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Triceps reflecting anconeus pedicle approach: a versatile exposure for intercondylar fractures of the humerus

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The aim of the study is to describe the surgical technique and to report the outcomes of triceps reflecting anconeus pedicle (TRAP) approach for intercondylar fractures of the humerus.

Twenty two patients with intercondylar fractures of the humerus were operated on by open reduction via the TRAP approach and internal fixation with dual precontoured locking plates. Data were collected on union time, postoperative complications, range of motion (ROM), triceps power, and objective clinical measurement. All fractures were united with a mean union time of 16.5 weeks (range 12-22). All patients had good-to-excellent Mayo Elbow Performance (MEP) score results with a mean ROM of 118.2 degrees (range 90-135). Triceps power was grade 5 in 16 patients and grade 4 in 6. There were 3 transient ulnar nerve palsy and 1 heterotopic ossification. TRAP approach is safe and effective in terms of utility for articular reduction, restoration of elbow motion, and triceps function for intercondylar fractures of the humerus.

Key words: TRAP approach, intercondylar fracture of humerus.

INTRODUCTION

Intercondylar fractures of the humerus are regarded as a taskmaster in orthopedics trauma owing to the complexity of anatomical geometry, limited area of the articular component to be addressed as well as the difficulty to achieve stable fixation, especially in osteoporotic bone. Open reduction and internal fixation are the mainstay of treatment to establish anatomical reduction, stable fixation, and early rehabilitation.

One of the controversies in operative management of this particular fracture is the appropriate surgical approach for exposing the articular surface and minimizing further complications from the surgery. Olecranon osteotomy which provides the best visualization of the articular surface is considered as a gold standard approach for intraarticular fractures of the distal humerus[1]. However, several shortcomings of this approach have been reported including osteotomy site nonunion, implant irritation, triceps weakness, and revision operations from the osteotomy[2-4].

Triceps reflecting anconeus pedicle (TRAP) approach was initiated by O'Driscoll to provide adequate articular exposure without the need for olecranon osteotomy[5]. Furthermore, in the fractures with a high possibility of conversion from fixation to arthroplasty, the operations could move on easily when the TRAP approach is selected. However, several possible drawbacks such as insufficient visualization of the articular surface, failure of triceps repair, and triceps weakness from extensile dissection of the triceps muscle-tendon unit by this approach are still under scrutiny.

The purpose of the present study is to describe the surgical technique and retrospectively review the patients with intercondylar fractures of the humerus who received open reduction and internal fixation via the TRAP approach. We report the outcomes focusing on complications of the triceps muscle from the approach, as well as radiologic and clinical outcomes.

MATERIAL AND METHODS

A retrospective case series of open reduction and internal fixation via the TRAP approach was performed on intercondylar fractures of the humerus in 22 consecutively recruited patients by one surgeon at a trauma unit in a tertiary center between January 2016

and December 2018. No eligible patients declined to participate. The inclusion criteria were closed/open intercondylar fractures of the humerus and age ≥ 18 years. The exclusion criteria were pathological fracture, age <18 years, and more than 1 week of delayed fractures. The demographic data, cause of injury, associated injury, fracture configuration by AO/OTA classification, and time-to-operate were recorded. This study has been approved by the ethical committees of Buddhachinaraj Hospital in accordance with the Declaration of Helsinki.

Surgical technique

All patient operations were performed under general anesthesia and with the patient in the lateral decubitus position with the affected arm on a radiolucent platform or pillow and the elbow hanging free. After tourniquet inflation, a longitudinal skin incision was made from 8-10 cm proximal to 5-6 cm distal to the olecranon process. Sharp dissection to the triceps muscle-tendon, olecranon process, and ulnar crest was carried on (Fig. 1a and 1b). The skin flap beneath the subcutaneous layer was created from the midline to the lateral border of the triceps muscle, lateral epicondyle, and lateral forearm fascia. The border of the triceps muscle was sharply mobilized from the lateral intermuscular septum to expose the posterior cortex of the humerus, lateral humeral condyle, olecranon fossa, and fracture site. The forearm fascia overlying the anconeus-ECU interval was incised from the lateral epicondyle to the ulnar crest 5-6 cm distal to the olecranon process (Fig. 1c-e).

