New, Minimally Approach for Middle and Distal Third Humeral Shaft Fractures a Cadaveric Study and Clinical Case Series

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Abstract

Purpose Fractures of the humeral shaft, especially the treatment of extraarticular fractures of the distal third of the humerus, which is a challenge. We hypothesize that a new feasibility and safety minimally invasive surgical approach can be used for the treatment of middle-and distal-third humeral fractures. The main purpose of this study was to evaluate this new approach and develop it.

Methods In 13 adult cadaver arms, a minimally invasive surgical approach to the anteromedial humerus was simulated, followed by fixation with a locking compression plate and the measurement of several sets of anatomical data to clarify the possible risk of iatrogenic vascular and nerve injury in this surgical approach. Between 2017 and 2019 in 18 patients with humeral fractures who were treated with this surgical approach.

Results Patients were followed for average 20.1 months (range, 15 – 34 months). The distance from the vertex of the medial epicondyle to the median nerve was 2.96 cm (range, 2.30 – 3.40 cm). The distance from the tip of the distal end of the screw in the medial epicondyle to the ulnar nerve was 1.7 mm (range, 0.00 – 4.00 mm). The shortest distance between the Olecranon Fossa and the tip of the screws at the distal end of the plate in the medial humeral epicondyle was 0.69 mm (range, 0.00 – 7.00 mm). The distance from the vertex of the epicondyle to the intersection of the median nerve and the distal end of the underlying steel plate was 6.28 cm (range, 5.70 – 6.90 cm).

Conclusions This approach does not cause iatrogenic neurovascular injury and provides sufficient strength for the fixation of fractures of the middle and distal thirds of the humerus. This approach can be used as an alternative in the treatment of extraarticular fractures of the middle and distal thirds of the humerus.

Type of study/level of evidence Therapeutic Level IV.

Introduction

In most cases, humeral shaft fractures can be treated nonsurgically, but research results have shown that compared with functional braces, initial surgery promotes early functional exercise in patients and enables a faster and more predictable recovery process.¹

Anterolateral open reduction or minimally invasive plating for internal fixation are common treatment methods. However, these methods involve great trauma and risk of iatrogenic radial nerve injury of 8.3%. Especially for fractures of the distal third of the humeral shaft, nonsurgical treatment leads to greater rates of angular deformity and joint stiffness. Surgical treatment is still the preferred method of most orthopedic surgeons, and the posterior approach is the most common approach but is more traumatic, with a greater incidence of joint replacement.²

Minimally invasive plate osteotomy (MIPO) is emerging as an effective alternative.³ In the treatment of humeral shaft fractures, three surgical approaches, the anterior approach, anterolateral approach, and posterior approach, are commonly used. Each has its advantages and disadvantages. To the best of our knowledge, there is a paucity of published literature evaluating a minimally invasive anteromedial approach for the treatment of middle and distal humeral fractures or conducted related case series studies.⁴

We hypothesize that the use of a minimally invasive anteromedial approach for internal fixation in the treatment of middle humeral fractures does not carry the risk of radial nerve injury and that this approach can be used to treat middle and distal humeral fractures. The purpose of this study was to evaluate the feasibility of this new minimally invasive anteromedial surgical approach for the fixation of extra-articular fractures of the middle and distal humeral shaft.

Materials And Methods

Cadaveric verification study

The study was approved by the hospital's ethics committee. In all, 13 adult cadaver arms (8 left arms and 5 right arms) were used. The donors had no history of deformity or upper extremity surgery. First, the medial epicondyle was palpated, and the skin was cut 3–4 cm proximal to the medial edge of the intermuscular sulcus of the biceps. Then, the gap between the biceps and triceps was determined, the basal vein and the medial cutaneous nerve of the forearm were identified and protected, and the brachial muscle fascia was cut to expose the anteromedial surface of the distal humerus. The brachialis muscle was retracted laterally to protect the anterior blood vessels and nerves, while the triceps brachii protected the posterior ulnar nerve. Then, the pronator teres muscle was retracted medially to expose the upper part of the medial condyle of the humerus and allow steel plate insertion.

The locking compression plate (LCP) was placed on the skin, and the Location of the incision at the proximal humerus was determined. By palpation, the gap between the proximal end of the proximal biceps and the pectoralis major was determined. After the skin was cut, the long head of the biceps brachii tendon was identified, the long head of the biceps brachii tendon was pulled to the medial, and dissection was continued down to the proximal anteromedial surface of the humeral shaft between the pectoralis major and the long head of the biceps brachii tendon.

