TRAUMA

The extended deltoid-splitting approach to the proximal humerus

VARIATIONS AND EXTENSIONS

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Fractures and nonunions of the proximal humerus are increasingly treated by open reduction and internal fixation. The extended deltopectoral approach remains the most widely used for this purpose. However, it provides only limited exposure of the lateral and posterior aspects of the proximal humerus. We have previously described the alternative extended deltoid-splitting approach. In this paper we outline variations and extensions of this technique that we have developed in the management of further patients with these fractures.

Recent innovations in the operative treatment of fractures and nonunions of the proximal humerus, including site-specific locking plates and adjuvant bone grafting, have increased the spectrum of fractures in which open reduction and plate fixation can now be considered. The deltopectoral approach remains the most widely used to treat these injuries, but it provides only limited exposure of the lateral aspect of the proximal humerus, where the plate is applied, and the posterior aspect of the shoulder, where the fragment of the greater tuberosity tends to retract in Neer three- and four-part fractures. The deltoid insertion also prevents the use of longer plates to stabilise fractures that extend into the shaft.

The limited deltoid-splitting approach is widely used for open and mini-open repair of the rotator cuff and for the treatment of isolated fractures of the greater tuberosity. The so-called Mackenzie limited deltoid-splitting approach is also used for arthroplasty of the shoulder. However, all of these approaches provide limited distal access owing to the presence of the anterior branch of the axillary nerve, which traverses the deltoid approximately 4 cm to 6 cm distal to the tip of the acromion. Because of the practical problems associated with the use of the deltopectoral approach, we developed a modified extended deltoid-splitting approach to the proximal humerus in which the area where the anterior terminal branch of the axillary nerve crosses the deltoid is identified and protected throughout the procedure. This enables placement of a locking plate on the lateral aspect of the proximal humerus beneath the nerve. Upper and lower ‘windows’ above and below the area of the nerve allow for safe placement of screws. Fractures that extend into the diaphysis can be stabilised, using a longer locking plate placed across a split in the insertion of deltoid. The aim of this paper is to review the details of the surgical approach and to draw attention to the variations and extensions that we have developed in the management of further patients with these fractures.

Patients and Methods

Pre-operative preparation and patient positioning

In addition to anteroposterior and modified axillary plain radiographs, we now routinely use pre-operative helical CT with three-dimensional reconstructions to facilitate planning of the reduction and fixation that will be required. The patient is positioned in the beachchair position, enabling satisfactory access for the image intensifier.

Surgical approach

Skin incision. The approach may be made through either the Edinburgh ‘shoulder-strap’ skin incision or the direct lateral longitudinal skin incision (Fig. 1), each of which has advantages and disadvantages.

The Edinburgh shoulder-strap incision is elliptical, with its apex centred over the tip of the acromion. A distally based flap is formed by dissection in the subcutaneous tissues, superficial to the fascia overlying the deltoid muscle. The skin incision tends to heal cosmetically, as it is parallel to Langer’s lines in this area, and is subsequently concealed by the bra-strap in
Figure 1a – diagram showing the various skin incisions. The incision for the direct lateral approach (dashed line) is a distal longitudinal extension of the traditional limited deltoïd-splitting incision that can be extended to the elbow if required. The apex of the Edinburgh shoulder-strap incision (solid line) should be centred over the acromion. Figure 1b – intra-operative photograph showing the distally based flap formed by dissection of the subcutaneous tissues, allowing full exposure of the superior deltoïd muscle.

The deltoid can only be split up to its insertion because the distally based skin flap prevents further distal exposure. This incision is therefore not suitable for fractures that extend distally into the shaft. However, a simultaneous deltopectoral approach can also be made through the anterior part of the shoulder-strap incision. This may be useful if greater access is required to the front of the shoulder or the medial neurovascular structures. The authors use the shoulder-strap incision in the majority (80%) of fractures, which are confined to the metaphyseal area, or where a simultaneous deltopectoral approach may be required.12,22

The direct lateral approach is a distal longitudinal extension of the traditional limited deltoïd-splitting incision. Because the incision is parallel to the muscle fibres of the middle aspect of the deltoïd it may be extended distally to the deltoïd insertion and as far as the elbow, if required. However, it tends to provide a more unsightly scar, as it is perpendicular to the Langer’s lines in this area.21 The authors use the direct lateral incision for the minority of fractures that extend distal to the metaphysis and require a longer plate to secure adequate fixation of the shaft.

Deep exposure. Irrespective of the initial skin incision used, the deltoïd is split in the line of its fibres for 3 cm to 4 cm at the site of its anterior raphe (Fig. 2). As this is a watershed area of the blood supply to the deltoïd,23-25 the site is relatively avascular. The upper window of the approach is created through this superior split.