The skin flap was generated from the midline to the medial border of the triceps muscle, medial epicondyle, and medial forearm fascia. After the ulnar nerve was identified and mobilized from the intermuscular septum and epicondylar groove, the medial border of the triceps was elevated to expose the humerus and connected to the lateral dissection. An incision over the medial forearm fascia was made distally from the medial epicondyle to the same point of the lateral forearm incision at the ulnar crest generating a V-shape forearm fascial flap (Fig. 1f-j).

On the medial side, the medial forearm fascia was elevated from the underlying FCU muscle. Meanwhile, on the lateral side, the anconeus muscle and overlying fascia were dissected from the lateral cortex of the proximal ulna (Fig. 2a and 2b). Due to the firm attachment between the forearm fascia and ulnar crest, the fascia needed to be gently and subperiosteally dissected from the crest to avoid perforation of the fascia (Fig. 2c). At the level of the olecranon process, the triceps tendon was sharply detached from its insertion and then the triceps muscle-tendon unit, anconeus muscle as well as the V-shape fascial flap were turned proximally to expose the articular surface of the distal humerus and posterior cortex of the humeral shaft (Fig. 2d and 2e). Visualization of the joint could be increased by hyperflexion of the elbow and then an attempt to reduce the articular component could be performed.

After achieving good articular reduction, Kirchner (K)-wires were inserted to maintain reduction. Then the articular block was reduced to the humeral shaft and temporarily stabilized by K-wires. Two precontoured anatomical locking plates were positioned on the medial and posterolateral cortex and then locking screws were inserted. All of the K-wires were removed and then the alignment of fracture as well as implant position was confirmed by an image intensifier.

The triceps tendon was repaired with Ethibond suture material using Krackow's method (Fig. 2f). Two crossed holes were made at the triceps insertion of the olecranon process. Two ends of the Ethibond were passed through the holes and then tightened over the ulnar crest in full elbow extension position (Fig. 2g and 2h). The triceps repair was completed by augmenting with the repair of the forearm fascia (Fig. 2i).

Transposition of the ulnar nerve was not attempted in all of the cases. Hemostasis was done after tourniquet deflation and then the wound was closed under vacuum drain.

The drain was removed at 2 days after the operation. Long arm splint was applied to the elbow for 2 weeks and then physical therapy by passive motion exercise was encouraged to regain elbow motion. Active extension of the elbow was prohibited for 6 weeks. Radiographic assessment for fracture union was performed during the immediate post-operative period and every 4-6 weeks. Clinical assessment including post-operative complications, ROM of the affected elbow, triceps muscle power by Medical Research Council (MRC) grading, and Mayo Elbow Performance (MEP) score were assessed and recorded.

RESULTS

The present case series included 9 males and 13 females with a mean age of 44.3 years (range 21-63). Seventeen patients were injured from motor vehicle accidents, 3 from a simple fall, 1 from a football injury, and 1 from a bicycling accident. Seventeen fractures were closed and 5 were open. AO/OTA classification included 13C1 (n=3), 13C2 (n=17) and 13C3 (n=2). Ipsilateral

