

# Are olecranon osteotomies preferred to triceps-elevating approaches in intraarticular distal humerus fractures? a literature review

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**Received:** 10-Jul-2023

**Revised:** 23-Jul-2023

**Accepted:** 29-Jul-2023

**Published:** 01-Mar-2024

The Egyptian Orthopaedic Journal 2024, 59:6–11

## Background

The outdated 'bag of bones' concept for managing intraarticular distal humerus fractures (IDHF) has historically given way to precise articular reduction made possible by modern implant designs and the option of joint replacement as a last resort for unreconstructable fractures. Several posterior approaches to the distal humerus have been described since the last century, among which the olecranon osteotomy is considered the most invasive yet the most employed approach in cases of intraarticular distal humerus fractures.

## Objectives

The advantages and reported complications of the triceps fascial tongue approach, the triceps reflecting anconeus pedicle (TRAP) approach, and the olecranon osteotomy in cases of intraarticular distal humerus fractures were the subjects of a thorough literature search in the PubMed, SCOPUS, Cochrane Library, and Google Scholar databases. This literature review made use of all pertinent data.

## Keywords:

anconeus pedicle, distal humerus, olecranon osteotomy, triceps reflecting, triceps tongue

Egypt Orthop J 2024, 59:6–11

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1110-1148

## Introduction

In 1969, Riseborough and Radin [1] conducted a study comparing surgical to conservative treatment for intraarticular distal humerus fractures (IDHF). They found that surgical treatment was unexpected and frequently associated with subpar results; hence they advised against it. Over the past 40 years, however, advancements in surgical techniques and implant designs have significantly improved the stability of distal humerus fractures [2,3]. Modern fixation techniques have been shown to promote stability and enable early mobilization, particularly for type C distal humerus fractures of Arbeitsgemeinschaft für Osteosynthesefragen (AO) [4–6]. Nonetheless, exposure of the distal humerus, particularly its articular surface, poses challenges due to its distinctive anatomy, articulation with the radial head and olecranon, and closeness to many critical neurovascular structures. Various surgical approaches have been outlined for managing these fractures, with each strategy's proponents highlighting distinct benefits [7–10]. Yet, there is an ongoing debate over which approach offers optimal access to the articular surface of the distal humerus while ensuring satisfactory functional outcomes [11]. The objective of this study is to provide a narrative literature review compiling the most recent data to compare the benefits and drawbacks of the olecranon osteotomy (OO), the triceps tongue flap (TTF), and the triceps reflecting anconeus pedicle (TRAP) approaches in the setting of IDHF.

## Surgical approaches

### Olecranon osteotomy (OO)

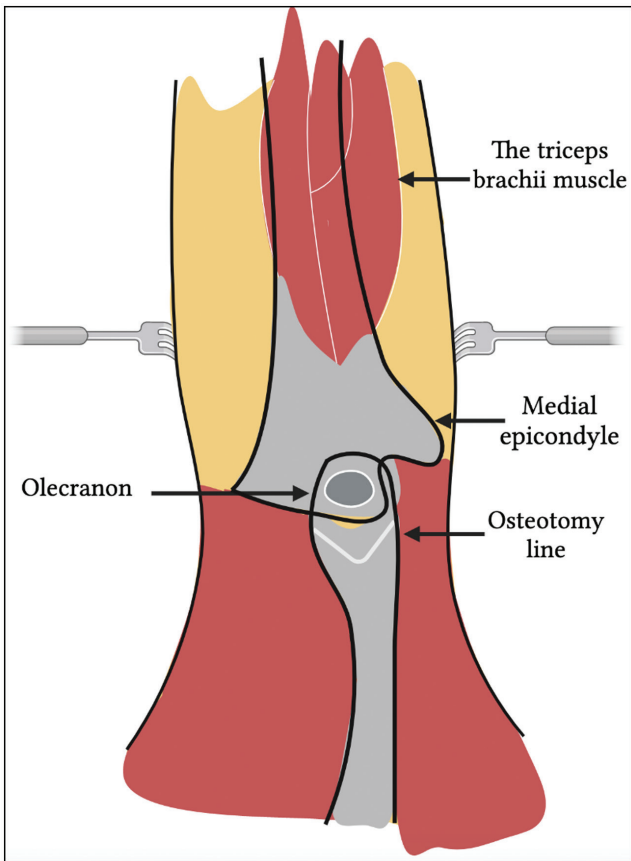
The OO was first proposed by MacAusland [12] as a viable option to treat ankylosis of the elbow joint. Since then, several modifications of the classical oblique osteotomy have been described [13–15]. The Chevron-shaped osteotomy (Fig. 1) is commonly employed to address IDHF. As there is the least amount of articular cartilage there, it is advised that the osteotomy be performed at the level of the semilunar notch [3]. By enhancing accessibility to the articular surface of the distal humerus, this procedure facilitates accurate articular reduction and fixation [13]. However, delayed union, nonunion, ulnar nerve injury, and symptomatic hardware have all been documented as serious osteotomy-related complications [16–19].