If there is uncertainty about whether the fracture or nonunion is amenable to open reduction and internal fixation, we recommend performing this limited deltoïd-splitting approach first to assess the fracture. If it is revealed that the humeral head is not reconstructable, then a replacement arthroplasty may be performed.
without the requirement for extension of the deltidial split distally. If plate fixation is feasible, the extension of the deltidial split is identical through both incisions. With all variations of the extended deltidial-splitting approach, the anterior branch of the axillary nerve and its accompanying vessels are identified and traced back to where it emerges from the quadrilateral space posteriorly by inserting an index finger and directing it distally and laterally. In order to minimise the risk of a traction injury, no attempt is made to split the deltidial in the area crossed by the nerve, which is protected by a rubber sling. The deltidial split is then continued below the area protected by the sling to produce a lower window, which allows visualisation of the lateral shaft. The upper and lower windows can be opened using self-retaining or hand-held retractors, to improve visualisation of the proximal humerus and the shaft of the humerus respectively. We have found that excision of the blood-filled subacromial bursa greatly improves visualisation of the proximal humerus through the upper window.

**Extensions and variations of the surgical approach.** Using the shoulder-strap incision, the deltidial split cannot be extended further than its insertion at the lower extent of the skin flap. As described previously, a simultaneous deltopectoral approach can be made through the same skin incision. The deltopectoral interval is identifiable in the anterior part of the wound, and is easily developed with identification and protection of the cephalic vein throughout. The ability to perform a simultaneous deltopectoral approach may be particularly useful if there is an anterior fracture-dislocation, where the head of the humerus has displaced medially towards the axilla and cannot be readily reduced through the deltidial split. The ability to perform a simultaneous deltopectoral approach is essential if exposure of the axillary artery or brachial plexus is required for management of a neurovascular injury associated with a fracture. This is most commonly encountered in grossly displaced fractures and anterior three- or four-part fracture-dislocations.

The direct lateral incision can be extended as far as the elbow by continuing distally in line with the initial skin incision (Fig. 3), as a standard anterolateral approach to the humerus. This is required for fractures or non-unions of the proximal humerus that extend into the shaft, to allow adequate plate fixation distal to the fracture. This should comprise three screws distal to the fracture (six cortices) in younger patients, or four screws (eight cortices) in elderly or osteoporotic patients. In order to provide plate fixation to the shaft, the deltidial insertion may be split to allow a standard locking plate to be applied distal to the insertion. If the split is extended in this manner, the radial nerve should be identified and protected where it emerges anteriorly from behind the lateral intermuscular septum. The alternative to splitting the deltidial insertion to apply the plate would be to use either an anterior conventional locking plate or a helically contoured locking plate that skirts around the deltidial insertion and provides lateral fixation proximally and anterior fixation distally.
Closure. The deltoid-splitting incision is closed without drainage, using heavy resorbable sutures to re-approximate the split. At the proximal end, the deltoid aponeurosis is reattached to the acromion with transosseous sutures. If the deltoid has been split to insert a longer plate, it is closed meticulously over the plate (Fig. 3). The skin is closed with a resorbable subcuticular suture.

Operative techniques used with the approach
Either open reduction and plate fixation or replacement arthroplasty may be performed through the extended deltoid-splitting approach. If the former is selected, the plate is passed through the proximal opening in the deltoid, beneath the area of the nerve, and advanced distally where it can be viewed through the lower window. The upper window is used to place screws through the plate into the humeral head, and the lower window to secure the plate to the metaphysis and shaft. The fixation can be augmented as necessary with a bone substitute or allograft to fill any metaphyseal defects.

Patient series
The extended deltoid-splitting approach was first developed and used in our centre in 1997, and has been used almost exclusively for the operative treatment of proximal fractures of the humerus since then. Between June 1997 and December 2009, 386 proximal fractures of the humerus involving 96 men and 290 women with a mean age of 70 years (26 to 87) have been treated using the approach. The fracture classification, type of skin incision and the treatment used are summarised in Table I.

Results
To date there have been no instances of necrosis of the skin flap, wound dehiscence or deep infection, although 24 patients have required antibiotic treatment for superficial wound infections. No patient had a clinically detectable sensory deficit in the cutaneous distribution of the axillary nerve or evidence of weakness of the anterior deltoid. Re-operation has been required in 28 patients for complications predominantly related to fracture healing, post-traumatic stiffness, osteonecrosis or osteoarthritis.