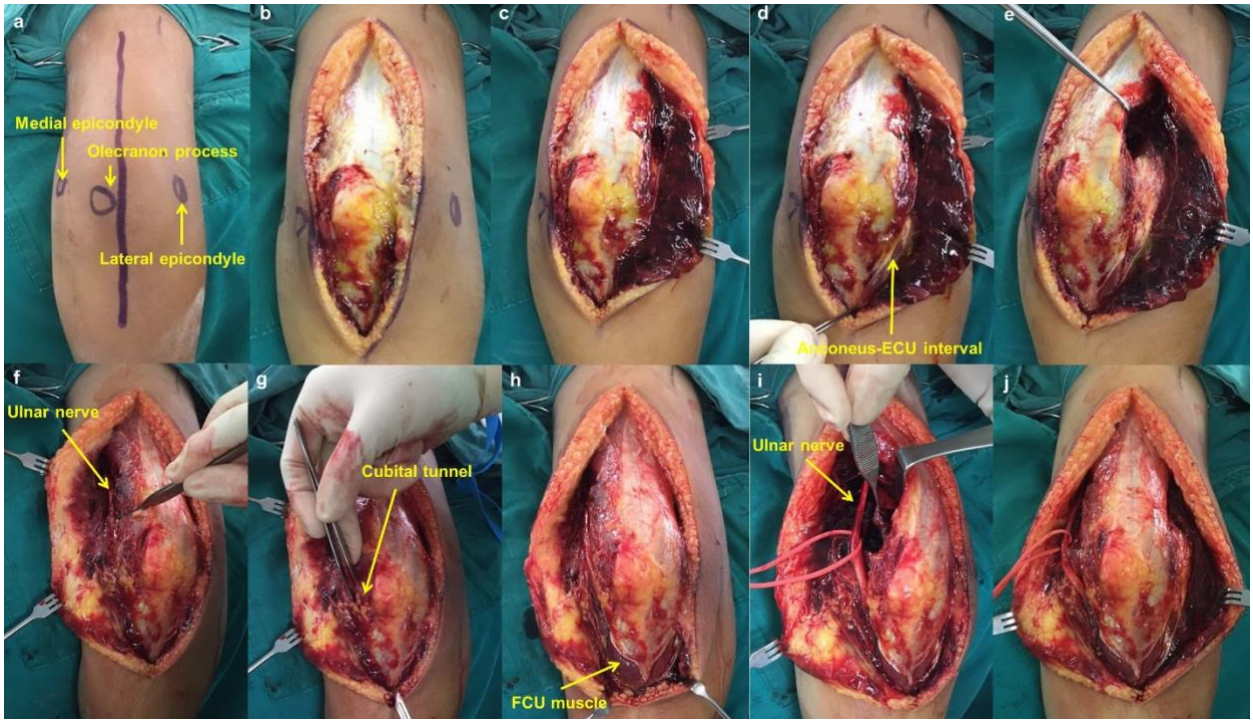

Figure 1.— (a,b) Longitudinal midline incision. (c-e) Exposure of lateral column and anconeus-ECU interval. (f-j) Ulnar nerve mobilization and exposure of the medial column.

