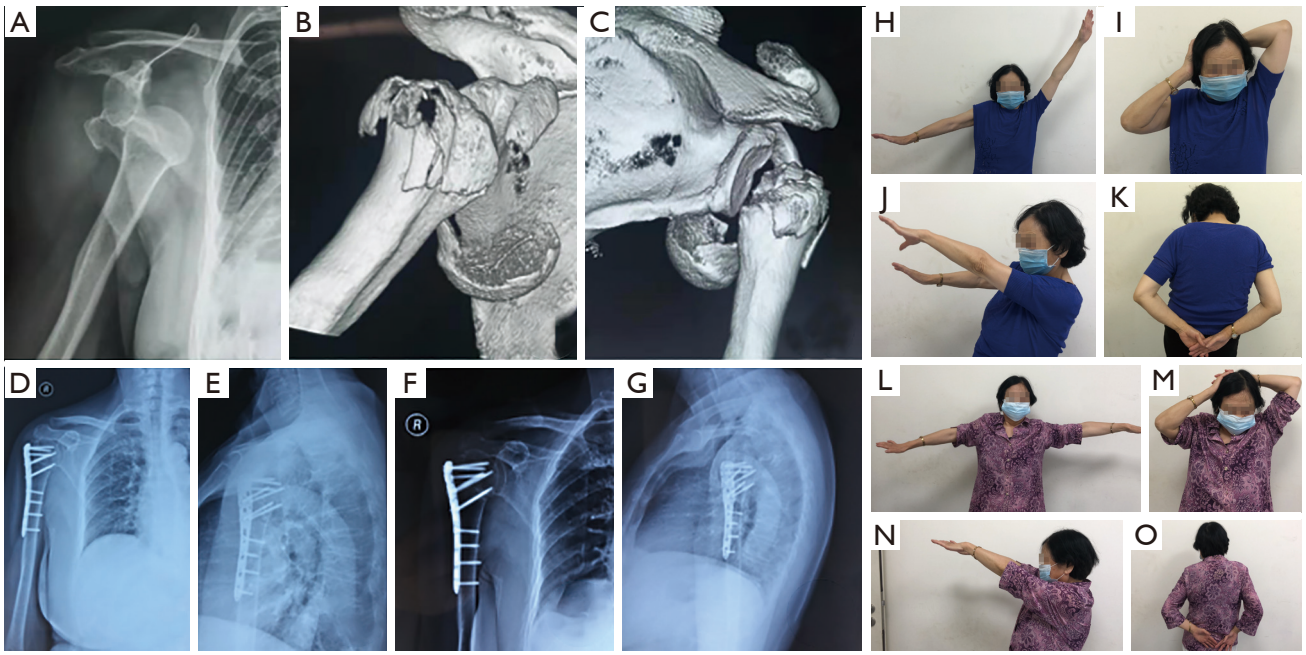

Figure 4 A typical case underwent PHILOS fixation + rotator cuff suture operation. (A-C) X-ray and CT before operation. (D,E) Postoperative X-ray. (F,G) X-ray 12 months postoperation. (H-K) Functional photos of patient 3 months postoperation. (L-O) Functional photos of patient 12 months postoperation. PHILOS, proximal humeral internal locking osteosynthesis system; CT, computed tomography. The images are published with the participant's consent. The "R" in (D) and (F) means the right side.