Where longer plate osteosynthesis has been required for fixation of fractures or nonunions that extend into the shaft, there have been no instances of detachment of deltoid or dysfunction related to placement of the plate through the deltoid insertion using an extended direct lateral approach. There have been no palsies of the radial nerve related to this extended version of the approach.

Discussion
The extended deltoid-splitting approach allows good access to the lateral aspect of the proximal humerus for the reduction and internal fixation of fractures in this area. Since we first described this approach we have developed a number of variations and extensions as a result of further experience with these fractures. In comparison with the deltopectoral approach, there is greater visualisation of the principal fragments, especially in three- or four-part fractures, where there is posteromedial retraction of the greater tuberosity. Adequate reattachment of the greater tuberosity is mandatory to prevent later complications with the rotator cuff irrespective of whether plate fixation or an arthroplasty is used. This may be difficult using the deltopectoral approach. In the rarer posterior fracture-dislocations of the shoulder, the deltopectoral approach provides only limited access to the posteriorly extruded head of the humerus, making disimpaction from the posterior aspect of the glenoid difficult. It is also easier to place the plate on the lateral cortex of the humerus through the deltoid-splitting approach, as definitive fixation of a proximal humeral fracture requires the plate to be placed just posterior to the bicipital groove on the lateral aspect of the proximal humerus. This dictates that if the deltopectoral approach is used, the anterior deltoid often has to be forcibly retracted during placement of screws into the humeral head and shaft.

<table>
<thead>
<tr>
<th>Type of fracture</th>
<th>Type of deltoid-splitting approach</th>
<th>Type of skin incision</th>
<th>Type of treatment used</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Open reduction and plate fixation</td>
<td>Replacement arthroplasty</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direct lateral incision</td>
<td>Open reduction and plate fixation</td>
<td>Replacement arthroplasty</td>
</tr>
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<td><strong>Acute fractures</strong></td>
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<td>Two-part surgical neck</td>
<td>64</td>
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<td>1</td>
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<tr>
<td>Three-part fracture</td>
<td>22</td>
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<tr>
<td>Four-part fracture</td>
<td>83</td>
<td>11</td>
<td>2</td>
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<tr>
<td>Two-part surgical neck with diaphyseal extension</td>
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<td>14</td>
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</table>
The deltoid-splitting approach is now our preferred exposure for all fractures of the proximal humerus, with the exception of isolated displaced fractures of the lesser tuberosity, where better access for reduction and placement of screws is achieved through an anterior deltopectoral approach. Theoretical concerns have been raised regarding the risk of intra-operative injury to the axillary nerve and later deltoid pull-off in this approach, which may adversely affect the outcome.32 However, these complications have not been encountered in most series,11,12,14,15,19,33 and not in our experience. Cadaveric and in vivo electrophysiological studies suggest that the nerve is protected in this approach.16,18,34

Our approach to the treatment of fractures and nonunions that extend into the diaphysis has been to use an extension of the direct lateral incision with splitting of the deltoid insertion to allow the application of a longer proximal humeral locking plate through this area. Although there might be concern about defecting the deltoid using this technique, we have not encountered problems in practice. This type of treatment would not be possible through a deltopectoral approach, where alternative strategies would be required involving the application of either an anterior plate or a contoured ‘helical’ locking plate that skirts the deltoid.30,31 We have concerns about using anterior plating since the proximal fixation is compromised by the inability to insert multiple locking screws into the head of the humerus, as is achieved using a proximal humeral locking plate applied laterally. We are apprehensive about the use of customised helical plates owing to the risk of breakage of the plate from the extensive contouring required. Other techniques, such as intramedullary nailing, are unsatisfactory in the treatment of these injuries owing to the rotator cuff dysfunction produced by the proximal site of entry and the lack of rigid fixation achieved, particularly with nonunions that extend into the shaft.35,36

Despite the improved exposure obtained using this approach, there are some disadvantages to its use, particularly where further operative treatment is required. Exploration through the previously split deltoid may be more difficult than with the deltopectoral approach because fibrous adhesions tend to form from the deep aspect of the deltoid to the lateral aspect of the proximal humerus, making exposure of the anterior branch of the axillary nerve challenging. However, the majority of revisions involve removal of the osteosynthesis and conversion to an arthroplasty. In these circumstances, only limited access is required distally to remove the lower screws through the plate, and the remainder of the revision can be safely performed through the upper window of the approach.

The variations and extensions of the deltoid-splitting approach provide extensive access to fractures of the proximal humerus without placing the adjacent neurovascular structures at risk of injury. Our experience suggests that it should now be considered a viable alternative to the deltopectoral approach in the treatment of fractures of the proximal humerus.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References