### Triceps tongue flap approach (TTF)

The TTF approach was first described in 1940 by Van Gorder [10] to treat complex T-type fractures of the distal humerus. The distally based triceps flap (Fig. 2) is sharply dissected after superficial dissection. Once the collateral ligaments are released, the articular surface can be sufficiently exposed [20]. The closure should be performed using heavy non-absorbable

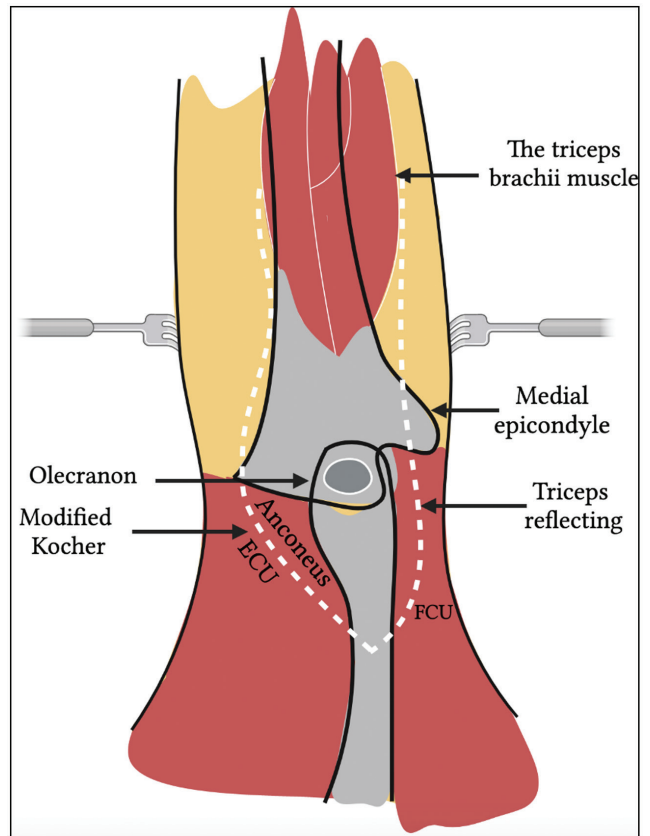
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Figure 1



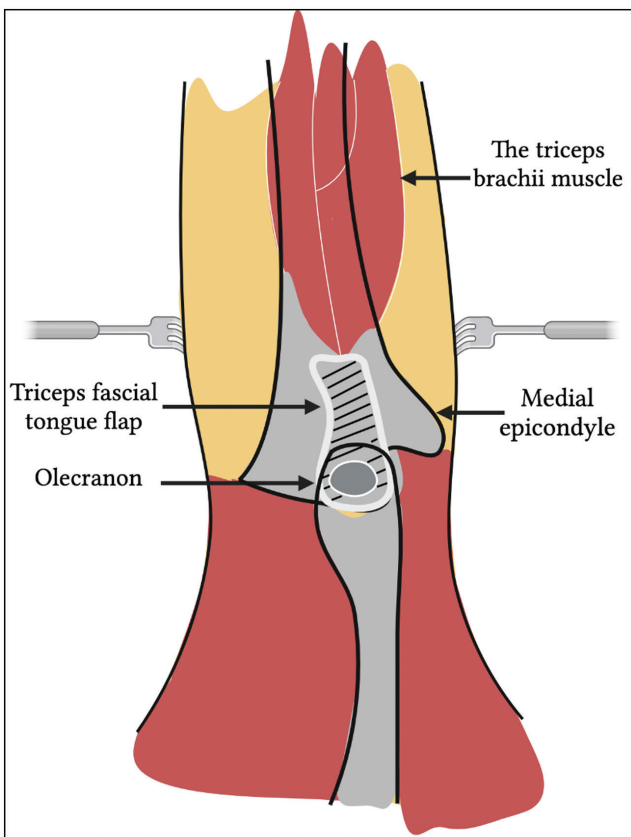
Author's illustration of the olecranon osteotomy approach.

Figure 3



Author's illustration of the triceps reflecting anconeus pedicle approach.

