Research article *Clin Ter 2021; 172 (6):552-558. doi: 10.7417/CT.2021.2377*

A combined paratricipital and triceps-splitting approach for distal humeral metaphyseal-diaphyseal fractures in adults

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Abstract

Background. Distal metaphyseal-diaphyseal fractures of the humerus can be challenging. The success lies in achieving a stable fixation that could allow early functional recovery. Our aim is to combine different approaches already reported, to obtain an ideal surgical strategy for treating these fracture patterns.

Methods. In this retrospective study, we present the clinical outcome of a 12-patient cohort in which we used a combined paratricipital and triceps-splitting approach to the distal humerus. The mean age of the group was 50 years (range 17 - 88). Clinical and radiographic evaluation was performed at 1, 3, 6, and 12 months after surgery and thereafter, depending on the necessity of a further control. Patients' range of motion (ROM) of the elbow was reported, and functional outcome was assessed using the Mayo Elbow Performance Index (MEPI).The minimum follow-up was fixed at 12 months.

Results. Union was achieved in all fractures. After a median follow-up of 15.7 months (range 12-21), none of the patients complained of any limitation in daily activities. The ROM at the last follow-up was complete in eight patients. Instead, three patients had ROM limitations, but none of them mentioned limitations in the activities of daily living. We observed a single iatrogenic radial nerve palsy undergoing a full functional recovery at the final follow-up. No further complications occurred.

Conclusion. We believe that the here presented modified approach could represent a solution that meets the modern demands for both robust fixation and early mobilization, with minimal soft tissues damage around distal humeral fractures. ***Clin Ter 2021; 172 (6):e552-558. doi: 10.7417/CT.2021.2377***

Key words: *Distal humeral fractures, Surgical approach, Extra-articular, Posterolateral plate*

Introduction

Treatment of distal humeral metaphyseal-diaphyseal fractures is often quite is often a challenging task for trauma surgeons (1,2). Anatomical fixation of multifragmentary fractures of the distal shaft are hardly adressed by invasive or conservative treatment (3). Therefore, a stable fixation is mandatory to allow early rehabilitation. Furthermore a careful evaluation of the neurovascular status of the upper arm is essential to choose the most accurate treatment (4). The association between distal meta-diaphyseal humeral fractures and radial nerve palsy is well documented and surgical approach must be planned accordingly (5,6,7). In the present study we show the clinical results of a retrospective case series that includes patients treated with a locking compression plate (LCP) using a combined para-tricipital and triceps-splitting approach to the distal humerus. Indeed, in an attempt to guarantee stability and to increase the biomechanical resistance of the synthesis against torsional forces acting on the humerus, we used a 3.5-mm posterolateral extra-articular distal humerus pre-contoured LCP (DePuy Synthes, West Chester, PA, USA) we belive that this combination of approaches is suitable for an extensive exposure of the distal meta-diaphyseal, highlighting its importance for a better better fixation and, ultimately, an optimal functional outcome.

Methods

This case series includes patients with diaphyseal and metaphyseal humeral fractures, who underwent osteosynthesis through a combined triceps-splitting and triceps-reflecting posterior approach. The fixation was obtained in all cases using a3.5 mm LCP Extra-articular Distal Humerus Plate (DePuy Synthes, West Chester, PA, USA). Twelve patients were operated from September 2014 to January 2020. All surgical procedures were performed by two experienced surgeons. The follow-up visits consisted of an outpatient

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ISSN 1972-6007

consultation including a careful clinical examination and two x-ray images (anteroposterior and lateral projections of the humerus and the elbow). They were scheduled at 1,3,6,9, and 12 months after surgery, and thereafter depending on the necessity of a further control. The minimum follow-up time was fixed at 12 months after surgery. The pre-operative radiologic images of all the eligible patients were obtained from the Picture Archiving and Communication System of our institutions, whereas a pre-operative CT scan with 3D reconstruction was performed when necessary. Humeral fractures were classified using the AO/OTA Classification system. The duration of the surgical procedure was recorded and pain level after surgery was evaluated according to the visual analog scale (VAS) score. Elbow ROM at follow-up was recorded to assess functional outcome, while patient-reported functional outcome was assessed using the Mayo Elbow Performance Index (MEPI). MEPI scores of 100 - 90 were considered excellent, 89 - 75 good, 74 - 60 fair and < 60 poor. Complications, such as infections, implant failure, radial and ulnar nerve palsy, was taken into consideration before and after surgery.