The 12-hole LCP was inserted with a locking drill sleeve through the distal incision. Under the brachialis, a soft tissue tunnel was established on the anteromedial side of the humerus. The plate was inserted and positioned with two locking sleeves on the anteromedial surface of the humerus (Fig. 1A).

After the LCP was inserted, the MIPO tunnel was exposed through the distal and proximal incisions. Along the gap between the biceps brachii and triceps brachii, the underlying neurovascular structure was exposed. The relevant measurements were as follows: (1) parallel to the long axis of the humerus, the distance from the medial base of the humeral head to the intersection of the median nerve and the proximal end of the underlying steel plate, i.e., the safe area for proximal screw placement (Fig. 1B); (2) the vertical distance from the vertex of the medial epicondyle to the median nerve (Fig. 2A); (3) the distance from

the vertex of the epicondyle parallel to the long axis of the humerus to the intersection of the median nerve and the distal end of the underlying steel plate, i.e., the safe area for distal screw placement (Fig. 2B); (4) the mean distance from the medial condyle to the base of the coronal fossa (each specimen was measured 3 times, and the average was taken) (Fig. 2C); (5) located on the medial epicondyle, the distance between the tip of the bicortical screw and the ulnar nerve, which is crossed by the distal end of the plate with 4 screws (Fig. 2.D); and (Fig. 2.E) distance between the olecranon fossa and the tip of the 4 screws at the distal end of the plate in the medial humeral epicondyle. (6) the length of the humerus from the greater tuberosity to the apex of the lateral condyle, along with the width of the inner and outer condyles of the humerus; (Table 1).

Table 1
Analysis of measurement variability

Measurement area	Range of data.	Mean $\pm$ SD	95%CI
1. The distance from the medial condyle to the base of the coronal fossa (cm)	1.07–1.53	1.31 $\pm$ 0.175	1.21–1.41
2 The vertical distance from the vertex of the medial epicondyle to the median nerve (cm)	2.30–3.40	2.96 $\pm$ 1.62	2.79–3.14
3. The length of humerus. (cm)	27.0–32.5	29.22 $\pm$ 1.62	28.24–30.2
4. The width of medial epicondyle to lateral epicondyle of humerus(cm)	5.2–6.78	6.15 $\pm$ 0.56	5.81–6.48
5. The distance from the vertex of the epicondyle to the intersection of the median nerve and the distal end of the underlying steel plate. (cm)	5.70–6.90	6.28 $\pm$ 0.39	6.05–6.52
6. The distance from the medial base of the humeral head to the intersection of the median nerve and the proximal end of the underlying steel plate. (cm)	7.00 – 10.60	8.88 $\pm$ 0.96	8.30–9.47
7. Located on the medial epicondyle, the distance between the tip of the bicortical screw and the ulnar nerve, which is crossed by the distal end of the plate with 4 screws. (mm)			
(1). First distal screw of the plate	0.00–4.00	1.70 $\pm$ 1.25	0.94–2.45
(2). Second distal screw of the plate	4.00–10.00	7.00 $\pm$ 1.91	5.84–8.16
(3). Third distal screw of the plate	10.00–18.00	14.23 $\pm$ 1.88	13.10–15.37
(4). Fourth distal screw of the plate	18.00–23.00	20.00 $\pm$ 1.47	19.11–20.89
8. Distance between the Olecranon Fossa and the tip of the 4 screws at the distal end of the plate in the medial humeral epicondyle. (mm)			
(1). First distal screw of the plate	0.00–12.00	6.85 $\pm$ 3.31	4.84–8.84
(2). Second distal screw of the plate	0.00–3.00	1.31 $\pm$ 1.03	0.68–1.93
(3). Third distal screw of the plate	0.00–7.00	0.69 $\pm$ 1.93	-0.47–1.85
(4). Fourth distal screw of the plate	1.00–10.00	6.23 $\pm$ 2.68	4.61–7.85
Mean $\pm$ SD = Mean $\pm$ SD (<i>standard</i> deviations)			
95%CI = 95% Confidence Interval			

Clinical case series study

The patients' data were collected prospectively. Patients with humeral shaft fractures treated with anteromedial MIPO from 2017 to 2019 were selected (9 males and 9 females, aged from 26 to 82 years (47.89 ± 15.98), 10 cases on the left and 8 cases on the right). At the proximal incision, we typically placed the plate below or medial to the long head of the biceps brachii (Figs. 1C); if necessary, part of the pectoralis major insertion could be removed. Typical cases are shown in (Figs. 3–4) (Table 2).

