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Newcastle approach to the elbow, a cadaveric study

Rouin Amirfeyz · Damian Clark · Tom Quick · Neil Blewitt

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Abstract
Aim The aim of the current study was to assess the amount of the distal humerus articular surface exposed through the Newcastle approach, a posterior triceps preserving exposure of the elbow joint.
Method Twenty-four cadaveric elbows (12 pairs) were randomized to receive one of the four posterior surgical approaches: triceps reflecting, triceps splitting, olecranon osteotomy and Newcastle approach. The ratio of the articular surface exposed for each elbow was calculated and compared.
Results The highest ratio observed was for Newcastle approach (0.75 ± 0.12) followed by olecranon osteotomy (0.51 ± 0.1), triceps reflecting (0.37 ± 0.08) and triceps splitting (0.35 ± 0.07). The differences between Newcastle approach and other approaches were statistically significant ($p = 0.003$ vs. osteotomy and <0.0001 vs. triceps reflecting and splitting).
Conclusion The Newcastle approach sufficiently exposes the distal humerus for arthroplasty or fracture fixation purposes. Its use is supported by the current study.

Keywords Newcastle approach · Posterior approach to the elbow · Triceps preserving elbow approach

R. Amirfeyz (✉) · T. Quick
Trauma and Orthopaedics Department, Bristol Royal Infirmary, Level 5, Queen's Building, Bristol BS2 8HW, UK
e-mail: ramirfeyz@yahoo.com

D. Clark
Trauma and Orthopaedics Department, Musgrove Park Hospital, Taunton, UK

N. Blewitt
Southmead Hospital, Bristol, UK

Introduction

There are numerous surgical approaches described for exposure of the elbow joint [1]. The advantages of the posterior approaches are the relative simplicity of the anatomy and the safety of the dissection. The disadvantages are triceps failure, reported in between 1.5 [2] and 7% [3] of cases and ulnar nerve injury, which can be permanent. An ideal approach should have a low complication rate and sufficiently expose the joint in order to facilitate both fracture management and arthroplasty.

The Newcastle approach [4], a posterior triceps preserving exposure of the elbow joint has been in use in our institution for more than a decade. Its clinical outcome has already been reported elsewhere [5]. The aim of the current cadaveric study was to compare the exposure achieved through this approach, and to compare it with the other commonly known and utilised posterior approaches both in arthroplasty and complex fracture fixation. These were Campbell's triceps splitting as modified by Van Gorder [6], triceps reflecting as popularised by Bryan and Morrey [7] and MacAusland's olecranon osteotomy [8].

Materials and methods

Twenty-four adult cadaveric elbows (12 pairs) free from deformity or degenerative changes were used. All the specimens were ethanol-formalin preserved and disarticulated from the shoulder joint. Stratified block randomization was employed in order to allocate each elbow to one of the four posterior surgical approaches. This method ensured equal number of allocations to each group (six elbows) and no same approach being repeated in a pair. Each arm was fixed to the table, ensuring the possibility of

full flexion at the elbow joint (reproducing intra-operative positioning). All the approaches were performed by one of the authors. The following surgical exposures were carried out as previously described in the literature: Van Gorder's modification of Campbell's triceps splitting [6], triceps reflecting [7] and olecranon osteotomy [8].

Newcastle approach [4, 5]: The incision starts 10–12 cm proximal to the tip of the olecranon, skirting either on the medial or lateral part of the olecranon itself, ending at the subcutaneous border of the ulna, 8–10 cm distal to the tip of the olecranon. Fascio-cutaneous skin flaps are raised and held in position using two proximal and two distal stay sutures. The ulnar nerve needs to be identified proximally, decompressed at the level of the two heads of FCU, and left in its bed (Fig. 1a). In the proximal part of the wound a transverse incision is made through the triceps aponeurosis, taking care not to cut the muscle tissue, and is directed towards the lateral aspect of the arm over the fascia of the anconeus to the subcutaneous border of the ulna (Fig. 1b).

Then the proximal aponeurosis is freed from the raphe and retracted using a stay suture (Fig. 2a). Anconeus is raised from the ulna by sharp dissection, and the incision is continued along the muscle fibres of the lateral head of the triceps on the radial aspect of the raphe. The lateral head and anconeus are raised as one from the underlying bone. The raphe is cut obliquely 2 cm proximal to the olecranon (Fig. 2b) and retracted distally (Fig. 3).

