Journal of Orthopaedic Surgery

Article

Journal of Orthopaedic Surgery
27(3) 1–5
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DOI: 10.1177/2309499019865954
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The modified anterolateral approach to the humerus

Angela Christine Chang[1,2], Ngoc Buu Ha[2], Christopher Sagar[2], Gregory Ian Bain[3] and Domenic Thomas Leonello[2]

Abstract

Introduction: The anterior and anterolateral approaches to the humerus describe splitting brachialis longitudinally, assuming its fibres run parallel to the shaft. Recent improvements in the understanding of brachialis anatomy however have demonstrated it has two distinct heads, with the bulk of its fibres running oblique relative to the humerus. Attempting to split brachialis longitudinally to the extent required for plate osteosynthesis invariably leads to transection of a significant number of muscle fibres. The authors present a less muscle destructive modification to the anterolateral approach (ALA) based on a bicipital brachialis muscle. **Method:** In order to preserve brachialis muscle fibres, the modified ALA elevates the superficial head from the underlying humerus and longitudinally splits the deep head to allow a fixation device to be tunnelled. Case notes of patients with a humeral shaft fracture fixed via the modified ALA were retrospectively reviewed. **Results:** Ninteen humeral shaft fractures were fixed via the modified ALA. No post-operative nerve palsies were reported. Of the 19 patients, 14 (73.7%) received clinical and radiological follow-up. All reported being satisfied with their outcome. One developed a superficial wound infection and one (previous diagnosis of spondyloepiphyseal dysplasia tarda) developed a non-union requiring revision surgery. Of the five patients lost to follow-up, two died, and three reported no ongoing orthopaedic issues via telephone. **Conclusions:** Improved anatomical understanding of brachialis has resulted in the described modification to the ALA which is less muscle destructive and follows a truer inter-nervous plane. This small series demonstrates satisfactory outcomes using this approach.

Keywords

brachialis, deep head, humerus, modified anterolateral approach, superficial head

Date received: 28 March 2019; Received revised 9 June 2019; accepted: 7 July 2019

Introduction

Traditional approaches to the humerus such as the anterior or anterolateral approach (ALA) assume homogenous brachialis muscle morphology with fibres that run parallel to the humeral shaft.[1] Based on this assumption, such approaches describe splitting the muscle, either centrally or laterally, in line with the muscle fibres to allow extensile access to the humerus. Recent improvements in the understanding of brachialis muscle anatomy[2–4] have demonstrated that it is not a singular homogeneous muscle, rather a bicipital muscle with the bulk of its fibres running oblique, not parallel, relative to the humeral shaft. As a result of this, any attempt to split the muscle longitudinally to expose the humerus to the extent required for plate osteosynthesis will invariably lead to oblique transection of a significant number of muscle fibres. This improved understanding of brachialis muscle anatomy[2–4] has allowed a proposed modification to the ALA. The modified

[1] The University of Adelaide, Adelaide, Australia
[2] Department of Orthopaedics and Trauma, Royal Adelaide Hospital, Adelaide, Australia
[3] Flinders University, Adelaide, Australia

Corresponding author:
Angela Christine Chang, Department of Orthopaedics and Trauma, Royal Adelaide Hospital, Port Road, Adelaide, SA 5000, Australia.
Email: ang.c.chang@gmail.com

Figure 1. Diagram demonstrating the difference in length and direction of muscle fibres superficial head (SH) and deep head (DH) of brachialis.

approach is less muscle destructive, more easily extended proximally and follows a truer inter-nervous plane.

Brachialis muscle anatomy

The brachialis muscle consists of two heads: deep and superficial.[1] The larger superficial head originates proximally from the lateral aspect of the humerus (encircling the insertion of the deltoid muscle) and the proximal aspects of the lateral intermuscular septum. The tendon of the superficial head inserts onto the ulnar tuberosity. With its lateral origin and medial insertion, the fibres of the superficial head are oblique relative to the axis of the humerus. Compared to the deep head, the superficial head is larger in cross section, has longer muscle fibres and has a more distal insertion on the ulna, suggesting it provides the bulk of flexion strength.

The deep head originates more distally from the distal humeral metaphysis and medial intermuscular septum and inserts via an aponeurotic band on to the base of the coronoid process. The more anterior insertion on the ulna implies it may be important in the initiation of elbow flexion from the fully extended position (Figure 1).

The radial nerve, after passing from the spiral groove on the posterior aspect of the humerus, pierces the lateral intermuscular septum and runs in the interval between the deep and superficial heads. Exposing the radial nerve in this region ensures avoidance of iatrogenic injury intraoperatively, as well as signalling the interval between the deep and superficial heads (Figure 2).