Table 2
Statistical details of the 18 patients.

Patient	Age (years)	Gender	Side	AO/OTA Classification	Blood loss (mL)	Intraoperative time (minutes)	Follow-up (months)	X-ray Union (weeks)	3-months Shoulder flexion (degree)	3-months Shoulder abduction (degree)	3-months Elbow flexion (degree)	6-months DASH score	1 n C s
1	64	M	L	A1.2	45	80	16	15	166	162	130	13	5
2	47	F	L	A1.2	40	97	17	16	170	169	133	12.5	6
3	39	M	L	A3.2	45	93	30	13	173	172	135	2.5	1
4	52	M	L	A1.2	45	85	34	15	170	173	130	6	2
5	46	M	L	A3.2	50	90	18	16	172	169	125	2.3	1
6	65	M	L	A2.2	45	86	15	18	160	162	120	7	1
7	64	F	L	A2.2	56	96	16	18	169	166	120	12.5	2
8	75	F	R	B1.2	60	93	18	19	165	160	100	7	4
9	26	F	R	B1.3	66	90	16	15	168	167	135	2.5	3
10	36	F	L	B1.3	60	79	17	13	170	165	128	6	2
11	82	M	L	A3.2	65	82	16	20	158	155	95	20	9
12	32	F	R	B1.3	65	81	34	14	173	170	125	8	4
13	45	M	R	A2.3	40	79	20	16	169	168	139	9.6	3
14	35	F	L	A1.3	50	82	18	13	165	168	130	8.5	1
15	44	M	R	B1.2	56	85	17	18	170	169	138	8.3	2
16	29	F	R	A2.2	50	81	19	14	176	172	135	8.5	1
17	39	F	R	A3.2	45	83	19	16	175	173	130	7.6	2
18	42	M	R	A1.3	49	90	21	13	168	166	135	6	3

Clinical observation indexes

The intraoperative blood loss (mL), operation time (minutes), X-ray Union (weeks), follow-up time (months), shoulder flexion degree, shoulder abduction degree, elbow flexion degree and DASH score were evaluated (Table 3).

Table 3
Patient descriptive characteristics

Parameters	Range	Mean $\pm$ SD	95% CI
1. Age. (years).	26.00–82.00	47.89 $\pm$ 15.98	39.93–55.84
2. Blood loss. (ml).	40.00–66.00	51.78 $\pm$ 8.57	47.52–56.04
3. Intraoperative time. (minutes).	79.00–97.00	86.22 $\pm$ 5.90	83.28–89.16
4. X-ray Union (weeks).	13.00–20.00	15.67 $\pm$ 2.20	14.57–16.76
5. 3 - months Shoulder flexion (degree).	158.00–176.00	168.72 $\pm$ 4.69	166.39–171.05
6. 3 - months Shoulder abduction (degree).	155.00–173.00	167.00 $\pm$ 4.81	155.00–173.00
7. 3 - months Elbow flexion (degree).	95.00–139.00	126.83 $\pm$ 12.01	120.86–132.80
8. 6 - months DASH score.	2.30–20.00	8.21 $\pm$ 4.33	6.06–10.37
9. 12 - months DASH score.	1.60–9.00	3.25 $\pm$ 1.98	2.26–4.24
Mean $\pm$ SD = Mean $\pm$ SD <i>standard</i> deviations			
95% CI = 95% confidence interval			

Statistical analysis

Results

Cadaveric research

The average length of the humerus was 29.22 ± 1.62 cm. The safe area for proximal fixation was 8.88 ± 0.96 cm from the anterior medial base of the humeral head to the distal end; three to four screws could be inserted. The mean width of the medial condyle to the coronal fossa of the humerus was 1.31 ± 0.17 cm. The distance from the distal bicortical screw tip of the medial condyle to the ulnar nerve was 2.96 ± 1.62 cm. The distance from the medial base of the humeral head to the intersection of the median nerve and the proximal end of the inferior plate was 6.28 ± 0.39 cm. When fixing mid-humeral fractures with an LCP, at least 3 locking screws could be placed at the distal end; at least 3 screws could be inserted into the medial condyle; and to avoid injury to the ulnar nerve, the insertion of 3 screws into the distal cortex is recommended (Table 1).