The oblique cut in the raphae ensures appropriate approximation of the two ends of the raphae if lengthening has happened during arthroplasty procedure. The long and deep heads of triceps are raised from the medial supracondylar ridge of the humerus as far as the tip of the medial epicondyle. The joint is now dislocated (Fig. 4a).

If needs be the medial collateral ligamentous complex can be detached from the proximal ulna and lateral complex from the lateral epicondyle (Fig. 4b). The closure has been described elsewhere [4, 5].

The ulnar nerve was identified and protected in all exposures. After the dissection, the elbow joint was flexed to the maximum possible, and the exposed articular surface of the distal humerus was marked with black paint. The elbow joint was then disarticulated and the rest of the distal humeral articular surface painted in yellow. Whilst the paint was still wet, a tissue paper was wrapped over the entire articular cartilage to translate the three-dimensional structure to a two-dimensional map. The 2-D map was then traced on to paper and scanned into digital format. Each individual map was saved as a RGB jpg image. A MATLAB® (version 7) script was then developed to read and calculate the exposed area for each exposure, expressed as the ratio of the whole articular surface. The accuracy of the

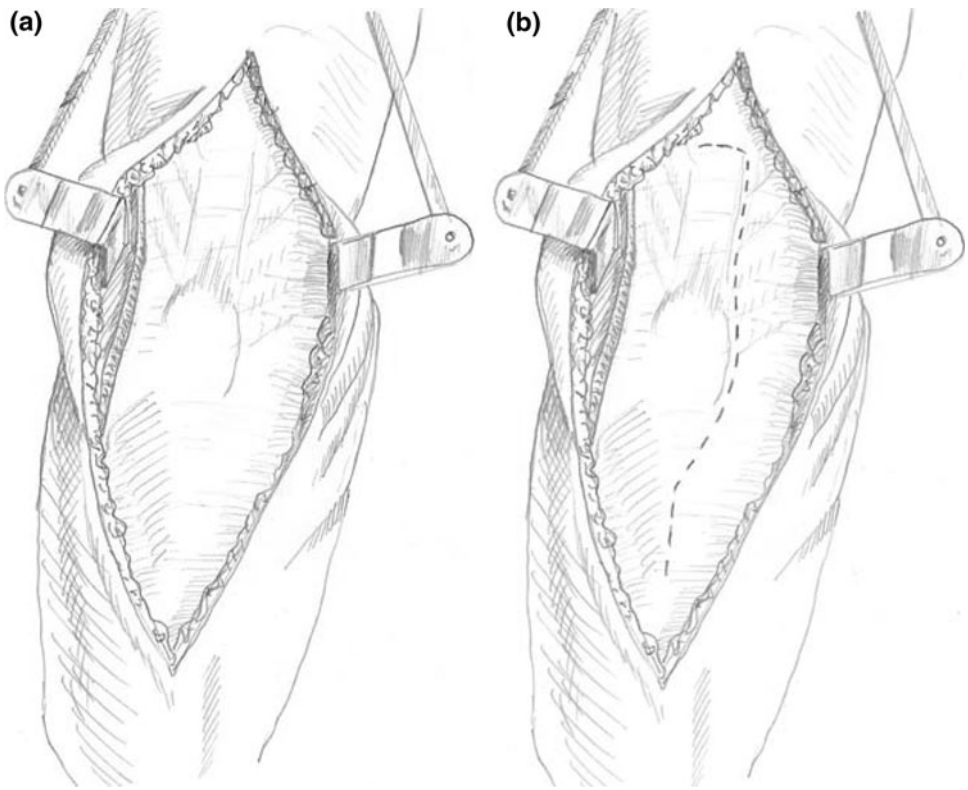

Fig. 1 **a** Skin exposure and ulnar nerve decompression. **b** The cut through the apneurosis is *highlighted*

