Chinese Journal of Traumatology 21 (2018) 356–359

Contents lists available at ScienceDirect

Chinese Journal of Traumatology

journal homepage: http://www.elsevier.com/locate/CJTEE

Original Article

Surgical exposures of the distal humeral fractures: An anatomical study of the anterior, posterior, medial and lateral approaches

Zi-Zheng Wu [a, b], Jian-Dong Wang [a], Xiao-Xi Ji [a], Zhi-Jian Ma [a], Jian-Hong Wu [a], Qiu-Gen Wang [a, *]

[a] Shanghai Trauma & Emergency Center, Shanghai General Hospital of Nanjing Medical University, Shanghai, China
[b] Department of Orthopaedics, Baoshan Branch of Shanghai General Hospital of Shanghai Jiaotong University, Shanghai, China

ARTICLE INFO

Article history:
Received 6 April 2018
Received in revised form
3 August 2018
Accepted 13 September 2018
Available online 13 December 2018

Keywords:
Elbow
Exposures
Distal humerus fractures
Surgical approach

ABSTRACT

Purpose: Exposure of the articular surface is the key to the successful treatment of intra-articular fractures of distal humerus. Anterior, posterior olecranon osteotomy as well as medial and lateral approaches are the four main approaches to the elbow. The aim of this study was to compare the exposure of distal articular surfaces of these surgical approaches.

Methods: Twelve cadavers were used in this study. Each approach was performed on six elbows according to previously published procedures. After completion of each approach, the exposed articular surfaces were marked by inserting 0.5 mm K-wires along the margins. The elbow was then disarticulated and the exposed articular surfaces were painted. The distal humeral articular surfaces were then closely wrapped using a piece of fibre-glass screen net with meshes. The exposed articular surfaces and the total articular surfaces were calculated by counting the number of meshes, respectively.

Results: The average percentages of the exposed articular surfaces for the anterior, posterior olecranon osteotomy, medial and lateral approaches were 45.7% ± 2.0%, 53.9% ± 7.1%, 20.6% ± 4.9% and 28.5% ± 6.3%, respectively.

Conclusion: The anterior and posterior approaches provide greater exposures of distal humeral articular surface than the medial and lateral ones in the treatment of distal humeral fractures.

Introduction

Fractures of the distal humerus are common injuries, constituting 30% of all elbow fractures.[1,2] Up to 96% of these injuries are intra-articular fractures, which can be classified as AO type C fractures.[3] Various challenges, including the complex anatomy, the limited surgical exposure, the comminuted articular surface and the osteoporotic bone stock, bring tremendous difficulties to the management of distal humeral fractures.[4] Anatomical reduction of the joint surface is regarded the key to achieving secure fixation and satisfactory outcome.[5,6] A larger exposure of the joint surface is the premise to the joint surface anatomical reduction, so it is very important to choose a surgical approach that can better expose the joint surface with less trauma.

Many approaches are at the surgeons' disposal for exposure of the distal humerus. These mainly include the anterior, posterior olecranon osteotomy, medial and lateral approaches. Though posterior approach has three modes, olecranon osteotomy could provide the largest articular surface exposure and commonly used in complex elbow injuries[7] and thus discussed in this study. In recent years the anterior, medial and lateral approaches were modified and reported increasingly. However, few comparative studies have been performed to investigate which approach can provide better exposure of the distal humeral articular surface, which is critical in the treatment of comminuted distal humeral fractures. The aim of this study was to compare the exposed areas of the distal humeral articular surface via the anterior, posterior olecranon osteotomy, medial and lateral approaches. We hypothesized that the anterior and posterior olecranon osteotomy approaches can provide larger distal humeral articular exposures compared to the medial and lateral approaches.

* Corresponding author.
E-mail address: wangqiugen@163.com (Q.-G. Wang).

Peer review under responsibility of Daping Hospital and the Research Institute of Surgery of the Third Military Medical University.

https://doi.org/10.1016/j.cjtee.2018.07.006

Methods

This study was approved by the Ethics Committee of the authors' institution. Twelve adult (7 male) fresh-frozen cadavers with a mean age of 55.4 (range, 37–76) years were used in the study. Twenty-four arms were dissected from the shoulder. All specimens were eliminated deformity, trauma and significant joint degeneration. Each elbow was assigned to one surgical approach using a stratified block randomization so that each pair of elbows underwent different approaches and each approach was performed on 6 elbows. Each elbow was exposed by two senior orthopaedic surgeons (Wu ZD and Wang JD), using the following four approaches.