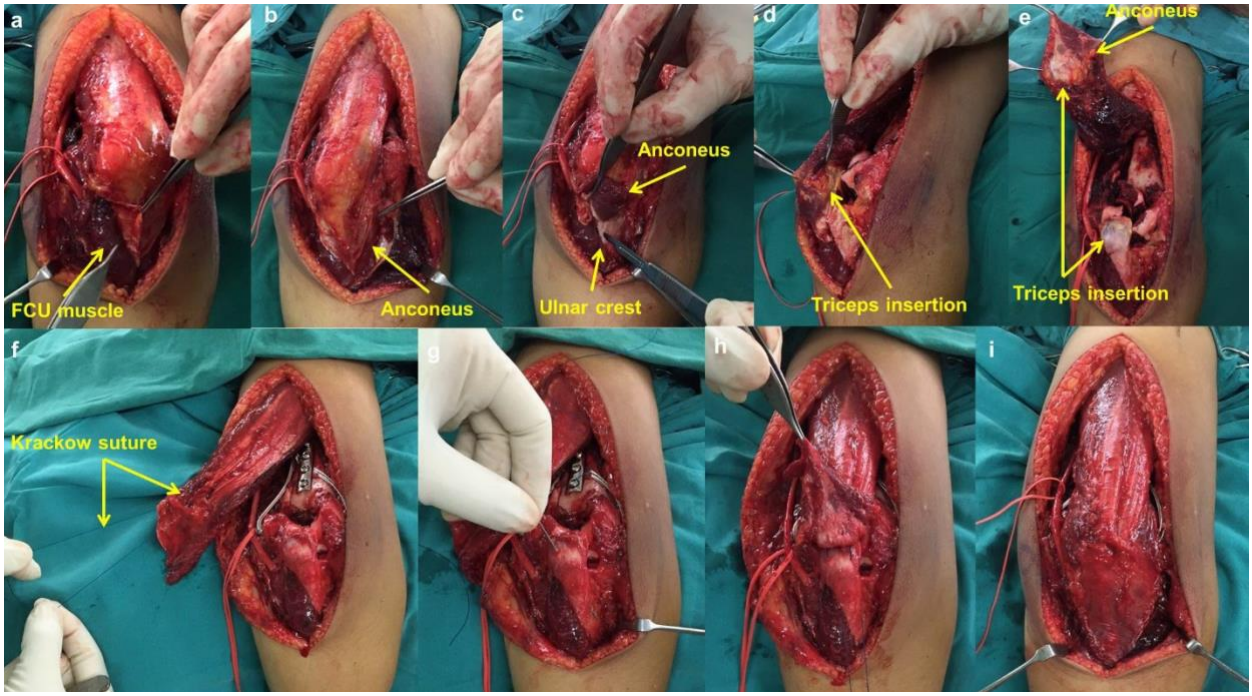

Figure 2. — (a-e) Elevation of the triceps tendon and anconeus muscle from their insertions. (f-h) Triceps reattachment by pullout suture technique. (i) Repair of forearm fascia.

distal radius fractures were present in 4 patients, an ipsilateral proximal humerus fracture in 1 patient, and an ipsilateral femoral neck fracture in 1 patient. The mean time-to-operate was 18.9 hours (range 7-60) (Table I).

The mean follow-up time was 18.6 months (range 12-32). All fractures were united in a mean duration of 16.5 weeks (range 12-22). The mean ROM was 118.2 degrees (range 90-135). The triceps power was grade 5 in 16 patients and grade 4 in 6 patients. The

Table I. —Demographic and clinical characteristics.

Pt No.	Sex	Age	Side	Cause of injuries	Type of fracture	AO/ATO Classification	Associated injuries	Time to operate (hour)
1	F	44	L	Motor vehicle accident	closed	13C2	None	20
2	M	28	R	Football injury	closed	13C1	None	16
3	F	63	L	Simple fall	closed	13C1	None	60
4	F	55	L	Motor vehicle accident	open	13C2	Lt. distal radius fracture	8
5	M	40	L	Motor vehicle accident	closed	13C2	None	12
6	M	38	L	Motor vehicle accident	closed	13C3	None	10
7	F	57	L	Motor vehicle accident	closed	13C2	None	12
8	M	41	R	Motor vehicle accident	closed	13C3	None	24
9	F	21	L	Motor vehicle accident	closed	13C2	None	26
10	F	40	L	Motor vehicle accident	closed	13C1	None	32
11	M	24	L	Motor vehicle accident	closed	13C2	None	30
12	M	59	L	Motor vehicle accident	open	13C2	Lt. proximal humerus fracture	16
13	M	35	L	Motor vehicle accident	open	13C2	None	10
14	M	27	L	Motor vehicle accident	closed	13C2	Lt. distal radius fracture	22
15	F	56	R	Motor vehicle accident	closed	13C2	Rt. distal radius fracture	16
16	F	62	R	Simple fall	open	13C2	None	14
17	F	43	L	Motor vehicle accident	closed	13C2	None	26
18	F	60	L	Motor vehicle accident	closed	13C2	None	14
19	F	48	R	Motor vehicle accident	closed	13C2	Rt. distal radius fracture	16
20	F	58	L	Simple fall	closed	13C2	None	15
21	F	21	L	Motor vehicle accident	closed	13C2	None	10
22	M	55	L	Bicycling injury	open	13C2	Lt. femoral neck fracture	7

mean MEP score was 91.6 (range 75-100), There were 13 considered to be excellent values and 9 to be good (Table II). Postoperative ulnar nerve palsy occurred in 3 patients and all recovered within 6 months. One patient had asymptomatic heterotopic ossification (Fig. 3). No triceps detachments were observed in any patients