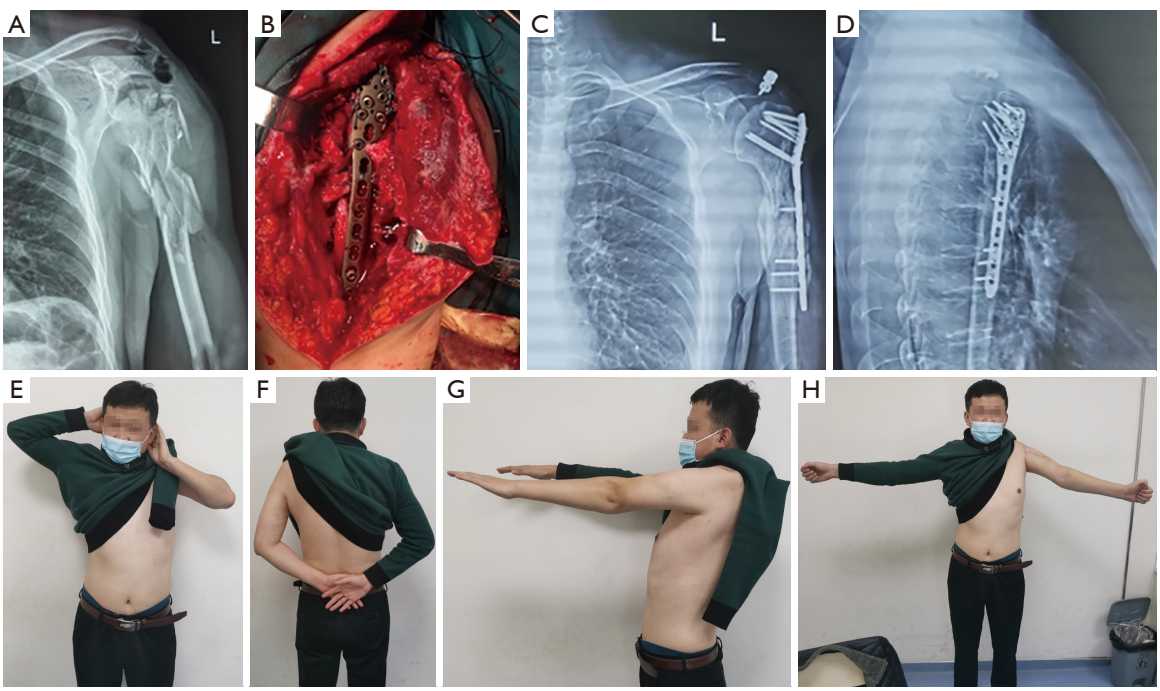

Figure 5 A typical case underwent PHILOS fixation + rotator cuff suture operation. (A) X-ray before operation. (B) Intraoperative photo. (C,D) Postoperative X-ray. (E-H) Functional photos of patient 12 months postoperation. PHILOS, proximal humeral internal locking osteosynthesis system. The images are published with the patient/participant's consent. The "L" in (A) and (C) means the left side.

with an endosteal strut allograft could be considered a reasonable option for maintaining anatomic reduction in elderly patients with comminuted PHF. A meta-analysis by Dasari (14) showed that 95% of patients with proximal humerus fractures treated with a locking compression plate (LCP) augmented with a fibular allograft will have improved radiographic outcomes, improved ASES clinical outcome scores, and decreased odds of a major complication when compared to patients treated with an LCP alone. Xing *et al.* (15) believed that a fibular allograft combined with locking plate could be a new and effective treatment for PHFs. However, the long-term follow-up results were insufficient, the final fibula outcomes uncertain, and the long-term potential adverse reactions caused by this treatment remain unknown. Caforio *et al.* (16) used Diphos Proximal Humeral Nail treatment in PHFs, highlighting the essential features of this new kind of endomedullary humeral nail to allow for early rehabilitation without creating displacement or consolidation delay. Ye *et al.* (17) found that finite element analysis has made some progress in the study of PHFs. This powerful tool could be used for routine clinical management and appropriate simulation, but more studies are needed to provide an evidence base. Kloub *et al.* (18) reported that intramedullary nailing could be used as a possible fixation technique for the treatment of four-part fractures of proximal humerus. In experienced hands, nailing osteosynthesis provided similar results to reconstruction with locking plates. Appropriate reduction of fracture fragments is the key for good functional result. Cvetanovich *et al.* (19) found that reverse total shoulder arthroplasty has gained popularity for the treatment of complex PHFs due to a rapid recovery of active elevation and daily living activity function. Although complications remain a concern, early results of reverse total shoulder arthroplasty for PHFs have been promising. D'Ambrosi *et al.* (20) reported that the Galaxy Fixation System was a safe and efficient procedure for the treatment of three- and four-part PHFs, providing an excellent outcome.

The ultimate goal of PHF treatment is to restore the function of the shoulder joint. PHILOS fixation combined with rotator cuff reconstruction is similar to the "net bags" structure. It is used to treat three- and four-part fractures of the proximal humerus and can stabilize fractures and reconstruct soft tissues to achieve the purpose of "compromising soft and hard". Additionally, during fracture reduction, the subscapularis tendon is not cut off, the rotator cuff is not separated, and best efforts are made to protect shoulder joint-related tissues.

In summary, PHILOS fixation + rotator cuff suture is a reliable treatment method that is easy to operate, providing firm fixation and good postoperative recovery. It can restore shoulder joint function to the greatest extent, but it also has some shortcomings, such as longer functional recovery time. Due to the small number of cases in our study, there may be a certain bias in the evaluation of clinical efficacy. In the later stage, the sample size needs to be expanded for further observation. With advancements in medical treatments, the concepts of "knee preservation" (21), "hip preservation" (22), and "ankle preservation" (23) are being accepted and adopted by more and more orthopedic doctors. Therefore, we put forward the "shoulder preservation" initiative and call on orthopedic doctors to reduce shoulder joint replacements and continue to explore new "shoulder preservation" surgical procedures.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://apm.amegroups.com/article/view/10.21037/apm-22-195/rc

Data Sharing Statement: Available at https://apm.amegroups.com/article/view/10.21037/apm-22-195/dss

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://apm.amegroups.com/article/view/10.21037/apm-22-195/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). Ethical approval was waived by ethics committee of Affiliated Hospital of Qinghai University. All patients were aware of the contents of this study and signed an informed consent form voluntarily.

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