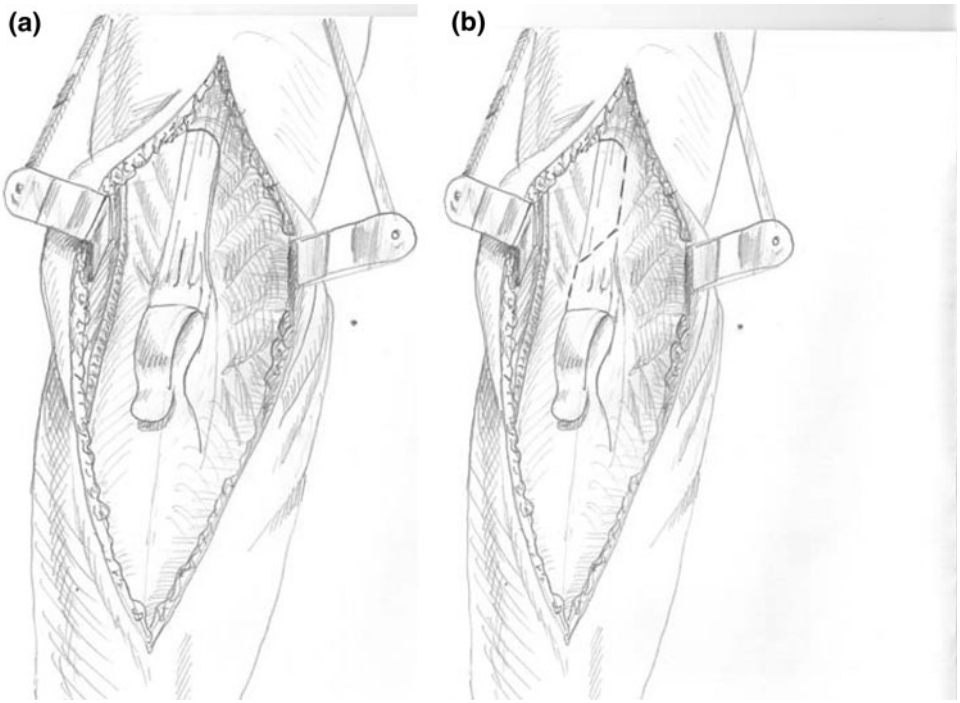

Fig. 2 **a** Aponeurosis is reflected back and **b** the *line* of incision through raphae is shown

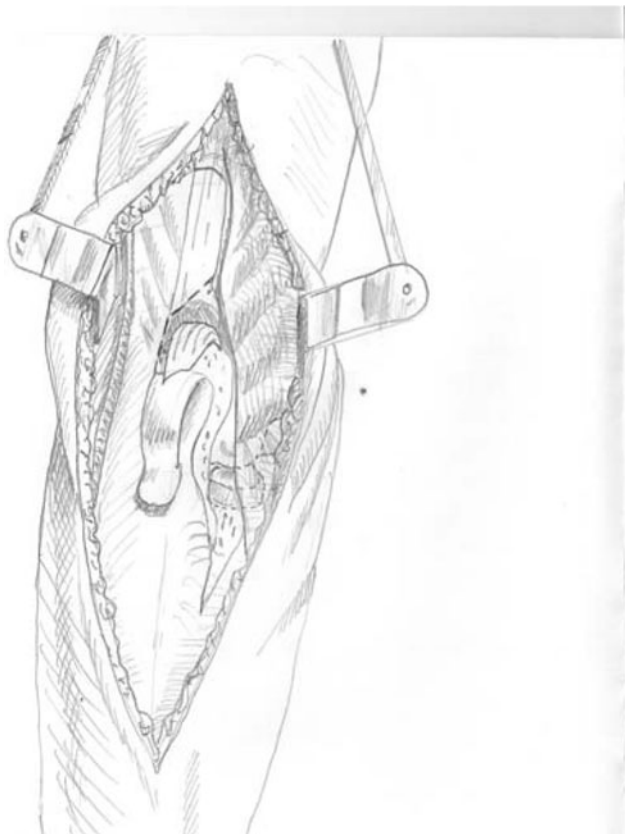

Fig. 3 The raphae is reflected back, anconeus and lateral head are reflected as a layer and the medial head is elevated distal to the raphae incision

script was checked with predefined computer-developed jpg images with known area of exposure. The repeatability and accuracy of the script were 100%.

The distribution of data was checked using Kolmogorov–Smirnov method. The Student t test was used for comparisons of the means. Where multiple calculations were performed Bonferroni correction was done to the significant value which was predefined as under 0.05. SPSS (version 13) used for statistical analysis.