DISCUSSION

The selection of the surgical approach which provides sufficient exposure of the articular surface and minimizes further morbidities of intraarticular fractures of the humerus is currently still debatable. In the present study, fracture union without deterioration of triceps function, as well as good to excellent clinical outcomes, were established in all 22 of the intercondylar fractures operated by open reduction and internal fixation via the TRAP approach.

The utility of several approaches including olecranon osteotomy, paratricipital, triceps split, triceps reflecting, and TRAP approach for intercondylar fractures of the humerus have been reported in the literatures. Each approach has different distinct advantages and disadvantages.

Olecranon osteotomy is a commonly used approach that provides the best visualization of the articular surface and has a theoretical advantage of bone-to-bone healing of the osteotomy site[1,4]. However, nonunion even by chevron-shape osteotomy, implant irritation, triceps weakness and revision surgery due to osteotomy site complications have occurred[2-4,6]. Furthermore, in the case of trochlear comminution, restoration of normal intercondylar is inherently difficult due to the loss of an intact olecranon process as a template.

Paratricipital posterior approach is an useful option for sparing the extensor mechanism and avoiding the complications of triceps-off exposure. Ali et al reported using paratricipital approach in 22 intra-articular fractures of distal humerus and no functional deficit of extensor mechanism was demonstrated in any cases[7]. Nevertheless, this exposure was not recommended for substantial displacement and severe comminution of the articular component.

The triceps split approach is another option to address the articular surface of the distal humerus[8]. To date,

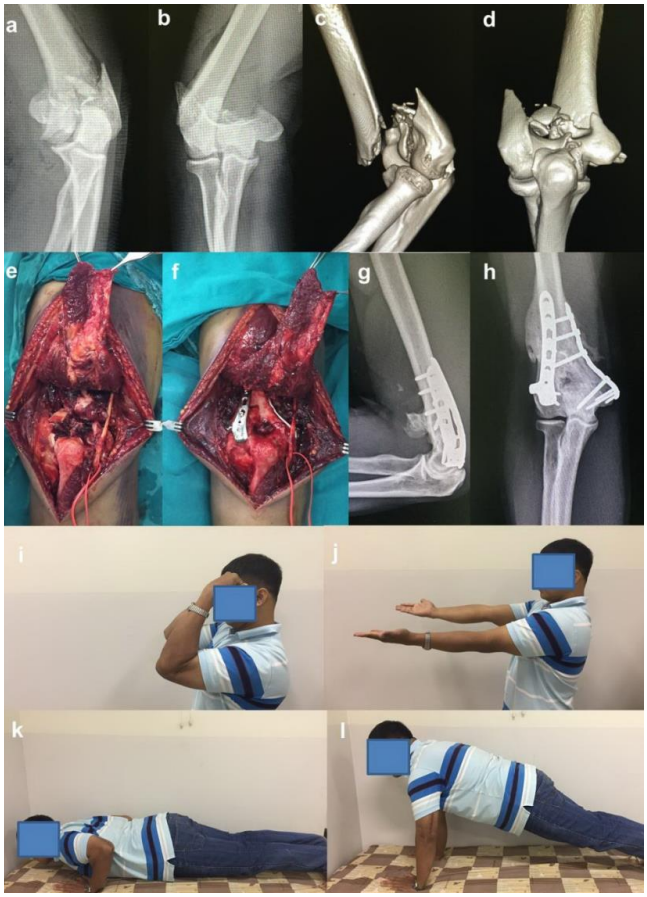

Figure 3. — (a-f) Open intercondylar fracture of the left humerus; open reduction was performed via TRAP approach. (g-l) At postoperative 1 year, the fracture was united with asymptomatic heterotopic ossification formation and the injured limb is fully functional.

this approach has not been popularized because of the limited area for articular visualization, intramuscular denervation, and intramuscular scarring of the triceps muscle from surgical dissection.