Clinical case study

The intraoperative blood loss was 51.78 ± 8.57 mL, the operation time was 86.22 ± 5.90 min, the X-ray union was 15.67 ± 2.20 months, and healing was achieved in all cases, the 3 - months shoulder flexion angle was 168.72 ± 4.69 degree, the 3 - months shoulder abduction angle was 167.00 ± 4.81 degree, the 3 - months elbow flexion angle was 126.83 ± 12.01 degree and the DASH score was 3.25 ± 1.98 at the 1 - year postoperative follow-up, with no cases of infection or nosocomial nerve damage. All patients demonstrated fully recovered elbow function at the last follow-up. (Table 3).

Discussion

The results of the anatomical study indicate that the minimally invasive anteromedial approach is an anatomically safe and effective technique for the treatment of extraarticular fractures of the middle or distal third of the humerus. The distal incision avoids the risk of the median nerve and brachial artery injury due to the protection provided by the brachialis muscle. There is a thicker layer of muscle between the distal incision and the vascular nerve, which allows for more extensive dissection of the proximal humerus under direct vision and fixation with 5–6 locking screws was safely performed under direct vision in the proximal to the apex of the medial condyle. Three distal locking screws and two layers of cortical fixation provided adequate stability for distal fractures⁵. Distal screws can be fixed in the supracondylar region of the medial cortex to avoid injury to the ulnar nerve. In the case of fracture of the distal third of the humerus with a sphenoid mass, the fracture would be unstable if fixed by an anteromedial approach alone. Our experience has been that in such cases, MIPO can be used to add a lateral LCP and maintain the distal humerus medially and laterally, which is more consistent with biomechanical fixation of the distal humerus.

If percutaneous screws are used between the two incisions, neurovascular injury may occur, which is consistent with the results reported by T. Buranaphatthana et al. The anteromedial distal incision was close to the bone surface, and the soft tissue tunnel under the brachialis muscle was created proximal to the internal fixation, without damaging the vascular or neural structures in the middle of the distal incision.⁶

The radial nerve runs around the posterior side of the humerus to the anterolateral side of the humerus, so the anteromedial approach to the humerus avoids the risk of radial nerve injury. To our knowledge, iatrogenic radial nerve injury has been a major complication of anterolateral, lateral, and posterior approach in previous studies. MIPO has been used for fractures of the distal third of the humerus, with a relatively high incidence of postoperative radial nerve palsy of 5.4%.⁷ MIPO using the distolateral Kocher approach resulted in a rate of radial nerve palsy of 42%.⁸ These surgical approaches require exposure of the radial nerve during surgery, which is inconvenient for the surgeon and increases the possibility of iatrogenic radial nerve injury.

Intraoperative ulnar nerve injury is also a concern. The ulnar nerve runs posterior to the medial epicondyle. In the specimens, the fixation area of the medial epicondylar plate of the humerus was very narrow, and the distal bicortical screw tip was very close to the ulnar nerve. And the distance is very close between the olecranon fossa and the tip of the 4 screws at the distal end of the plate in the medial humeral epicondyle, especially the second and the third most distal screw (Fig. 2E). Monocortical fixation is recommended for screws in the medial epicondylar region of the humerus.

Some scholars believe that fixation at the proximal end of the plate may interfere with the strength of the long head of the biceps tendon and affect the sliding of the biceps tendon.⁹ In our cadaveric study, the plate was placed medial to the biceps tendon, but in clinical practice, it can also be pulled laterally and placed under the biceps tendon. At a follow-up of up to 34 months, the position of the proximal plate did not affect the biceps tendon or shoulder motion, but with new adopters of this technique and additional cases added to the list, it is likely there will be some the biceps tendon or shoulder motion.