Surgical Technique

The patient was usually placed in either prone or lateral decubitus with a 90 degrees flexion of the interested elbow. No tourniquet was used. To perform the approach, the whole tricipital muscle needs to be exposed. For this reason, a posterior midline humeral skin incision was made. This approach combines features of a tricipital split approach for a more proximal exposure and para-tricipital approach for a distal one (Fig. 1). Skin flaps could be mobilized widely to allow an extensive visualization. Proximally, the skin incision stars about 8 cms distal to the acromial process. from the acromion process, whereas distally a lightly curved posterior incision was performed, being radial to the olecranum. Then, the tricipital fascia was opened and the actual surgerycould start. It consisted of three surgical steps: first a medial paratricipital approach with medial-to-lateral triceps reflection, first a medial-open "stab and split' incision to the distal posterolateral epicondyle; third a triceps splitting approach proximal to the humeral shaft. The medial para-tricipital approach was performed after

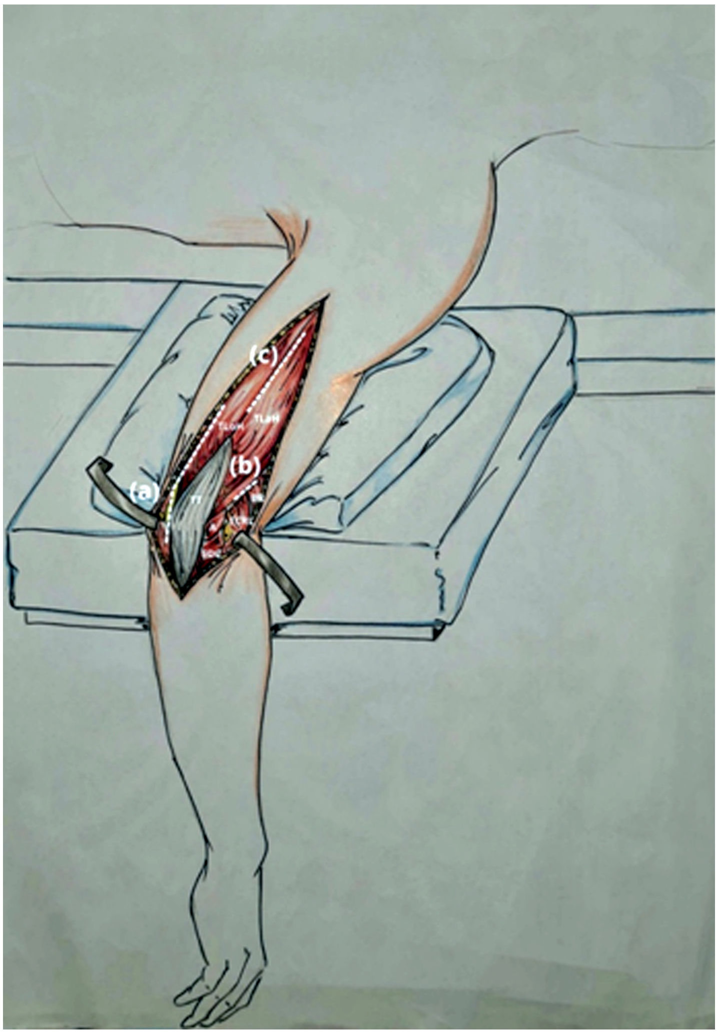

Fig. 1. TLoH = Tricep Long Head muscle, TLaH = Tricep Lateral Head muscle, TT = Tricep Tendon, BR = Brachioradialis muscle,
ECRL = Extensor Carpi Radialis Longus muscle, A = Anconeus muscle, EDC = Extensor Digitorum Communis muscle,
a = Medial paratricipital step,
b = Mini lateral paratricipital step,
c = Triceps split step.