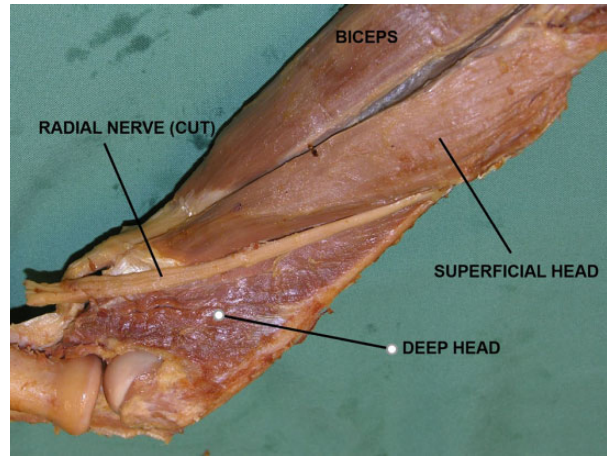

Figure 2. Lateral view of the brachialis muscle demonstrating the position of the radial nerve between the superficial and deep head.

A consistent branch from the radial nerve supplies the inferolateral aspect of the deep head. The musculocutaneous nerve consistently supplies the superficial head. Neurovascular connections between the superficial head and deep head can be observed more medially in this intramuscular interval, suggesting musculocutaneous innervations of the medial aspect of the deep head.[1]

The aim of this study is to determine if the modified ALA is a safe and viable approach to fix humeral shaft fractures. The approach has several theoretical advantages including being less muscle destructive which may result in decreased post-operative pain and faster recovery times, and providing visualization of the radial nerve, decreasing the risk of nerve injury. Satisfactory outcomes in this study will lead to a randomized controlled trial to determine whether these theoretical advantages translate into improved clinical outcomes.

Methods

The case notes of all patients who sustained a humeral shaft fracture and underwent subsequent open reduction internal fixation (ORIF) by the senior author over a 5-year period at two trauma centres were retrospectively reviewed. Patients were included in this study if the humeral fracture was a closed injury with no neurovascular compromise, and fixed using the modified ALA described below. Simple and comminuted fractures of any pattern were included, as was osteosynthesis of any form. Fractures requiring fixation for non-unions and malunions, as well as revision fixation, were also included. Patients were excluded if the fracture was pathological or if concomitant neurological or vascular injury was present.

Data collected about each patient included age, gender, handedness, fracture mechanism, fracture comminution,

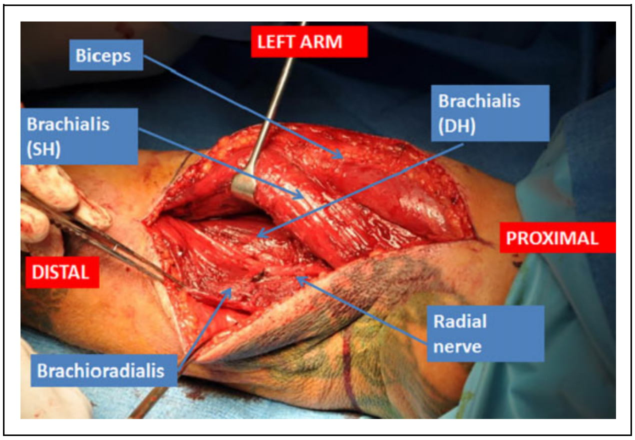

Figure 3. Surgical dissection demonstrating the superficial (SH) and deep head (DH) of brachialis.

non-operative trialled if any, operative treatment and post-operative care. Data relating to the outcome of the injury included the presence of post-operative nerve palsies, wound problems, fracture union, revision procedures and any other adverse outcome or complication. Patients were contacted via telephone a minimum of 1 year following the procedure. Data collected included patient satisfaction (very satisfied, satisfied, unsatisfied and very unsatisfied), pain score (0 = *no pain*, 10 = *worst pain ever experienced*) and Quick DASH score.

The modified ALA

The modified ALA consists of an initial skin incision on the anterolateral aspect of the arm. If distal extension is required, a curvilinear component is incorporated around the cubital fossa to reduce the risk of a skin flexion contracture.

The subcutaneous fat and deep fascia is divided in line with the skin incision. Several large veins of variable anatomical location are often encountered in this fatty layer and haemostasis, either with diathermy or suture ligation, should be performed should these cross the surgical field.

After deep facial incision is performed, the plane between the fascia and musculature is developed in order to facilitate retraction of the fasciocutaneous flaps and identification of individual muscles.

The modified ALA is based on the understanding that the fibres of the large superficial head run oblique relative to the humeral axis and cannot simply be longitudinally split to expose the humerus without transection of a significant number of its fibres. In order to preserve the integrity of the superficial head, it is mobilized from the underlying humerus leaving the origin and insertion intact, and the deep head only is longitudinally split to allow a fixation device to be tunnelled deep to it. In order to achieve this, two 'windows' to the humerus are required: (1) proximal and medial to the superficial head and (2) distal and lateral to the superficial head.