Figure 2



Author's illustration of the triceps fascial tongue flap approach.

sutures as it relies on tendon-to-tendon healing. Even though triceps insufficiency may theoretically be considered the most worrisome complication related to this approach, except for one patient who developed postoperative extensor mechanism failure following total elbow arthroplasty (TEA) via the TTF approach, as reported by Kahan and colleagues [21], the authors could not even identify a single case report describing this issue. That might be attributed to the insufficient material available in the literature about the clinical and functional outcomes related to this specific approach following the operative management of IDHF.

**Triceps reflecting anconeus pedicle approach (TRAP)**

The TRAP approach was introduced in 2000 by O'Driscoll [8]. This technique has lately gained wide acceptance due to indications that it preserves the triceps function while offering exposure comparable to that obtained with an OO, except for a segment of the anterior trochlea. By incorporating medial and lateral (modified Kocher) windows (Fig. 3), the TRAP approach meets the criteria for the ideal surgical technique for managing IDHF [8].

**Complications**

Despite the frequent employment of the OO approach, rather substantial complication rates are revealed in the vast outcome-reporting literature on

this topic [7,19,22–24]. According to a recent meta-analysis of 41 papers and 1700 olecranon osteotomies, the rate of osteotomy-related complications was 26%, including; superficial and deep infections, symptomatic hardware, delayed union, and nonunion [25]. The most commonly reported complication of the OO approach was the ulnar nerve injury, followed by symptomatic hardware and nonunion (Table 1). As for the TTF approach, no complications were reported except for triceps insufficiency, observed in one patient following primary TEA [21]. Complications related to the TRAP approach include ulnar nerve injury and posttraumatic arthrosis (Table 1).

## Discussion

Among other factors, including; fracture morphology, planned fixation technique, and the presence of concomitant injuries, the surgeon's preference is probably the most influential factor in determining the employed surgical approach [36,37]. Still, adequate exposure of the joint surface of the distal humerus can be best accomplished via posterior approaches. As O'Driscoll [38] has judiciously stated, 'The front door to the elbow is at the back'. Most elbow trauma experts advocate the OO approach to address IDHF as it is thought to provide optimal and maximal exposure of the articular surface of the distal humerus and thus enhance the reduction and fixation technique [3,39]. In their cadaveric study, however, Wu and colleagues [40] demonstrated that the OO approach allowed visualization of approximately  $53.9\% \pm 7.1\%$  of the articular surface of the distal humerus. In a similar context, Winek and colleagues [41] conducted another cadaveric study to compare the percentage of the articular surface of the distal humerus visible through the OO and the TTF approaches. They divided twelve cadavers into two groups, each consisting of 6 specimens. In the first group, the percentage of the

exposed articular surface of the distal humerus was measured using the TTF approach while retaining the collaterals and then again after releasing them. In the second group, the percentage was calculated using the OO approach. The results showed that the TTF approach, with the collaterals intact, allowed visualization of 36% of the articular surface (Fig. 4c), while the OO approach allowed visualization of 57.9% (Fig. 4a). However, after releasing the collaterals, the TTF approach showed an increase, with up to 85.09% of the articular surface being visualized (Fig. 4d) [41]. Regarding the articular surface exposure provided by the TRAP approach, O'Driscoll revealed in his original paper that complete flexion of the elbow following deep dissection of the medial and lateral windows provides an ideal view of the articular surface, except for an insignificant area on the anterior Trochlea (Fig. 4b)[8].