The anterior humeral approach is suitable for fractures of the proximal and middle thirds of the humeral shaft. Because of the unique anatomy of the distal humerus, the fracture line needs to be at least 6 cm above the coronal fossa to stabilize the distal bone mass. For fractures of the distal third of the humerus, the plate is placed anterior to the humerus and distal to the coronal fossa and will affect the movement of the elbow joint.¹⁰ MIPO via an anterior approach to the humerus requires splitting of the brachialis muscle, which may lead to iatrogenic injury of the radial nerve or MCN, resulting in motor weakness.^{11 12} Concha et al. suggested that brachial scarring and poor postoperative recovery may be related to limitations in elbow range of motion after treatment with MIPO via an anterior approach. However, we may be able to avoid these complications by using a medial approach. The distal humerus is triangular, and adequate fixation of fractures of the distal third of the humerus is difficult to achieve while avoiding vascular and nerve damage. To avoid these problems, most physicians use a posterior approach with posterior open reduction and anterolateral plate placement, which requires the identification and protection of the ulnar and radial nerves and increases both the difficulty of the surgical procedure and the risk of iatrogenic nerve injury.^{13,14}

To stabilize extraarticular fractures of the distal third of the humerus, it is necessary to use an anatomical plate placed away from the posterolateral column of the humerus. Some authors have recognized that exploration for identification of the radial nerve is difficult and may increase the risk of iatrogenic radial nerve palsy. Additionally, a straight LCP is used to fix fractures of the distal end close to the olecranon fossa, which will affect the movement of the elbow joint. Because of the triangular anatomy of the distal humerus, shows that the monocortical distal screw fixation may be applied, and these screws may be easily removed or dislocated in osteoporosis.^{15 16,17} Yin P et al. Although both lateral and posterior approaches have achieved satisfactory results in treating extraarticular fractures of the distal third of the humerus, iatrogenic radial nerve injury still occurs, especially with the posterior approach (11.53%).¹⁷ To avoid iatrogenic nerve injury, it is necessary to increase the length of the incision and expose the nerve, furthering increasing the surgical trauma.

The posterior approach allows medial and lateral double-plate fixation, which is more consistent with the biomechanics of the distal humerus. However, the posterior approach is highly traumatic, and the placement of medial and lateral humeral plates increases the risk of iatrogenic radial and ulnar nerve injury. Our experience has been that a simple fractures of the distal third of the humerus can be fixed with a minimally invasive anteromedial approach alone. In cases where the fracture of the distal third of the humerus is accompanied by a sphenoid bone mass, if anteromedial MIPO is used alone, the medial epicondylar area is fixed by single-cortical screws, which makes the fracture unstable. We recommend the additional use of anterolateral MIPO for LCP fixation, bicortical fixation, and reconstruction of the medial and lateral columns of the distal humerus, which is in line with the biomechanics of the distal humerus and will strengthen the stability of the fixation. At the same time, the blood supply of the surrounding tissues is preserved, the length of the surgical incision and the surgical trauma are reduced, fracture healing is accelerated, and the patient's postoperative recovery time is shortened.

The medial approach, as an option for humeral shaft fractures, was first proposed by Judet et al. However, due to the complex anatomical structure of the medial upper arm, it is not suitable for open reduction and internal fixation.^{18 19} There have also been a few studies on open reduction and internal fixation of the medial humerus.^{20 21,22} These studies have shown that the anteromedial approach is a feasible surgical approach for the treatment of humeral fractures. Moreover, the anteromedial surface of the humerus is flat, and it is not necessary to prebend the steel plate when treating fractures of the middle of the humerus. Additionally, since the incision is on the medial side, the scar of the surgical incision is more hidden. Zheng YF et al. compared the biomechanical properties of anteromedial, anterolateral, and posterior plate fixation for humeral shaft fractures.²³ The results of the study show that the effect of anteromedial plate fixation for humeral fractures is better than that of anterolateral or posterolateral plate fixation.

However, due to the complex anatomical structure of the inner upper arm, anteromedial open reduction and fixation is rarely used in the treatment of humeral shaft fractures. This study shows that anteromedial MIPO can be performed through a soft tissue tunnel under the brachialis muscle without exposing the neurovascular structures of the inner upper arm. This surgical approach does not carry the risk of iatrogenic radial nerve injury and reduces the risk of muscle weakness caused by anterior MIPO while affecting the movement of the elbow joint less.¹⁷

A recent cadaveric study described an anteromedial MIPO approach that requires an incision in the pronator teres muscle and the insertion of a steel plate. According to our experience, the fixation device can pull the pronator teres medially during placement on the internal epicondyle of the humerus, and the upper medial condyle of the humerus needs to be completely exposed without cutting the pronator round muscle.²

The minimally invasive anteromedial approach for the treatment of fractures of the middle and distal thirds of the humerus has some limitations. In some patients with a narrow anteromedial humerus, insertion of the LCP distal to the brachial muscle tunnel may damage the brachial artery and median nerve, and a distal epicondylar screw may injure the ulnar nerve. Therefore, insertion of the LCP should be performed close to the bone surface, and distomedial epicondylar screws are recommended for monocortical fixation. When presenting a novel technique, the results in even a rather small case series might be relevant.

