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Comparative study of triceps reflecting anconeous pedicle approach (TRAP) versus olecranon osteotomy approach for open reduction internal fixation of supracondylar and intercondylar fractures of humerus

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Abstract
Introduction: Approximately, 7% of all adult fractures involve the elbow, of these approximately, one third (2%) are distal humeral fractures. Articular fractures of elbow are the most difficult one to treat. Currently the olecranon osteotomy approach is the most commonly used. O'Driscoll has described a triceps reflecting anconeous pedicle approach (TRAP) that avoids an osteotomy.
Objectives: To evaluate and compare the results of TRAP approach and olecranon osteotomy approach in open reduction internal fixation of supracondylar intercondylar fracture of humerus in term of Mayo Elbow Performance Score.
Methodology: The present study was a comparative interventional study on patients with intercondylar fracture of humerus admitted in department of Orthopaedics, S.M.S. Hospital, Jaipur during Jan 2012 to Oct 2013. Total 36 patients were taken, out of them 18 were in group-A (operated by olecranon osteotomy approach) and 18 were in group-B (operated by TRAP approach).
Results: Duration of surgery was considerably more in group B (1.36 ±. 067 hours) compare to group-A (1.26 ±. 096 hours). That was statistically significant. Mean duration for fracture union in group-A was 13.56 ± 2.007 weeks, while it was 12.56 ± 1.504 weeks in group-B. There was no statistically significant difference. Average of flexion was 110.56 ± 18.86 degrees and 112.78 ± 21.91degrees in group-A and group-B respectively shows there was no significant difference between two groups flexion. Average of extension lag was 19.72 ± 14.70 degree in group-A and it was 12.22 ± 11.90 degree in group-B shows there was no statistically significant difference between two groups extension lag. The mean elbow arc of motion in group A was 90.83 ± 30.35 degrees and in group B was 100.56 ± 28.28 degrees. There was no statistically significant difference. We observed that 3 patients of group-A and 1 patient of group-B had superficial infection during first 2 weeks after surgery. One patient of group-A had deep infection.
The average Mayo Elbow Performance Score in group-A was 84.17 ± 16.382 and in group-B was 87.78 ± 14.061. P-value was >.05 (0.483) show that there was no statistically significant difference between two groups MEPS. Overall 29 patients (80.55%) out of 36 shown excellent and good results with conclusion that there is no statistically significant difference between results of two groups.
Conclusion: TRAP approach is comparatively better than osteotomy approach. TRAP approach allows stable Fracture fixation, with the advantage of intact olecranon. The approach permits aggressive postoperative elbow rehabilitation.

Keywords: Intercondylar fractures, mayo elbow performance score, olecranon osteotomy

Introduction
Articular fractures of elbow are the most difficult one to treat. Because of their complex anatomy, proximity to vital structures, injury patterns, associated osteoporosis in elderly patients and limited space for instrumentation.
Approximately, 7% of all adult fractures involve the elbow, of these one third (2%) are distal humeral fractures [1]. These injuries occur in a bimodal distribution, with an early peak in young males, twelve to nineteen years of age, as a result of high-energy trauma, and a second peak in elderly women, with osteoporotic bone, as a result of simple falls[2]. The most common, pattern is, an extra-articular fracture accounting for 40%, bicolumnar or complete intraarticular fractures, are the second most common accounting for 37%.

Standard treatment protocols, has not been developed till date. The available options, for this type of fractures are, crossed screws or pinning, double tension banding technique, single plating techniques, dual plating techniques, minimal osteosynthesis and mobile fixation with hinged external fixators, hemiarthroplasty, and total elbow replacement. Advantages of posterior approach over others as, It allows a more adequate exposure, more freedom in the use of implants, contain no major neurovascular structures, the ulnar nerve have been identified, Less number of cutaneous nerves, when compared to medial and lateral approaches.