having created a thin medial subcutaneous flap. At this point, extreme care was required, and localizing the ulnar nerve was mandatory for a successful and safe surgical outcome. Proximally, the dissection was extended to the point where the ulnar nerve was found piercing the arcade of Struthers, while distally, the dissection could be extended to the inter-nervous plane, between the extensor and the flexor carpi ulnaris. The inter-nervous plane between the triceps and the brachialis muscles was bluntly dissected to seek the ulnar nerve. Once isolated, this nerve, which lies in the cubital tunnel region, could be mobilized to the anterior subcutaneous tissue depending on the fracture configuration. A humeral subperiosteal dissection maintaining tendon-fascia continuity was required to prevent nerve damage, since the ulnar nerve runs deep to the medial head of the triceps. Once the ulnar nerve was safe, a medial-to-lateral tricipital reflection could be performed to provide excellent visualization of the posterior humeral shaft and the distal epiphyseal region. the second surgical step consisting of a mini lateral and a distal paratricipital approach was then performed. A "stab and split" subcutaneous incision was made between the lateral head of the triceps and the brachioradialis. The lateral supracondylar ridge of the humerus was then reached, and the posterior part of the lateral epicondyle was exposed with a cob periostal elevator as far as the lateral supracondylar ridge of the humerus. The third step consist of, as a third step and after paratricipital approaches have been performed, a regular triceps-splitting technique was required to isolate the radial nerve. Triceps could be split throughout the interval between the long and the lateral heads, while the medial head has already been reflected by the previous paratricipital medial approach. The radial nerve commonly crosses over the posterior surface of the humerus in the spiral groove at the origin of the medial head of the triceps, therefore extreme care is required by surgeons during proximal dissection of this region. Once the radial nerve was isolated, the reduction of the fracture was performed together with a temporary fixation using both Kirchner wires and pointed reduction forceps, under image guidance. Finally, the plate was slid through the distal window, over the distal humerus lateral ridge, as high as the posterior face of the proximal humeral shaft and under the radial nerve, and then fixed. No ulnar nerve transposition was made. The height where the radial nerve crossed the plate was recorded in the operation report, in case of future reoperation. The wound was thoroughly irrigated and a layered closure was performed. A soft sterile dressing was placed over the wound and physical therapy wasallowed after the first post-operative day. Physiotherapy will be continued after patient discharge for adequate time.

Results

A total of twelve patients were operated: demographic and clinical data are illustrated. One patient presented an open fracture (Gustilo type 2). No radial or ulnar deficit were recorded before surgery. Surgery was performed either in prone position (7 patients) or in lateral decubitus (5 patients). Operation duration was registered for seven patients. The mean operative time was 130 min (range 100 – 180 min). On the first day after surgery, patients complained a mean VAS of 5.5 (range 8-3), while at discharge the mean VAS was 3.3 (range 2-5). After a median follow-up time of 15.7 months (range 12-21), none of the patients reported any limitation in daily activities and no cases of infection were recorded. One patient showed a radial nerve deficit at the post-operative check. That single radial nerve palsy was probably due to surgical maneuvers; during the follow-up, a gradual improvement was seen,and a complete recovery was noted 6 weeks after surgery ROM at the last follow-up was complete in eightpatients (Figs. 2a, 2b, 3a, 3b, 4a, 4b). Three patients had mild ROM limitations, reportedly

Table 1 .Characteristics and Outcome of Injured Patients

Case	Age (years)	Gender	Diagnosis (AO/OTA classification)	Operation time (minutes)	Decubitus (Pronus/ Lateral)	VAS at day 1 post-surgery	VAS at patient discharge	Follow-up (months)	ROM at the last follow-up	MEPI at the last follow-up
1	57	F	12A3	120	P	3	3	12	0-135	100
2	27	F	12A1	100	P	8	5	12	0-135	100
3	22	M	12A1	100	P	5	3	24	0-140	100
4	17	M	12A1	170	P	5	3	18	0-140	100
5	19	M	12A1	140	P	3	3	12	0-140	100
6	88	F	12C2	100	P	8	3	12	10-125	90
7	60	F	12C2	180	P	8	5	14	0-140	85
8	26	M	12C2	150	L	5	3	12	0-135	100
9	55	F	13A2(Gustilo 2)	110	L	6	3	24	5-125	95
10	45	M	12C3	160	L	5	2	12	0-125	95
11	65	F	13A2	170	L	5	3	12	0-140	100
12	67	F	12A1	120	L	5	3	24	0-140	100