In anteromedial MIPO, the implant passes through the soft tissue channel below the brachialis muscle and passes through the muscle space without tearing the muscle and without causing iatrogenic nerve injury. Complete exposure can be achieved in the safe area of the distal and proximal ends of the humerus for screw fixation. Due to the complex anatomical structure of the inner upper arm, there is no need to expose the blood vessels or nerves in the clinical operation. Percutaneous screw fixation is not suitable between the distal and proximal incisions. This approach can be used as another option for the treatment of extraarticular fractures of the middle and distal thirds of the humerus.

Declarations

Author contribution statement

C.T. T.L. and J.Y. conceived the study and designed the study. Z.X.L. provided the research materials. H.L. A.M. J.W. and Z.X. Y. performed statistical analysis and figure generation. All authors contributed to the interpretation and discussion of the results and wrote the manuscript. All authors have approved the manuscript for submission.

Data availability / Availability of Data and Materials

Not applicable

Conflict of Interest:

The authors have no relevant financial or non-financial interests to disclose.

The authors have no conflicts of interest to declare that are relevant to the content of this article.

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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Ethics approval:

The study was performed using adult human specimens at the laboratory of the Xinjiang Medical University. A written informed consent from the donor or next of kin has been obtained prior using the cadaver samples. All patients gave written informed consent before participation in this study. The cadaveric and clinical case series study was reviewed and approved by the institutional ethics board of the Xinjiang Medical University (NO. XYDWFYLSK-2021-11). The Xinjiang Medical University Subjects Protection Committee approved our methods, and all participants gave informed consent. This study involving human participants was in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

All authors certify that the methods were carried out in accordance with relevant guidelines and regulations.

All authors certify that the study was reviewed and approved by the Xinjiang Medical University.

All authors certify that the patients gave informed consent and agreed to participate in our study.

All authors certify that all patients provided a signed informed consent prior to the operation.

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Figures

Figure 1

(A) This figure shows proximal (blue arrows) and distal (green arrows) incisions of the right arm and diagrams of the plane of dissection. (Red arrows: the medial epicondyle). **(B)** This figure shows the parallel to the long axis of the humerus, the distance from the medial base of the humeral head to the intersection of the median nerve and the proximal end of the underlying steel plate. The green areas represent the safe area for proximal screw placement. The blue arrow represents the long head of the brachii tendon. **(C)** This figure shows the location relationship of plate and biceps brachii in the proximal incision. The blue pentagrams represent the long head of the brachii tendon. The blue arrow represents the plates.

Figure 2

(A) This figure shows the vertical distance from the vertex of the medial epicondyle to the median nerve (a); (The pentagrams represent the median nerves. Triangles represent ulnar nerves). (B) This figure shows the distance from the vertex of the epicondyle to the intersection of the median nerve and the distal end of the underlying steel plate. Green areas represent the safe area where the screw is placed at the distal end. The blue pentagrams represent the medial epicondyle. (C) The distance from the medial condyle to the base of the coronal fossa (a). Green areas represent the single-cortical fixation area for screws in the medial epicondyle region of the humerus. (D) This figure shows the Located in the medial epicondyle, the distal end of the plate with 4 screws crosses the distance between the tip of the bicortical cortex and the ulnar nerve. (E) This figure shows the distance between the olecranon fossa and the tip of the 4 screws (Region a–d) at the distal end of the plate in the medial humeral epicondyle. (e) Red area represents the olecranon fossa and articular surface of olecranon.

Figure 3

(A-D) A typical case. A 48-year-old woman a middle fracture of the left humeral shaft., preoperative X-rays. **and** 3 months after surgery, the bone was clinically united in anatomical alignment.

Figure 4

(A-D) A typical case. A 64-years-old patient that falls from stairs when walking down the stairs and sustained a distal humerus fracture, preoperative and postoperative X-rays. (E-H) 3 months after surgery, with full recovery of function.

Supplementary Files

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