Posterior surgical approaches: Triceps preserving approach (Alonso-Llames), Posterior triceps splitting approach (Campbell), Triceps splitting–tendon reflection (V-Y approach Campbell and Van Gorder), Posteromedial extensile (Bryan–Morrey approach)

Currently the olecranon osteotomy approach is the most commonly used surgical approach. However this approach too has its unique complications in the form of prominence/ migration of hardware, nonunion/displacement of osteotomy, need of secondary procedures [3, 4, 5, 7, 8, 9].

O'Driscoll has described a triceps reflecting anconeous pedicle approach (TRAP) that is extensor mechanism sparing paratricipital approach through a midline posterior incision that avoids an osteotomy and mobilizes the triceps and anconeous muscle off the posterior humerus and inter muscular septate and thus provides adequate exposure[10]. This approach also preserves the neurovascular supply of the anconeous that acts as a dynamic stabilizer of the elbow and allow aggressive postoperative elbow rehabilitation. However, various complications encountered such as increased incidence of postoperative hematoma due to extensive soft tissue dissection, wound complications including delayed healing, wound dehiscence and triceps weakness.

Aims and Objectives

To evaluate and compare the results of TRAP approach and olecranon osteotomy approach in open reduction internal fixation of supracondylar and intercondylar fracture of humerus in term of Mayo Elbow Performance Score.

Methodology

A hospital based comparative interventional study includes all patients with distal humeral fractures that operated by TRAP approach and olecranon osteotomy approach for osteo synthesis in between Jan 2012 and Oct 2013 at SMS Medical College and attached Hospitals, Jaipur. 36 patients were taken, out of them 18 were in group-A (operated by olecranon osteotomy approach) and 18 were in group-B (operated by TRAP approach).

Inclusion criteria

1. Intra articular fractures of distal humerus
2. Closed fractures (<2weeks old)
3. Patients consenting to study
4. Skeletally mature.

Exclusion Criteria

1. With vascular injuries
2. Open fractures
3. Old distal humeral fractures (more than 2weeks)
4. Associated with ipsilateral, comminuted olecranon fractures extending into elbow joint.

A detailed history, general condition, vitals were noted. Patients affected limb were x rayed in both antero-posterior and lateral views in slight traction. All routine investigations done. The patient, were given a general or regional anaesthesia and were positioned in the lateral position, with the involved limb supported over bolsters in OT table.

Operative technique

Skin incision

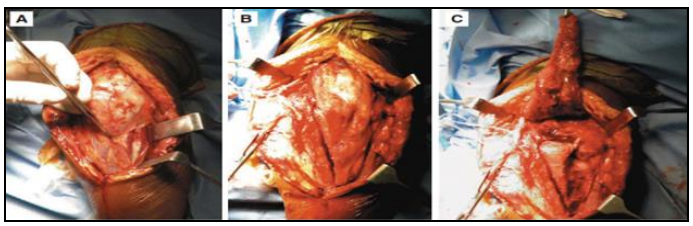
A 15 cm in either case, full-thickness fasciocutaneous flaps are elevated laterally and medially. Once released and mobilized, the ulnar nerve is dissected free and protected throughout the surgical procedure.

Surgical approach

a. TRAP approach
b. Olecranon osteotomy approach

Triceps reflecting anconeus pedicle approach

A fibrous inter muscular fascia "White line" was routinely amenable which separates the extensor carpi ulnaris (ECU) from the anconeous. Once the anconeous is visualized, we then incise the deep fascia directly over the "white line". Anconeous is then dissected off the capsule and lateral collateral ligament complex. At the level of the tip of the olecranon, an arthrotomy is made. The medial exposure consists of the triceps-reflecting approach to the posterior aspect of the elbow, as described by Bryan and Morrey. We then incise the periosteum on the subcutaneous border of the ulna. At the medial side of the olecranon, the incision is extended proximally along the medial border of the triceps while retracting the ulnar nerve. The triceps is reflected laterally off the distal humerus, carefully releasing Sharpey's fibers from their insertion at the tip of the olecranon. We then place a marking suture in the Sharpey's fibers at the time of their release. The fascial and periosteal attachments of the distal anconeous are released, and the entire triceps and anconeous pedicle is reflected proximally. Triceps Re-attachment done by make two criss-cross drill holes through the ulna, proximal to distal, beginning at the normal attachment site of Sharpey's fibers. One transverse hole is also drilled. A non-absorbable suture (ethibond no. 5) is placed through the triceps at the location of Sharpey's fibers. The suture is woven back again in a locking stitch manner. Next, the free ends of the suture are woven 3–5 cm proximally into the triceps tendon in a Bunnell fashion, pulled, and tied. Finally, the interval between ECU and anconeous is closed without tension and free edges of the triceps and periosteum are closed.