By the Bryan and Morrey triceps reflecting approach which is widely used for elbow arthroplasty, the triceps muscle-tendon unit is mobilized and reflected from the medial to the lateral side[9]. Thus reduction and fixation of lateral structures such as the capitellum and lateral column are more obstructed when compared with the olecranon osteotomy or TRAP approach.

The TRAP approach which was initiated by O'Driscoll has remarkable advantages of providing a sufficient area for articular reduction, preserving anconeus muscle innervation, avoiding osteotomy site complications as well as no need for intramuscular dissection of the triceps muscle[5]. By this approach, an intact olecranon process can be used as a reference for restoring normal intercondylar width in case of severe trochlear comminution (Fig.. 4). Additionally, if the articular component is unsalvageable, total elbow arthroplasty can be proceeded easily when compared with prior olecranon osteotomy. Nevertheless, possible subsequent complications including declination of elbow motion, triceps detachment after repair as well as triceps weakness make the versatility of this approach still doubtful.

Elbow stiffness is a common complication after substantial trauma of the elbow including intra-articular fractures of the humerus. Restoration of the elbow motion to 30-130 degree flexion is generally required for necessary activities of daily living[10]. Ozer et al reported 11 cases of intercondylar fractures treated with the TRAP approach and an average of 116 degree ROM in type C1 and C2, and 85 degree in type C3[11]. In the study of Pankaj et al, an average ROM was 118.4 degrees (range 80-130) in 40 cases[12]. Azboy et al compared the clinical outcomes of 22 cases of the TRAP approach and 18 cases of olecranon osteotomy[13].

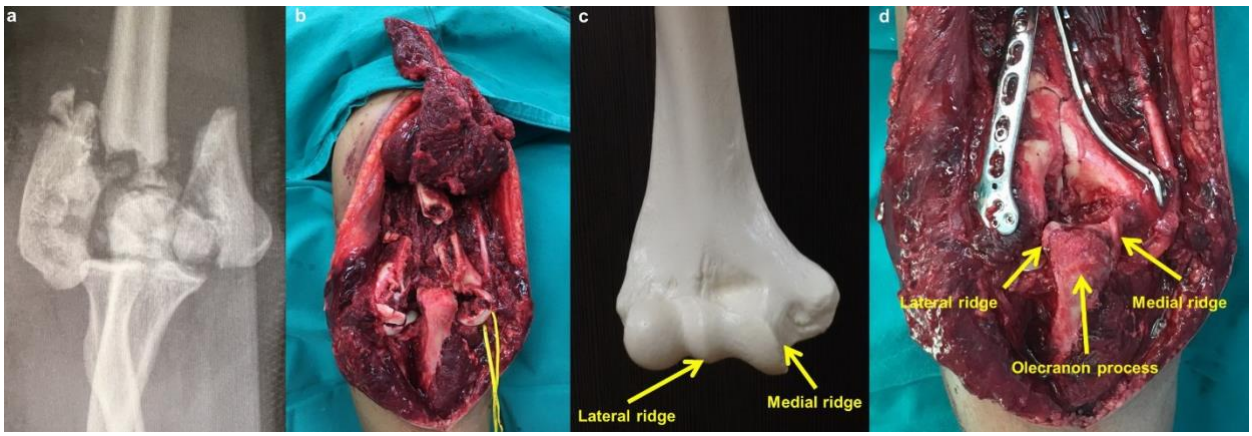

Figure 4. — (a) Intercondylar fracture of the humerus with severe comminution of the trochlea. (b) Open reduction via the TRAP approach. (c,d) Restoration of normal intercondylar width is illustrated by medial and lateral ridges of the trochlea positioned at the borders of the olecranon process

Table II. — Radiographic and clinical outcomes.