The anterior approach

The specimens were installed in dorsal position, and the elbows in extention. A curved incision was made transversely along the anterior aspect of the elbow joint. It was below slightly the elbow flexion crease. The skin and subcutaneous tissue were reflected, followed by the Henry's and Reichel's elbow surgical approaches.[8,9] Firstly, between the brachioradialis and the biceps muscle, follow the border of the biceps distally, the brachioradialis and the radial nerve were retracted laterally and the biceps medially. A longitudinal incision was made on the brachialis and the anterior capsule of the elbow joint to expose the articular surface. Then along the medial border of the distal biceps, between the biceps and the medial brachial neurovascular bundle, the brachialis and the anterior capsule of the elbow were incised. The medial trochlea and the coronoid process were exposed. The position of the elbow and the windows of soft tissue were changed properly to expose the articular surface ultimately and the exposed articular surface was marked by drilling holes along the margin of the exposed articular surfaces with a 0.5 mm K-wire. The K-wires indicated an accessible surgical area which guaranteed sufficient screw insertions (Fig. 1).

The posterior olecranon osteotomy approach

The specimens were installed in ventral position, and the elbows in extention. A 10 cm posterior skin incision was made on the elbow (5 cm above the top of the olecranon and 5 cm below it). The skin and subcutaneous tissue were reflected and the olecranon osteotomy was made transversely approximately 2 cm from its tip.[10] The elbows were then bent maximally and the exposed humeral articular surfaces were marked by drilling holes along the margin with a 0.5 mm K-wire as above.

The medial approach

A medial incision was made over the tip of the medial epicondyle from 5 cm distal to the joint to about 5 cm proximal to it. The ulnar nerve was isolated and reflected posteriorly. All the soft tissues were dissected from the medial epicondyle and reflected anteriorly and distally. The capsule was incised and the elbow joint was subluxated to expose the distal humeral articular surfaces which were marked as above.[10]

The lateral approach

The skin incision was begun approximately 5 cm proximal to the lateral epicondyle of the humerus and was extended distally to the epicondyle for about 10 cm. The origins of the extensor carpi radialis and brachioradialis were separated and reflected anteriorly. The triceps and the common origin of the extensor muscles posteriorly and distally. The capsule was incised and the elbow joint subluxation was made to expose the lateral aspect of the elbow joint. The exposed articular surfaces of the humerus were marked as above.[10]

Following disarticulating the elbow joint and removing all the soft tissue attachments of each sample, the marked exposed articular surfaces of the four groups were painted with dye (Shanghai SIIC Marie Painting Materials Co., Ltd, China) (Fig. 2). Each distal humeral articular surface was then wrapped with a piece of fibre-glass screen net (9 cm × 10 cm) with meshes (standard mesh: 12 × 12 mesh, mesh size: about 1.70 mm produced by Shanghai Iron Wire Netting Works, China). The net was closely applied to the dissected articular surface. The number of meshes covering the painted articular surface and the number of meshes covering the total humeral articular surface were counted, respectively. The meshes at the margin of the exposed area which were partially covered were counted as 0.5.

Statistical analysis

Statistical analysis of the data was performed with SPSS statistical software version 13.0. The percentages of the exposed articular surfaces were analysed using one-way ANOVA method. The results were considered to be significant at $p < 0.05$.

Results

The mean percentages of the exposed distal humeral articular surface for the anterior, posterior olecranon osteotomy, medial and

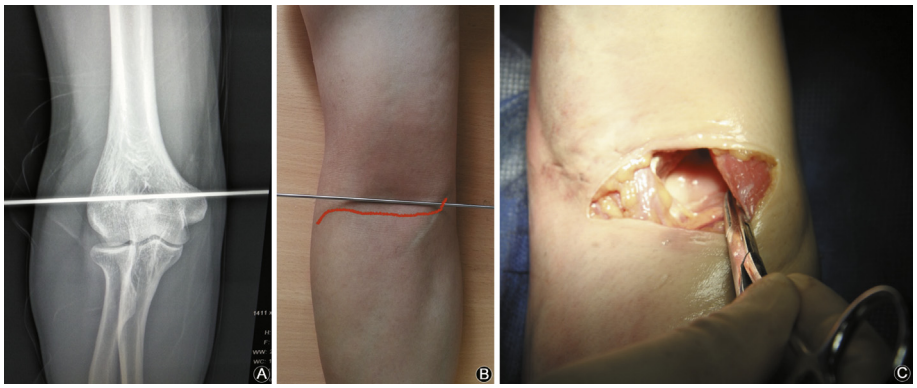

Fig. 1. Photographs of the anterior approach of the elbow. A: The relationship between the elbow flexion crease and the elbow joint line; B, C: The skin incision and the exposed medial articular surfaces.