Proximal medial window

A readily identifiable plane exists between the biceps and brachialis. This plane is developed easily and the musculocutaneous nerve and its respective supplies to biceps and brachioradialis can be identified and protected throughout the procedure. Proximally the deltopectoral interval is identified and can be developed by partial releases of these musculotendinous units to allow sufficient room for a fixation device if such proximal positioning is required for adequate fracture fixation. The medial aspect of the superficial head of brachialis is identified and the muscle bulk mobilized from the humerus exposing the periosteum. At this level, the superficial head is retracted laterally. Care should be taken to avoid injury to the musculocutaneous supply of brachialis with the aid of visual identification.

Distal lateral window

The other important intermuscular plane to identify is between the deep head of brachialis and brachioradialis. This plane is often more difficult to identify visually but with careful blunt dissection a definable bloodless plane is present between these muscles and confirmation can be sort by the observation of the radial nerve within this interval. The radial nerve lies within a muscular groove formed by the deep and superficial heads of the brachialis muscle and is an important landmark to guide the next stage of dissection.

With the radial nerve mobilized proximally to the level of its transit through the lateral intermuscular septum, it is tagged with a coloured elastic loop to facilitate easy identification throughout the case. The plane between the superficial and deep head of the brachialis is then developed (Figure 3). When the mid sagittal line of the humerus is reached, a longitudinal split of the deep head is performed exposing the underlying periosteum of the humerus. The deep head can then be dissected circumferentially from the humerus to the extent required to expose the fracture. It should be noted that in the context of acute trauma, the deep head is often heavily contused and often contains a traumatic perforation. In such cases, it is advantageous to utilize this existing muscular rent rather than performing a new muscular split of the deep head.

Once both windows are prepared, a periosteal elevator can be carefully manipulated on the anterior aspect of the humerus to release any residual attachments of the superficial head to the humerus and a sub-muscular tunnel is created that not only allows access to the fracture for debridement and accurate reduction, but a conduit for passage of a fixation device to maintain reduction (Figure 4).

Results

Nineteen humeral shaft fractures were identified for inclusion in this study. There were 10 male and 9 female patients.

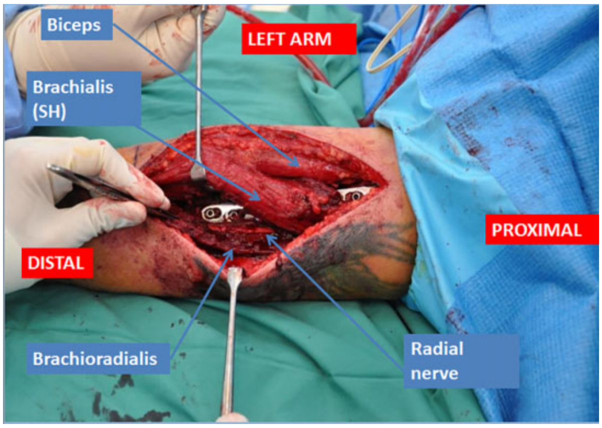

Figure 4. The proximal medial and distal lateral windows have been developed allowing a plate to be tunnelled under the elevated superficial head (SH) of brachialis.

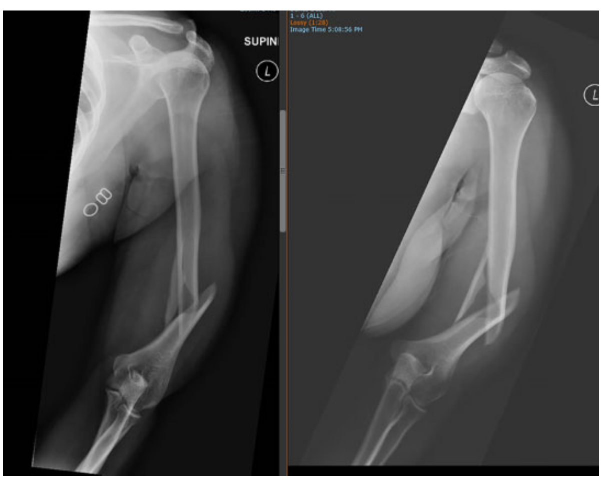

Figure 5. Pre-operative radiograph showing a comminuted humeral shaft fracture.

Mean age at time of injury was 48.3 years (range 14–84 years). Seven fractures resulted from low energy falls, five from high energy falls, five from motor vehicle accidents, one from arm wrestling and one was a non-union of a previously internally fixed humerus. Twelve (63.2%) were fractures to the left humerus and eight (36.8%) were to the right. Seventeen of the humeral fractures were displaced (89.5%). Four fractures were comminuted (21.1%). Eleven fractures (57.9%) were located in the middle third of the humeral shaft, four (21.1%) in the distal third and four (21.1%) in the proximal third. All fractures were closed and no patients had an associated neurovascular injury.