Results

The average age of the cadavers was 85 (±7) years. The female to male ratio was 7/5 (1.4). The data were normally distributed. The average exposed area for triceps splitting was 0.35 (±0.07), for triceps reflecting 0.37 (±0.08), olecranon osteotomy 0.51 (±0.1) and Newcastle approach 0.75 (±0.12; Fig. 5).

Newcastle approach significantly exposed more of the distal articular surface compared with the other approaches (Table 1).

All the approaches sufficiently exposed the posterior articular surface and the olecranon fossa. The main difference observed was the most distal articular surface which was adequately exposed in olecranon osteotomy and Newcastle approach. The anterior articular surface, the capitellum and the coronoid were only exposed in the Newcastle approach.

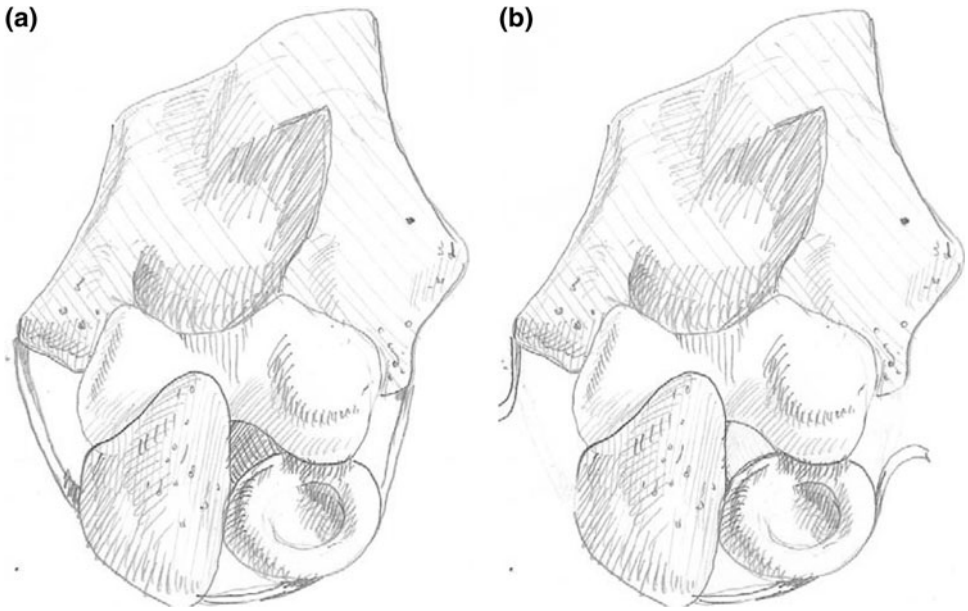

Fig. 4 **a** Joint is dislocated with collaterals intact. **b** If release is required it can be performed from the proximal ulna on medial and lateral epicondyle on lateral side