Trap Approach (A) The interval between anconeous and extensor carpi ulnaris muscles; **(B)** the ulnar nerve is retracted; medial approach interval is completed between flexor carpi ulnaris and the periosteum over the subcutaneous border of the ulna; **(C)** completed approach with triceps muscle seen reflected along with the flap of the anconeous muscle.

Olecranon osteotomy approach

Subcutaneous border of the proximal ulna is exposed. An apex

distal chevron osteotomy entering into the bare area is then marked on the subcutaneous border of the ulna. A micro sagittal saw is used to complete two thirds of the osteotomy. To avoid unpredictable propagation of the osteotomy, multiple perforations are carefully created through the remaining third using a Kirchner wire (K-wire). Two osteotomies, placed into each arm of the chevron, apply controlled leverage of the olecranon fragment causing fracture of the remaining third. Following the osteotomy, the olecranon fragment along with the triceps tendon and musculature can be bluntly dissected off the posterior aspect of the distal humerus. Fixation of the olecranon osteotomy can be achieved with tension band wiring, screw/tension band constructs, or compression plating. The preferred method is compression plating.

Reconstruction

All fractures were stabilized with use of parallel plating or by the perpendicular plating technique. Both the columns were fixed using standard 3.5 mm pelvic reconstruction plate.

Post-operative care and follow UP

Post operatively, elbow POP slab was applied in 90° flexion for two weeks. Check x rays will be taken and after two weeks, removal of stitches done. Active extension was prohibited until eight weeks. All patients were examined at monthly intervals for three months and then at 6 and 12 months after surgery. Outcomes are measured in terms of Mayo elbow performance score (MEPS) and triceps strength. Radiographs were obtained in anteroposterior and lateral projection on each follow up visit till bony union.

Mayo elbow performance score [22]

(A) Pain Intensity: (1) None – 45 (2) Mild-30 (3) Moderate-15 (4) Severe - 0

(B) Range of Motion: (1) Arc of motion greater than 100º - 20 (2) Arc of motion between 50º and 100º - 15 (3) Arc of motion less than 50º - 5

(C) Stability: (1) Stable – 10 (2) Moderate instability-5 (3) Grossly unstable - 0

(D) Function: (1) Can comb hair -5 (2) Can eat food-5 (3) Can wear shoes-5 (4) Can perform hygiene-5 (5) Can wear shirt- 5

Mayo Elbow Score: (1) Score greater than 90: Excellent (2) Score 75 to 89: Good (3) Score 60 to 74: Fair (4) Score less than 60: Poor

Results

Operating time (Duration of surgery)

The mean operating time in group A was 1.26 ±. 096 hours and in group B was 1.36 ±. 067 hours. P value<.05 (0.001) shows that there was significant difference in operating time between two groups.

Table 1: Mean + Sd of operating time (hours) in surgery of group-A & group-B subjects

IN Hours	Group-A	Group-B	t (df)	P
Operating Time (Mean ± Sd)	1.26 ±. 096	1.36 ±. 067	-3.604 (34)	.001

Time for fracture union

Radio logically fracture union was achieved at an average of 13.56 ± 2.007 weeks in group A and 12.56 ± 1.504 weeks in group B. P-value >.05 (.100) show that there was no significant difference between two group of period of fracture union.