Three (15.8%) fractures were initially treated non-operatively in a sling and brace. Two of these went on to ORIF after 2 weeks as the patients were unable to tolerate the pain and brace. The other underwent ORIF after 2.5 months when the fracture failed to demonstrate radiographic or clinical evidence of union.

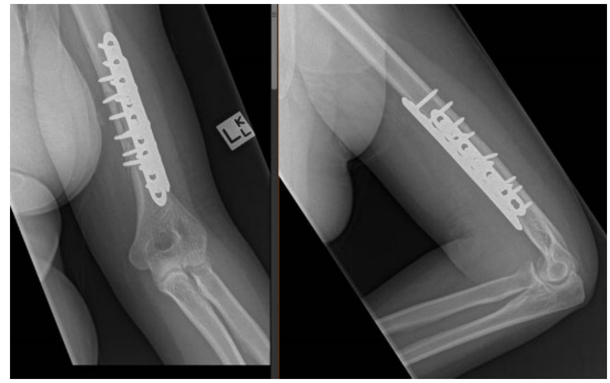

Figure 6. Two-week post-operative radiograph showing the same fracture fixed using dual plates.

All patients were treated with ORIF with a plate-and-screw construct via the modified ALA described. Eleven fractures (57.9%) were fixed with a single plate and eight (42.1%) with dual plates (Figures 5 and 6). No post-operative nerve palsies were reported.

All patients (100%) attended their initial post-operative follow-up appointment. One superficial post-operative wound infection was recorded. Of the 19 patients, 14 (73.7%) had long-term follow-up documentation available for review. Of these 14 patients, all but 1 (94.7%) achieved radiographic union. This patient had a previous diagnosis of spondyloepiphyseal dysplasia tarda with a significant history of musculoskeletal abnormalities and required revision surgery with bone grafting. Of the five patients with no available long-term follow-up documentation available, two had died from unrelated issues and the other three were contacted via telephone (two receiving interstate follow-up) and stated satisfactory outcomes with no ongoing orthopaedic issues.

Of the 19 patients included in this study, 13 were contactable by telephone. All were >1 year following fixation of their fracture. All (100%) reported being either very satisfied (57%) or satisfied (43%) with their outcome. The mean pain score out of 10 was 1.2 with eight patients (61.5%) having a pain score of 0. The mean Quick DASH score was 19.9.

Discussion

The results of this study suggest that humeral fracture fixation utilizing the modified ALA can be performed safely and with satisfactory results. It has several theoretical advantages over traditional approaches. It is less muscle destructive which may result in decreased intraoperative bleeding and less operative pain and weakness. It is also more easily extendable proximally allowing more flexibility of plate positioning and conversion to a proximal humerus pre-contoured plate if necessary. It also allows ease of visualization of the radial nerve, decreasing the likelihood of iatrogenic nerve injury. Previous studies have demonstrated iatrogenic radial nerve injuries occur in 6–32% of plated humeral shaft fractures.[5–9] None were observed in this study.

This study demonstrated a 93% fracture union rate which compares favourably to other studies that have demonstrated a non-union rate following humeral shaft fracture ORIF of 1.6–30%.[10,11,12] The infection rate of 5% was also comparable with larger studies showing infection rates following ORIF of 3% up to 20%.[10,11,12] Despite these potential advantages, minimal clinical data yet exist to demonstrate improved clinical outcomes.

Potential disadvantages of this approach include increased operating time as the approach does require several additional steps when identifying the surgical windows and defining the two heads of brachialis, and reduced exposure of the humerus. This study however included eight cases of dual plating, demonstrating the approach allows sufficient visualization for flexible plate positioning and multiple plates if necessary.

This study had several limitations. As it was a retrospective, it relied on detailed and accurate documentation for data collection and has the inherent selection bias associated with its retrospective nature. The patient group examined was small due to this being a single surgeon study and the limited number of fractures requiring surgical fixation. No control group was utilized, so no conclusion can be drawn regarding the superiority or inferiority of the approach relating to patient outcomes. Despite these limitations, the study was able to demonstrate the safety and viability of the modified ALA. The senior author has observed that patients have improved strength and decreased pain following the modified ALA compared to traditional muscle splitting approaches, suggesting a randomized, controlled trial may be warranted.

Conclusions

Improved anatomical understanding of brachialis musculature has resulted in the described modification of the ALA which is less muscle destructive and follows a truer internervous plane. This small series demonstrates satisfactory outcomes using this modified approach. Further research is required to determine if this muscle-sparing approach results in improved clinical outcomes.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship and/or publication of this article.

ORCID iD

Angela Christine Chang https://orcid.org/0000-0002-5694-0136

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