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ORIGINAL ARTICLE

Triceps-sparing extra-articular step-cut olecranon osteotomy for distal humeral fractures: an anatomic study

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Background: This anatomic study investigated the distal humeral articular surface exposure achievable through a triceps-sparing oblique extra-articular osteotomy of the olecranon with a step-cut modification compared with the anconeus flap transolecranon apex distal chevron osteotomy. In addition, the bone contact surface areas of the osteotomized surfaces after transolecranon and extra-articular osteotomies were compared.
Methods: Seven pairs of fresh adult cadaveric elbow joints were examined. Each of the right elbows underwent triceps-sparing extra-articular step-cut olecranon osteotomy (SCOOT) with an anconeus flap, and the left elbows underwent the anconeus flap transolecranon apex distal chevron osteotomies (CO). The articular surface exposed by each of the osteotomy techniques was then digitally analyzed using a 3-dimensional measurement system. The bone contact surface area of the osteotomized surfaces was also assessed.
Results: The percentage of total joint exposed by the SCOOT group was less than the CO group (SCOOT: 64% ± 3% vs. CO: 73% ± 3%; $P = .002$). There was significantly greater bone contact surface area of the osteotomized surfaces in the SCOOT group compared with the CO group (SCOOT: 1172 ± 251 mm^2 vs. CO: 457 ± 133 mm^2; $P = .002$).
Conclusion: The triceps SCOOT procedure with an anconeus flap provides excellent distal humeral articular surface exposure with the added benefit of a substantially increased (2.6-times) bone contact surface area of the osteotomized surfaces.
Level of evidence: Basic Science; Anatomy Study; Cadaver Dissection

Keywords: elbow; trauma; distal humeral fracture; olecranon osteotomy; surgical approach; osteosynthesis; open reduction internal fixation

Distal humeral fractures in adults are complex and technically demanding injuries to manage. The fracture pattern in 96% of adult distal humeral fractures is complex, involving both columns and with extension to the articular surface.[15,19] Operative intervention is indicated in most cases.

This study did not require ethical approval.

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Achieving adequate exposure to safely apply stable internal fixation is difficult because of multiple fracture planes, fragmentation of the articular surface, and the intricate anatomy of the elbow.[19] There is controversy regarding a number of issues pertaining to the management of distal humeral fractures, including the best operative approach.

An ideal surgical approach to the distal humerus should provide exposure to allow anatomic reconstruction of the articular surface and the application of stable internal fixation, while protecting neurovascular structures.[21] Numerous operative approaches for the management of distal humeral fractures have been described. With the exception of approaches described for the fixation of coronal shear fractures, these all use a posterior skin incision with various strategies of working through or around the triceps muscle. Described approaches include the paratricipital (Alonso-Llames),[1,31] triceps-reflecting (Bryan-Morrey),[8] triceps-reflecting anconeus pedicle,[27] triceps-splitting,[20,40] and olecranon osteotomy techniques.[2,4,23,28,35,37]

The paratricipital, triceps, and triceps-splitting approaches are generally adequate for extra-articular fractures. The major disadvantage of this approach is limited visualization of the articular surface in complex intra-articular distal humeral fractures; therefore, different extra-articular and intra-articular osteotomy approaches have been described.[23,35,37] An anatomic study by Wilkinson and Stanley[38] found that the percentage of articular surface visible after triceps-splitting, triceps-sparing, and olecranon osteotomy were 35%, 46%, and 57%, respectively. This is one of the major reasons why the transolecranon approach, using the apex distal chevron osteotomy (CO), remains the gold standard for most surgeons.[5,16,38] Because the traditional transolecranon approach causes denervation of the anconeus muscle,[26] variations of the olecranon osteotomy that preserve the anconeus have been described.[2,26]

At the conclusion of the procedure, the osteotomy site is fixed with a tension band construct, an intramedullary screw, or a plate. Depending on the method of fixation of the transolecranon osteotomies, several complications have been reported. The reported union rates are up to 100%,[4,28] but other authors have observed complications, with failure of fixation, delayed unions, or even nonunions.[14,30,33]

A triceps-sparing extra-articular step-cut olecranon osteotomy (SCOOT) with an anconeus flap was developed to address some of the limitations of the classic transolecranon distal apex CO. The adequacy of joint exposure with this extra-articular osteotomy of the olecranon is not known. To our knowledge, median joint surface exposure has been compared between transolecranon osteotomy, triceps-reflecting, and triceps-splitting approaches,[38] but no comparison has been made between exposures achieved through intra- articular and extra-articular osteotomes.

The aims of this anatomic study were to:

1. investigate the articular surface exposure achievable through the triceps-sparing extra-articular SCOOT with an anconeus flap compared with the anconeus flap transolecranon apex distal CO; and
2. evaluate the bone contact surface area of the osteotomized surfaces after SCOOT and CO.

Materials and methods

Specimens

Seven pairs of fresh adult cadaveric elbow joints were examined (7 left and 7 right). All investigations were performed according to ethical guidelines and recommendations for working with cadavers.[6] To preserve the anonymity of the donors, information such as personal identity and medical history was not disclosed.

Each elbow consisted of an arm segment from midhumerus to midforearm and was completely intact of all fascia as well as skin. All specimens were free from deformity, significant joint degeneration, previous operations, and any previous dissection of deep structures. Each of the right elbows underwent triceps-sparing extra-articular SCOOT with an anconeus flap (Fig. 1, *A*), and the left elbows underwent the anconeus flap transolecranon apex distal CO (Fig. 1, *B*).

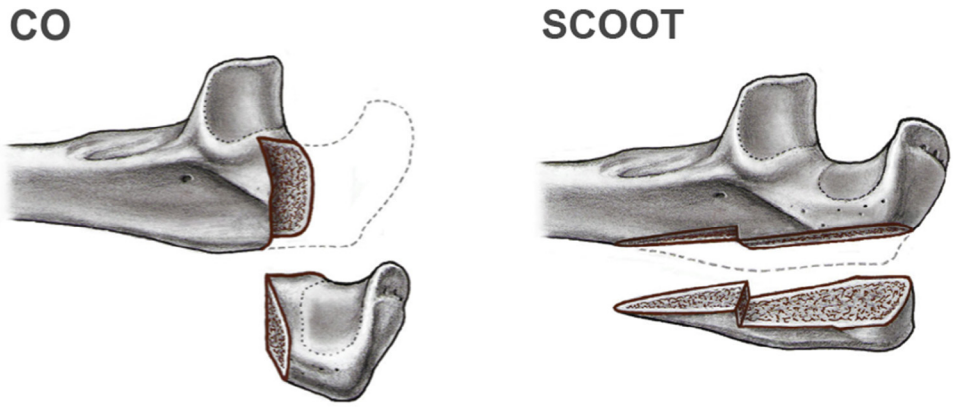

Figure 1 The transolecranon apex distal chevron osteotomy (*CO*) on the right compared with the triceps-sparing extra-articular step-cut olecranon osteotomy (*SCOOT*) with an anconeus flap on the left.