Table 2: Distribution of time for fracture union of group-A & group-B subject

Weeks	Group-A	Group-B	t (df)	P
Time for Bone Union (Mean ± Sd)	13.56 ± 2.007	12.56 ± 1.504	1.692 (34)	0.100

Elbow flexion

The mean elbow flexion in group A was 110.56 ± 18.86 degrees (Range from 70 to120 degrees) and in group B was 112.78 ± 21.91degrees (Range from 50 to 140 degree). P value was >.05 (0.746) show that there was no significant difference between two groups flexion.

Table 3: Mean ± Sd of Flexion of group-A & group-B subjects

In degree	Group-A	Group-B	t (df)	P
Flexion (Mean ± Sd)	110.56 ± 18.86	112.78 ± 21.91	-.326 (34)	0.746

Extension LAG

The mean elbow extension lag in group A was 19.72 ± 14.70 degrees (Range from 0 to 45 degrees) and in group B was 12.22 ± 11.909 degrees (Range from 0 to 30 degree). P value was >.05 (0.102) show that there was no significant difference between two groups extension lag.

Table 4: Mean ± Sd of extension lag of group-A & group-B subjects

In degree	Group-A	Group-B	t (df)	P
Extension Lag (Mean ± Sd)	19.72 ± 14.70	12.22 ± 11.909	1.682 (34)	0.102

Arc of motion

The mean elbow arc of motion in group A was 90.83 ± 30.35 degrees (Range from 30 to 140 degrees) and in group B was 100.56 ± 28.28 degrees (Range from 50 to 140 degree). P-value was >.05 (0.327) show that there was no significant difference between two groups arc of motion.

Table 5: Mean ± Sd of arc of motion of group-A & group-B subjects

In degree	Group-A	Group-B	t (df)	P
Arc of Motion (Mean ± Sd)	90.83 ± 30.35	100.56 ± 28.28	-.994 (34)	0.327

Complications

Out of 18 patients 9 patients of group-A had complication in form of tension band wire protruding, bursitis, ulnar nerve paraesthesia, infection etc. In group-B, 2 patient out of 18 had complication in form of ulnar nerve paraesthesia and knot protuberance. P value was <.05 (0.011) show that there was significant difference between complications of two groups.

Table 6: Distribution of complications of group-A & group-B subjects

Complications	Group A		Group B		χ^2 (df)	P
	No.	Percent	No.	Percent		
Present	9	50 %	2	11.11 %	6.415 (2)	0.011
Absent	9	50 %	16	88.89 %		
Total	18	100 %	18	100 %		

Mayo elbow performance score

The mean MEPS in group-A was 84.17 ± 16.382 (Range from 50 to 100) and in group-B was 87.78 ± 14.061 (Range from 55 to 100). P-value was >.05 (0.483) show that there was no statistically significant difference between two groups mayo elbow performance score.

In our study we observed that 8 (44.44%) patients in group-A

and 9 (50%) patients in group-B achieved excellent results. 6 (33.33%) patients in both groups achieved good results. 3 (16.66%) patients in group-A and 2 (11.11%) patients in group-B attained fair results. 1 (5.55%) patient of each group show poor result. P-value was >0.05 (0.968), so that there was no statistically significant difference between results of two groups.

Table 7: Distribution of results of group-A & group-B subjects

Results	Group A		Group B		χ^2 (df)	P
	No.	Percent	No.	PERCENT		
Excellent	8	44.44 %	9	50 %	.259 (3)	0.968
Good	6	33.33 %	6	33.33 %		
Fair	3	16.66 %	2	11.11 %		
Poor	1	5.55 %	1	5.55 %		
Total	18	100 %	18	100 %		

Discussion

For open reduction internal fixation of intercondylar fracture of distal humerus prime challenge is adequate surgical exposure. For this, olecranon osteotomy approach is considered as gold standard, many other approaches like triceps splitting approach, paratricipital approach, TRAP approach etc.6 These approaches have their unique complications like triceps weakness, fibrosis, stiffness of elbow, inadequate exposure. TRAP approach provide about equal exposure to olecranon osteotomy approach without its complications. The mean age of group A was 36.06 ± 18.22 years (range- 18 to 81) and the mean age of group B was 38.06 ± 16.58 years (range- 18 to 80), there were 28 males (group A-14; group B-14) and 8 females (group A-4; group B-4) in our study. Out of 18 patient of group-A, 7 (38.9%) got injured by road traffic accident (RTA), 9 (50%) got injured by fall from standing height (slip and fell), and 2 patient by fell from height. In group-B out of 18 patient, 8 (44.44%) got injured by RTA, 7 by slip and fall and 3 injured by fall from height.