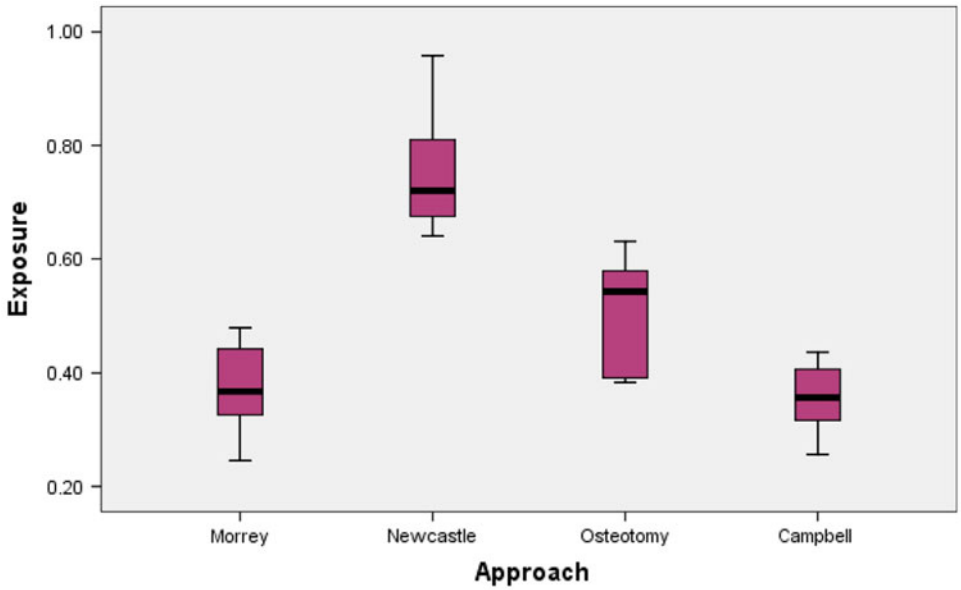

Fig. 5 *Box-plot* of exposed areas in different approaches

Table 1 Comparison between different posterior surgical exposures to the elbow

Comparison of the approaches	*p* values
Triceps splitting vs. reflecting	0.723
Triceps splitting vs. olecarnon osteotomy	0.01
Triceps splitting vs. Newcastle	<0.0001*
Triceps reflecting vs. olecranon osteotomy	0.028
Triceps reflecting vs. Newcastle	<0.0001*
Olecranon osteotomy vs. Newcastle	0.003*

Bonferroni correction defined a *p* value of <0.008 to be significant

* Statistically significant

Discussion

An ideal surgical approach should be easy to perform, with no or minimal complication and most importantly ensure adequate exposure for the purpose. The elbow is a complex joint in proximity to important neurovascular structures. The sparse soft tissue covering of this joint combined with high-energy trauma or osteopaenia (in case of fragility fractures), makes it susceptible to comminuted and complex intra-articular fractures. The incidence of distal humeral fractures is reported to be 5.7 cases per 100,000 population per year [9], many requiring operative fixation.

Also erosive involvement of this joint as part of rheumatoid arthritis is common with more than 60% of patients showing radiographic changes [10]. In symptomatic patients total elbow arthroplasty has shown to be an effective method of pain relief with good mid-term longevity [11].

Most surgeons use different approaches for trauma and elective elbow procedures. Whilst olecranon osteotomy has been demonstrated to expose distal humeral articular surface well for the purpose of fracture fixation [12] most surgeons are disinclined to employ it in arthroplasty due to the risk of olecranon non-union, failure of triceps mechanism and a poor outcome. As the result, other posterior approaches are used for arthroplasty procedures, mostly being of triceps splitting or reflecting variants. However, these are suboptimal as limited exposure means they cannot be used for complex fracture cases. In view of theses problems, a single approach with the capacity for preserving the triceps mechanism and of adequately exposing the articular surface of the distal humerus would be a preferable alternative.

In the current study, the area exposed through the Newcastle approach was significantly greater in comparison with the other approaches. The main difference observed was the very distal part of the articular surface and the anterior region of the distal humerus and capitellum. In all six cadaveric elbows, the anterior surface was sufficiently exposed if a congruent reduction was to be assessed or confirmed. Also the capitellum was readily accessible should fixation be necessary. This is important as the anterior shear type fractures are difficult to fix through the posterior exposures and usually require a lateral approach, placing the radial nerve in danger. Also, the coronoid was sufficiently exposed, making fixation or a capsular repair possible.

Olecranon osteotomy also gave a better exposure when compared with triceps splitting and reflecting (0.51 vs. 0.35 and 0.37, respectively). Albeit small p values observed, the difference was not significant following a Bonferroni correction. Increasing the number of cadaveric elbows could have potentially alleviated the problem; however, the importance of that is debateable as exposure achieved through an olecranon osteotomy has been previously demonstrated to be superior compared with the other two approaches [12].

All four approaches mentioned sufficiently exposed the posterior surface of the distal humerus, making it possible to easily apply the cutting jig during joint replacement surgery. The exposure in the Newcastle approach is sufficient enough alleviating the need to cut the distal humerus first to get access to the coronoid and anterior capsule. Hence, the ulna intramedullary canal can be prepared even before the distal humerus is cut. The radial head was sufficiently exposed as well; this is an advantage both for fracture fixation and arthroplasty should the radial head excision be part of the operative plan.

The surgical time to expose the joint was not measured as the familiarity of the authors with the Newcastle approach could have been a point of bias. In a previously reported series of patients with total elbow arthroplasty using this approach, no case of triceps failure was observed, and the rate of ulnar nerve paresis was comparable to the other posterior approaches [5].

In summary, the Newcastle approach to the elbow safely and sufficiently exposes the joint both for fracture fixation and arthroplasty purposes. Through this exposure the entire articular surface is readily accessible. It has a very low triceps failure and ulnar nerve paresis. Its use for fracture fixation and elbow arthroplasty is supported by this cadaveric study.

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