Patient No.	Time to union (wk)	Arc of motion	Triceps power (MRC grading)	MEP score	Complication	Follow-up time (month)
1	17	125 (5-130)	5	100	None	32
2	15	130 (5-135)	5	100	Ulnar nerve palsy	20
3	15	135 (0-135)	5	85	None	24
4	22	95 (15-110)	5	75	None	28
5	18	125 (5-130)	4	100	None	18
6	15	105 (15-120)	5	80	None	12
7	14	90 (10-100)	4	80	None	24
8	20	110 (10-120)	4	80	Ulnar nerve palsy	20
9	14	135 (0-135)	5	100	None	22
10	16	130 (0-130)	5	100	None	24
11	14	110 (10-120)	5	85	None	18
12	20	100 (10-110)	4	80	None	20
13	14	115 (0-115)	5	100	Heterotopic ossification	18
14	20	130 (5-135)	5	100	None	15
15	15	95 (5-100)	4	75	None	18
16	18	100 (0-100)	4	75	None	16
17	18	130 (0-130)	5	100	None	12
18	20	130 (0-130)	5	100	None	16
19	16	135 (0-135)	5	100	None	12
20	15	120 (0-120)	5	100	None	14
21	12	125 (5-130)	5	100	None	14
22	16	130 (0-130)	5	100	Ulnar nerve palsy	12

The mean arc ROM was 108 degrees in the TRAP group and 98 degrees in the osteotomy group. Chou et al reported an average ROM of 121 degrees in 48 patients with type C distal humerus fractures using the TRAP approach[14]. In the present study, the mean ROM was 118.2 degrees (range 90-135) and no patient with more than 30 degrees of flexion contracture was demonstrated.

The reliability of tendon-to-bone healing after extensile dissection of the triceps tendon in the TRAP approach is still in doubt. Mishra et al reported 1 of 15 patients with triceps detachment after the TRAP approach[15]. Similar to former studies of Ozer et al, Pankaj et al, Azboy et al, and Chou et al, there were no complications of triceps reattachment in the present study affirming a high reliability and safety of this approach[11-14]. Two-week splinting after the operation would contribute to the protection of the triceps repair in the patients of the present series. Generally, in substantial trauma of the elbow joint, more than 3 weeks of immobilization is related to unsatisfactory results[16]. Thus, for patients who present with inter-condylar fractures later than 1 week after injury, the exposures other than the TRAP approach should be a consideration.

Restoration of triceps power is one indicator representing the effectiveness of each surgical approach of distal humeral fractures. The isokinetic strength testing of Ozer et al study demonstrated no significant impairment of triceps function after the TRAP approach[11]. In the study of Pankaj et al, 35 patients (87.5%) had good triceps strength and 5 patients (12.5%) had fair strength[12]. According to muscle grading in the study of Mishra et al, 14 of 15 patients demonstrated grade 4 or 5 of triceps power[15]. In the present series, all of the patients had grade 4 or 5 of triceps power representing a satisfactory restoration of elbow extensor function (Fig. 5).

There were some limitations to the present study. It was an uncontrolled retrospective case series, and the number of enrolled patients was small. Muscle strength testing by other objective measurements may represent more accurate outcomes. Due to a propensity to have late complications of these intraarticular fractures such

Figure 5. — (a-c) Ipsilateral distal radius fracture and intercondylar fracture of the humerus. (d-f) Open reduction and internal fixation of the distal humerus via the TRAP approach. (g-j) Clinical results at postoperative 1 year.

as chronic pain, late instability as well as posttraumatic arthritis, a longer-term study may influence the decision making to select the appropriate approaches.

CONCLUSION

The TRAP approach is safe and effective in terms of articular exposure, restoration of elbow motion, and triceps function for intercondylar fractures of the humerus. The obvious advantages of the TRAP approach over olecranon osteotomy would be in the fractures with trochlear comminution and fractures with a high possibility to be converted to arthroplasty. However, in the fractures with more than 1 week of delayed presentation, the other approaches should be considered.

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