Fig. 2a

Fig. 2b

Fig. 2a, 2b
Male patient, 26 years old, AO 12 C2 type fracture according to the AO/OTA classification located in the distal third of the humerus.

flexion-extension 10°-125°, 5°-125° and 0°-125° but none of them mentioned limitations in everyday life activities. MEPI score was evaluated in eight patients at the last follow-up visit, and the results are shown in Table 1.

Discussion and Conclusion

Despite several surgical approaches have beende scribed for the treatment of distal humerus articular fractures, only a few studies showed how to approach the metaphyseal and diaphyseal distal humeral fragments (8, 9, 10). The triceps reflecting (Bryan-Morrey) approach for distal humerus fractures allows adequate visualization (11). Nevertheless, it requires a good knowledge of the nerves anatomy. Moreover, the triceps reattachment itself is of crucial importance, as described by O'Driscoll (12). The posterior triceps-on (Alonso-Llames) approach to the distal humerus, and the triceps-elevating approach alone, are excellent options for distal humerus fractures, but with no assurance of a safe visualization of the humeral shaft portion (13). In the posterior triceps-sparing approach (triceps-on), the radial nerve can be detected at its penetration through the lateral intermuscular septum, and then it can be fol-

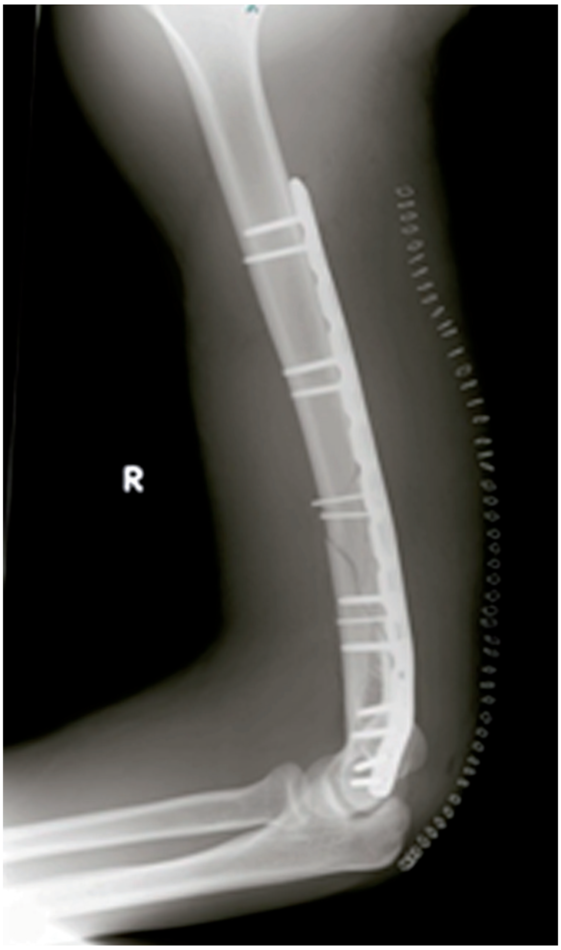

Fig. 3a

Fig. 3b

Fig. 3a, 3b. Post-operative images.