Pre op x-ray **postoperative x-ray**

Case 1 (TRAP Approach)

Preop x-ray **Postoperative x-ray**

Case 2 (Olecranon osteotomy approach)

This was mainly due to predominance of vehicular accidents in young males. In both groups distribution of patients according to age, sex and mode of injury had no statistically significant difference. In both group injury to the left sided predominant, out of 18 cases in both group 10 (55.55%) are left sided and 8 (44.44%) cases were right sided.

Duration of surgery was considerably more in group-B (1.36 ±. 067 hours) compare to group-A (1.26 ±. 096 hours). That was statistically significant. There was no complication regarding duration of surgery.

Mean duration for fracture union in group-A was 13.56 ± 2.007 weeks (range of 10 to 16 weeks), while it was 12.56 ± 1.504 weeks (range of 10 to 16 weeks) in group-B. There was no statistically significant difference. Union was achieved in all cases. No case of delayed union or non-union were there.

Results were better in TRAP approach group in term of Mayo elbow performance score, flexion, extension lag and range of motion. Complication rate and secondary intervention rate were lower in group-B than group-A. There was no significant difference between two groups in terms of flexion, extension lag and arc of motion.

The average Mayo Elbow Performance Score in group-A was 84.17 ± 16.382 and in group-B was 87.78 ± 14.061. P-value was >.05 (0.483) show that there was no statistically significant difference between two groups MEPS. Results were concluded on the basis of Mayo Elbow Performance Score. Overall 29 patients (80.55%) out of 36 shown excellent and good results with conclusion that there is no statistically significant difference between results of two groups.

Arc of motion and MEPS increased gradually with time and physiotherapy. To achieve good arc of motion main factor was compliance of patient and physiotherapy.

During our study we encountered symptomatic hardware problem in group-A between 4 months to 1 year. 8 patients (44.44%) in group-A showed protruding tension band wire implant and out of them 7 patients got implant exposure with superficial infection. In our single case of group-A Olecranon bursitis had seen after 1 year of surgery for which second surgery done to remove implant and then bursa excision done. In group-B protruding symptomatic ethibond knot occurred in one patient for which knot was excised by second surgery. We observed that 3 patients of group-A and 1 patient of group-B had superficial infection during first 2 weeks after surgery which was recovered by regular dressing and antibiotic coverage according to culture and sensitivity. One patient of group-A had deep infection.

All patients in both groups had good triceps strength. We observed triceps strength subjectively in all patients and it was graded according to the system given by Wolfe *et al*. [21] there was no extensor mechanism failure or triceps weakness in our series.

The TRAP approach allows extensive distal humerus exposure, including the supracondylar/intercondylar region as equal to olecranon osteotomy approach and articular reconstruction and fixation can be easily managed without creating an olecranon fracture. TRAP approach the dissection is in inter nervous plane and hence muscle injury with resultant fibrosis and injury to intramuscular nerve branches are avoided with this approach. Intact olecranon serves as a template to reconstruct articular surface hence good reduction can achieve. Learning curve for TRAP approach was steep compare to olecranon osteotomy approach and sound anatomical familiarity was necessary for it.

Conclusion

TRAP approach is comparatively better than osteotomy approach. TRAP approach allows adequate fracture visualization and stable Fracture fixation even in comminuted AO type C3

fracture of the distal humerus, with the advantage of intact olecranon that serve as a template around which critical intra-articular fracture reduction is afforded. The approach permits aggressive postoperative elbow rehabilitation without elbow instability. Accurate and strong reattachment of the reflected extensor mechanism is absolutely critical for postoperative elbow rehabilitation and good functional outcome.

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