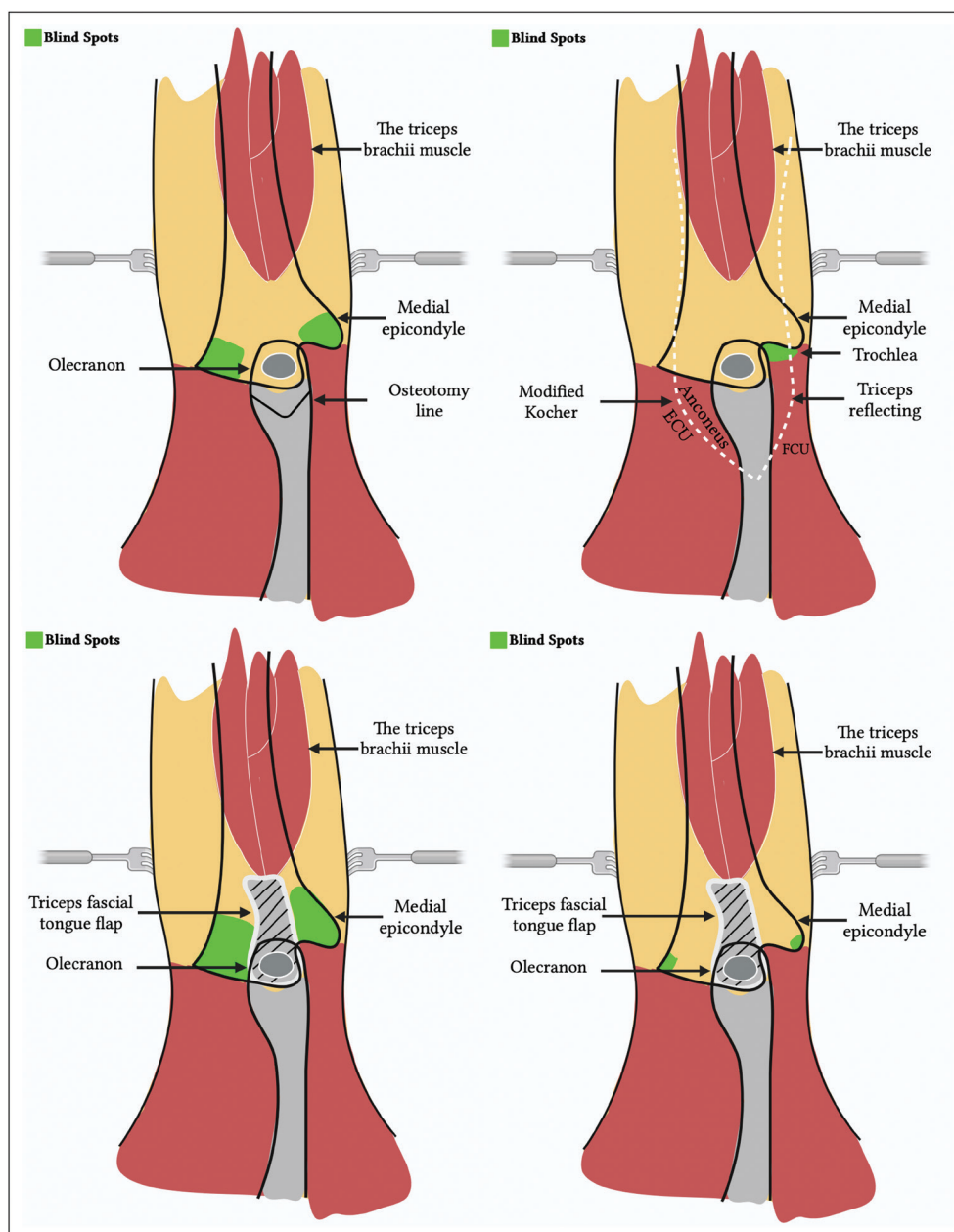
Aside from the osteotomy-related complications listed above (Table 1), two additional drawbacks are; 1) denervation of the anconeus muscle during soft tissue dissection for the OO and 2) violating the integrity of the olecranon and subsequently compromising the procedure if conversion to TEA becomes necessary O'Driscoll [8]. Also, preserving the integrity of the olecranon as a part of a three-dimensional template comprised of the olecranon, the coronoid process, and the radial head is preferred, given its articulation with the distal humerus as it serves as a reference for adequate reduction of the articular surface.

By exploring the current literature on the TTF approach, it becomes evident that, besides the original article authored by Van Gorder [10] in 1940, there is little more research on the technique, and during the past two decades, it has been left out of several review articles and comparison studies [11,42–44]. In 2015, the TTF was reinstated as a reliable approach for

**Table 1 Complications reported in the literature following the OO, TTF, and TRAP approaches**

Author	Approach	Number of participants	Nonunion (%)	Symptomatic hardware (%)	Posttraumatic arthrosis (%)	Ulnar nerve injury (%)	Triceps insufficiency (%)
Azboy [26]	OO	22	5.6	22.1	-	11.1	-
	TRAP	22	0	-	-	9.1	-
Chen [27]	OO	34	0	-	-	6.1	-
Chou [28]	TRAP	48	0	8.3	4.2	8.3	-
Coles [29]	OO	42	1.5	29	-	0	-
Kahan [21]	TTF	53	-	-	-	-	1.89
McKee [30]	OO	11	-	27.3	-	18.2	-
Mishra [31]	TRAP	15	-	-	-	6.7	-
Pankaj [32]	TRAP	40	0	5	-	0	0
Sharma [33]	TTF	23	-	-	-	-	-
Weber [34]	TTF	28	-	-	-	0	-
	OO	15	-	27	-	33	-
Zhang [35]	OO	36	-	16.7	-	11.1	-