lowed upwards in the radial groove. The exposure of the proximal one-third of the humerus through this approach is quite demanding as mobilization of the muscle complex from lateral to medial–which contains the long head, the lateral one and the medial head of the triceps - is not always possible due to the bulky and enlarged aspect of the triceps muscle group and its attachments over the posterior surface of the humerus. The posterior triceps-split approach is performed throughout the proximal interval between the two heads of the triceps obtained by dissection, in particular, by retracting the lateral head laterally and the long head medially. The radial nerve is identified by localizing first the brachial artery lying deeper. Distally, splitting of the common triceps tendon to reach the posterolateral side of the humerus weakens the triceps muscle complex anatomy and increases the risk of heterotopic ossification. The procedure that we propose here combines the advantages of the aforementioned approaches (14,15). Thus, this surgical technique could represent a minimally invasive procedure which maintains the soft tissue biology and allows treating humeral shaft fractures quite safely. According to the conventional surgical approaches in use to date, an overall anatomic exploration of the radial nerve is thought to be mandatory. Nevertheless, we believe that only the proximal tract of the radial nerve needs to be localized, mobilized, and therefore isolated for safe application of the plate. Consequently, here we propose a surgical approach exposing only the proximal tract of the radial nerve through a triceps–split approach, avoiding dissection and mobilization of its distal tract. Visualization of the metaphyseal and diaphysealhumeral fragments from the medial window is sufficient for an anatomic reduction of complex fractures. Distally, a surgical window through a minimum lateral para–tricipital approach is usually performed to properly placing both plate and screws. Overall, performing a mini – lateral para-tricipital approach while maintaining the integrity of the extensor has several advantages. First, a complete visualization of the distal part of the radial nerve and its proximal branches, such as the posterior antebrachial cutaneous nerve, is not required, consequently reducing the duration of the surgery (4). Therefore, this approach potentially decreases the incidence of iatrogenic radial nerve palsy, as described when identified between the brachialis and brachioradialis muscles (16, 17). Second, it is well known that fracture healing is promoted soft tissues are carefully preserved (18). As a result, our approach maintains an anatomical tricipital contiguity, and leads to less post-operative pain and edema, it reduces the possibilities of elbow contracture and improves the overall post-operative triceps function (19). However, our limited proximal exposure is not suitable in patients with preoperative radial nerve palsy, since a more extensive exposure of the radial nerve may be necessary to assess nerve integrity. In this study none of the patients had preoperative radial nerve palsy. Several authors have investigateddistal humerus fixation comparing plate designs and configuration. biomechanical studies have been investigating different fixation strategies for distal humerus fractures treatment by looking mainly at plate selection and plate configuration, such as parallel versus orthogonal double plate fixation (20, 21, 22). Only a few studies have specifically focused on fracture fixation with the pre-contoured 3.5 mm LCP Extra-Articular Distal Humerus Plate. Tejwani and colleagues compared the use of a single pre-contoured 3.5 mm LCP to two non-locking 3.5 mm reconstruction plates (23). The authors demonstrated a significantly stiffer construct in anterior, posterior, and lateral bending with dual plating, but no difference was seen either in axial compression or torsion, with both constructs having similar failure strengths. In a biomechanical study on forty synthetic humeri, Scolaro et al. showed that a pre-contoured posterolateral distal humerus 3.5 mm LCP provided greater bending stiffness, torsional stiffness, and yield strength than a single posterior 3.5 mm LCP plate, for a typical osteotomy fixation placed approximately 80 mm above the trochlea. In this study, dual plating proved to be biomechanically superior when osteotomies were performed more distally (50 mm above the trochlea) (24). These studies suggest that the application of a single pre-contoured LCP is a biomechanically feasible solution for distal humeral shaft fractures, while a dual column fixation is recommended in very distal fractures. The main limitations of our study are the small sample size and the heterogeneity of cases. In this article, we described the surgical steps of a newly proposed technique that combines features of the already known and popular approaches highlighting its benefit to some selected cases. Furthermore, we believe that the here presented modified approach could represent a solution that meets the modern demands for both robust fixation and early mobilization, with minimal soft tissues damage around distal humeral fractures. Short term results after surgery are quite satisfactory, but further studies need to be performed so as to better evaluate the overall outcome of such approach in the long run.

Conflict of interest statement

None declared.

Acknowledgment

The authors would like to thank MD Martina Mussi for providing careful anatomical illustration.

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