Fig. 2. Photographs of the lower part of the four humeri after disarticulation of the elbow revealing the articular surfaces exposed by the approach (painted). A: Anterior approach; B: Olecranon osteotomy approach; C: Medial approach; D: Lateral approach.

lateral approaches were 45.7% ± 2.0%, 53.9% ± 7.1%, 20.6% ± 4.9% and 28.5% ± 6.3%, respectively (Fig. 3). Significant fluctuations among different cadaver arms were found in the exposed distal humeral articular surfaces for the medial, lateral and posterior approaches. Posterior olecranon osteotomy approach provided significantly greater percentage of exposed articular surface compared to the other three approaches, and the medial one showed significantly lower percentage.

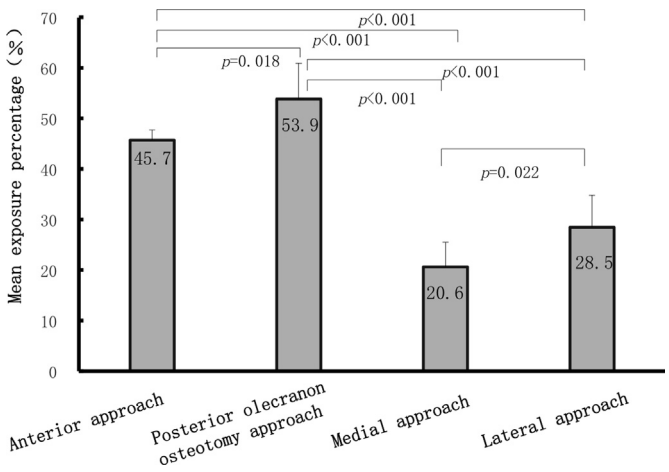

Fig. 3. The mean exposure percentage of the distal humeral articular surfaces by different approaches.

Exposure of the distal humeral articular surface was better achieved with the posterior olecranon osteotomy and the anterior approach.

Discussion

It is critically important to achieve anatomical reduction in intra-articular fractures. Sufficient surgical exposure facilitates the procedure. The main surgical approaches to the elbow are anterior, posterior, medial and lateral ones. Choosing the approach for a specific distal humeral fracture currently depends more on the surgeon's own experience and favour. However, few comparative studies have been performed to investigate which surgical approach can better expose the distal humeral articular surface. Thus, the current investigation was performed to quantify the exposure areas of the articular surface among different approaches.

In order to make the results authoritative and comparable, we referred to the classical Campbell's Operative Orthopaedics and the posterior, medial and lateral skin incision were all 10 cm long. Among the 4 approaches used, we found that the posterior olecranon osteotomy approach provided the greatest exposure of the distal humeral articular surface. However, a rate of 30% of nonunion of the osteotomy is a common complication of this approach,[11,12] along with a palpable implant and prolonged surgical time, which also limited its application.[13–15]

Because the distal humeral articular surfaces are mainly anterior structures (about 30° anteversion), The anterior approach to the elbow joint is commonly believed to provide the greatest direct access for anterior to posterior screw fixation under direct visualization, but a paucity of literature exists to advocate this point.[8,9,16,17] We combined Henry's and Reichel's descriptions of

anterior elbow surgical approaches.[8,9] We found that the anterior approach which passed through the interval between the brachioradialis and the biceps or the biceps and the medial brachial neurovascular bundle did not need to cut the medial or lateral ligaments or osteotomize the olecranon, which could provide about 45.7% ± 2.0% articular exposure. The anterior approach might be an appropriate option for distal humeral fractures, especially for the distal humeral coronal plane fractures, when it allowed relatively larger surgical exposure to the fracture site, as well as minimum invasion of soft tissue dissection.

Although the posterior olecranon osteotomy approach and anterior approach provided better exposure of the posterior and anterior distal humeral articular surface, they still left more than 40% of the distal humeral articular surface unvisualized. The other approaches provided even poorer exposure to the trochlear articular surface. In order to get access to more intra-articular fragments, maybe these approaches should be combined properly to address complex intra-articular fractures of the elbow, especially the combination of anterior approach and lateral or medial approach.