Figure 4



Author's illustration of the blind spots (green spots) associated with the olecranon osteotomy approach (A), the Triceps-reflecting anconeus pedicle approach (B), and the Triceps fascial tongue flap approach by retaining (C) and after releasing the collateral ligaments (D).

performing primary TEA Marinello and colleagues [20]. However, other than the studies conducted by Kahan *et al.*, [21], Sharma *et al.*, [33], Weber and colleagues [34], and Marinello and colleagues [20], results of operative management of IDHF via the TTF approach remain sparse. The TRAP approach, as initially described by O'Driscoll [8], while it may be technically demanding, fulfills the criteria for ideal surgical access to the distal humeral articular surface (Table 2). However, impairment of the extensor mechanism is regarded as the most serious complication following triceps-elevating exposures [45]. Ozer and colleagues reported the results of the isokinetic strength scores of eleven patients with IDHF that were treated via

the TRAP approach [46]. After comparing the peak torque deficits of the extensors and flexors of both the injured and uninjured sides, the results revealed no significant differences. Pankaj and colleagues [32] reviewed the functional outcomes of 40 patients who underwent internal fixation of IDHF via the TRAP approach. According to their findings, weakness of the extensor mechanism with an extension lag of 10° was detected in one patient (2.5%). Even though O'Driscoll [47] mentioned the risk of impairing the vascularity of the anconeus muscle after detaching the muscle subperiosteally (modified Kocher) and possibly compromising its function as a dynamic stabilizer of the elbow, to our knowledge, this issue has not been



**Table 2 Characteristics of each approach as per the criteria of ideal surgical exposure outlined by O'Driscoll**

No.	Criterion	Triceps fascial tongue flap approach (TTF)	Triceps reflecting anconeus pedicle approach (TRAP)	Olecranon osteotomy (OO)
1	Adequate exposure	Yes	Yes	Yes
2	Extensile options	Yes	Yes	No
3	Osteotomy-free soft tissue dissection	Yes	Yes	No
4	Dissection in the internervous plane rather than across the nerves	Yes	Yes	No
5	All surgical alternative procedures to be performed through the same exposure	Yes	Yes	No
6	Rapid rehabilitation of the afflicted extremity	No	Yes	Yes
7	Consecutive reconstructive procedures using the same approach	Yes	Yes	No

reported in the literature. In the setting of comminuted IDHF, poor bone stock, and unsalvageable articular surface, primary TEA may be the only option to address those injuries adequately [3,48,49]. In that instance, the TTF or the TRAP approach is recommended to preserve the integrity of the olecranon and thus avoid compromising the procedure [8,20]. Based on the available data for analysis: in terms of complication rates, the OO approach surpassed the TTF and TRAP approaches (Table 1). Also, according to the criteria defining the ideal surgical exposure outlined by O'Driscoll [8], the TTF and TRAP approaches appear superior to the OO approach, as shown in (Table 2).

The authors made several observations during the course of conducting this literature review. Firstly, we found a significant shortage of high-quality studies or randomized controlled trials that compare the outcomes of posterior approaches to the distal humerus. Secondly, while there have been numerous studies on complications and functional outcomes of the OO approach for IDHF, there is a scarcity of similar research on the TTF and TRAP approaches. In fact, similar works on the TTF and the TRAP approaches can be counted on the fingers of one hand (Table 1). Consequently, there is a lack of scientific evidence to guide surgeons in determining which technique works best in which circumstance. The authors suggest that future research should focus on well-designed comparative studies that examine the outcomes and complication rates associated with the aforementioned approaches.

## Conclusion

Compared with the TTF and the TRAP approaches, there are many more publications on olecranon osteotomies; thus, the latter may appear riskier. If total elbow arthroplasty is likely to be performed, however, it is risky to sacrifice the integrity of the olecranon by performing an olecranon osteotomy, which subsequently compromises the stability of the construct. Either the TTF or the TRAP approach is favorable in such cases as they allow for internal fixation

and joint replacement. Even though the extensor mechanism failure may be a devastating complication following TEA via the TTF approach, clinical reports in that regard remain limited.

## Acknowledgments

None.

## Informed consent

Not applicable.

## Institutional Ethical Committee Approval

Not applicable.

## Financial support and sponsorship

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

## Conflicts of interest

None.

## Authors contribution

First author: Conceptualization, Writing-Original draft, Review and Editing, Illustrations. Second author: Review. Third author: Review and Editing.

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