The geometry of the distal end of the humerus is complex and, therefore, it is not easy to measure the articular surfaces. The measurement technique proposed by Wilkinson & Stanley[7] and Dakoure et al[18] is very practical, efficient and cheap. There is no need for special cameras, computers, or image processing software. The results of articular surface exposed by olecranon osteotomy approach are similar to theirs. All of these can further prove that this method is reproducible and effective. Furthermore, we used a modification of this technique. The net we used contains square meshes with the side length about 1.7 mm, which made the articular surfaces count by the net more accurate.

This study has several limitations. The fibre-glass screen net could not be completely attached to the articular surface of the distal humerus because of its physical characteristics, which might lead to a certain degree of error in counting the meshes. However, the percentage of the exposed articular surface we persued, other than the absolute number of the meshes, might reduce this error. Furthermore, although the sample size of this study had reached sufficient statistical power, investigations of larger sample sizes are required in future.

In conclusion, the anterior and posterior approaches provided greater exposures of distal humeral articular surface than the medial and lateral ones.

Fund

The project is sponsored by the construction plan of characteristic medical specialties and community projects of Baoshan District, Shanghai City, China (Grant No.:BSZK - 2018 - B02).

References

1. Anglen J. Distal humerus fractures. *J Am Acad Orthop Surg*. 2005;13:291–297.
2. Galano GJ, Ahmad CS, Levin WN. Current treatment strategies for bicolumnar distal humerus fractures. *J Am Acad Orthop Surg*. 2010;18:20–30.
3. Pollock JW, Faber KJ, Athwal GS. Distal humerus fractures. *Orthop Clin N Am*. 2008;39:187–200. https://doi.org/10.1016/j.ocl.2007.12.002.
4. Wong AS, Baratz ME. Elbow fractures: distal humerus. *J Hand Surg Am*. 2009;34:176–190. https://doi.org/10.1016/j.jhsa.2008.10.023.
5. Alonso-Llames M. Bilaterotricipital approach to the elbow. Its application in the osteosynthesis of supracondylar fractures of the humerus in children. *Acta Orthop Scand*. 1972;43:479–490.
6. Gupta R, Khanchandani P. Intercondylar fractures of the distal humerus in adults: a critical analysis of 55 cases. *Injury*. 2002;33:511–515.
7. Wilkinson JM, Stanley D. Posterior surgical approaches to the elbow: a comparative anatomic study. *J Shoulder Elbow Surg*. 2001;10:380–382.
8. Henry AK. *Extensile Exposure*. second ed. New York: Churchill Livingstone; 1973.
9. Reichel LM, Milam GS, Reitman CA. Anterior approach for operative fixation of coronoid fractures in complex elbow instability. *Tech Hand Up Extrem Surg*. 2012;16:98–104. https://doi.org/10.1097/BTH.0b013e31824e6a74.
10. Canale ST, Beaty JH. *Campbell's Operative Orthopaedics*. twelfth ed. Philadelphia: Elsevier Mosby; 2013:106–116.
11. Gainor BJ, Moussa F, Schott T. Healing rate of the transverse osteotomies of the olecranon used in reconstruction of distal humerus fractures. *J South Orthop Assoc*. 1995;4:263–268.
12. Holdsworth BJ, Mossad MM. Fractures of the adult distal humerus: elbow function after internal fixation. *J Bone Joint Surg Br*. 1990;72:362–365.
13. Schmidt K, Hilker A, Miehlke RK. Differences in elbow replacement in rheumatoid arthritis. *Orthopade*. 2007;36:714–722.
14. Tak SR, Dar GN, Halwai MA, et al. Outcome of olecranon osteotomy in the trans-olecranon approach of intra-articular fractures of the distal humerus. *Ulus Travma Acil Cerrahi Derg*. 2009;15:565–570.
15. Schmidt-Horlohe K, Wilde P, Bonk A, et al. One-third tubular-hook-plate osteosynthesis for olecranon osteotomies in distal humerus type-C fractures: a preliminary report of results and complications. *Injury*. 2012;43:295–300. https://doi.org/10.1016/j.injury.2011.06.418.
16. Kang LQ, Ding ZQ, Sha M, et al. A minimally invasive anterior approach to reduction and screw fixation of coronoid fractures. *J Hand Surg Eur Vol*. 2010;35:224–227. https://doi.org/10.1177/1753193409352285.
17. Selesnick FH, Dolitsky B, Haskell SS. Fracture of the coronoid process requiring open reduction with internal fixation. A case report. *J Bone Joint Surg Am*. 1984;66:1304–1306.
18. Dakoure PW, Ndiaye A, Ndoye JM, et al. Posterior surgical approaches to the elbow: a simple method of comparison of the articular exposure. *Surg Radiol Anat*. 2007;29:671–674.