Most proximal humeral fractures are stable injuries of the ageing population, and can be successfully treated non-operatively. The management of the smaller number of more complex displaced fractures is more controversial and new fixation techniques have greatly increased the range of fractures that may benefit from surgery. This article explores current concepts in the classification and clinical aspects of these injuries, reviewing the indications, innovations and outcomes for the most common methods of treatment.

Fractures of the proximal humerus account for 5% of injuries to the appendicular skeleton.1,2 Most are stable, minimally-displaced osteoporotic fractures in the elderly, and are the result of low-energy falls.3 Most patients with these injuries will regain a functional shoulder without operation. Surgery should only be considered in approximately 20% of patients,4 either because they require better shoulder function or because their fracture is more complex. An ever-expanding range of reconstructive options has become available to treat these injuries, each with its advantages and disadvantages.

Clinical assessment
Careful clinical assessment is required in each case to identify the rare, but serious, problems related to skin or neurovascular damage, which warrant urgent investigation and treatment. Open fractures of the proximal humerus are rare, although severely displaced fractures may produce skin tenting, causing pressure necrosis. These fractures require treatment according to standard open fracture guidelines.

Vascular injuries are rare, but more likely in the presence of a fracture-dislocation. Signs of distal ischaemia may be absent, due to the rich collateral circulation, but a large expanding haematoma, pulsatile external bleeding, unexplained hypotension, delayed anaemia and associated nerve trunk or plexus injury should increase the level of suspicion. Digital subtraction angiography is the benchmark of assessment, but Doppler assessment of the pulse and single-injection angiography may be more appropriate in the emergency setting. Vascular injuries can be treated with endarterectomy for intimal tears, and resection with end-to-end anastomosis or grafting for major lacerations, or embolisation for false aneurysms.

Most nerve injuries are direct injuries to the brachial plexus or traction injuries to the axillary nerve, and are more likely in the presence of a fracture-dislocation.6-8 Most injuries are closed and are best treated non-operatively, though early exploration may be beneficial in younger individuals.9

Decision-making in treatment
There is a tendency to focus on the fracture configuration when deciding upon the method of treatment. It is important to appreciate that in addition to the ‘personality’ of the fracture, decision-making is also influenced by underlying patient- and surgeon-related factors (Fig. 1). Underlying patient factors. Most patients with these injuries are elderly and have limited expectations from treatment. Operative treatment is only rarely indicated in the very elderly (aged > 85 years), those with cognitive impairment, a non-functional limb, or with severe medical comorbidity. Poor outcomes and increased risk of complications are associated with severe osteoporosis, smoking, drug and alcohol abuse, diabetes mellitus, rheumatoid arthritis, immunocompromise including steroid medication and concurrent neoplasm.10-12

Underlying surgeon factors. The treating surgeon can influence outcome through both choice of treatment and technical expertise.11,13 There is substantial geographical variation in surgical expertise and operative treatment.14 There is a limited but growing culture of specialist tertiary referral, which should
be considered for more complex injuries, or if the treating surgeon does not treat these fractures regularly.

**Injury factors.** There is no entirely satisfactory fracture classification to serve as a guide to modern treatment and predict outcome. The Neer classification⁴ (Fig. 2), although the most widely used, has poor inter- and intra-observer reliability.¹⁵ This anatomic system is based upon the degree of involvement and displacement of the four major fracture segments on plain radiographs, or at surgery. It does not include some of the more recently described fracture types, which may have a more favourable prognosis. These include impacted-valgus fractures,¹⁰,¹² varus fractures,¹⁶,¹⁷ the various subtypes of anterior and posterior fracture-dislocations¹⁸,¹⁹ and those with partial articular involvement due to a displaced tuberosity fragment bearing a piece of the articular surface. Although refinements²⁰,²¹ and more detailed systems²²,²³ have been produced, none has gained the level of acceptance of the Neer classification.⁴,²⁴

Most fractures of the proximal humerus have a stable configuration and heal functionally with non-operative treatment.³,⁴ This treatment should be used for Neer one-part fractures involving the humeral neck,²⁵-²⁸ one-part greater or lesser tuberosity fractures²⁹ and impacted two-part fractures of the surgical neck with minimal angulation of the humeral head.¹¹ Neer two-, three- or four-part fractures with less severe varus or valgus angulation of the humeral head to the shaft (< 30° of displacement of the normal 130° head-shaft inclination), but with residual cortical contact to the shaft, may also regain a good functional outcome after non-operative treatment.¹²,¹⁷

The remaining 20% of fractures fall into three groups: those in whom surgery is essential, those who may benefit from a head-conserving reconstruction and those who require a replacement of the humeral head. Surgery is mandatory in less than 1% of fractures, and the indications for surgery in the other two categories are relative rather than absolute. Modern surgery for fractures of the proximal humerus requires considerable expertise and the full armamentarium of reconstructive implants, each with its advantages, disadvantages and complications (Table I).

**Fractures for which surgery is essential.** Operative treatment is mandatory for the rare situations in which there is either an open fracture, an associated vascular injury, a true head-splitting fracture, a pathological fracture, or a severe ipsilateral injury to the shoulder girdle, most commonly the ‘floating shoulder’ produced by a scapular fracture. In these circumstances, the feasibility of head-retaining reconstruction versus primary replacement arthroplasty dictates the choice of procedure.

**Fractures which may benefit from reduction and fixation.** Reduction and fixation is usually performed with the aim of improving the functional outcome as compared with non-operative treatment. Physiologically younger and more active patients usually have greater functional expectations.
Surgery also aims to reduce the risk of complications associated with non-operative treatment, including symptomatic nonunion or malunion. Whether reduction and fixation reduces the later risk of osteonecrosis of the humeral head is unclear, although prosthetic replacement to treat this complication is technically easier, and associated with a better outcome, if the shoulder has initially been reconstructed anatomically and the rotator cuff is functional. In patients who are medically fit for surgery, it is the
The authors’ view that reduction and fixation should be considered for:

1. Two-part greater or lesser tuberosity fractures, or three- and/or four-part fractures in which the greater tuberosity is displaced by more than 1 cm.

2. Fractures with a displaced fragment of the articular surface of the humeral head attached to a displaced tuberosity fragment.

3. Unstable two-part surgical neck fractures in which there is disengagement of the shaft from the humeral head, due to displacement or extensive metaphyseal comminution.

4. Two-, three- or four-part fractures in which there is varus or valgus deformity of the humeral head to the shaft by > 30° from the normal head shaft inclination angle of 130°.

5. Three- or four-part anterior fracture-dislocations caused by propagation of a posterior humeral head fracture (‘Hill-Sachs lesion’\(^{30}\)) and with retained soft-tissue attachments to the humeral head at surgery (‘Type 1’ anterior fracture-dislocation).

6. Three- or four-part posterior fracture-dislocations caused by propagation of a fracture of the anterior humeral head (‘reverse Hill-Sachs’) and with retained soft-tissue attachments to the humeral head at surgery.

This form of surgery only provides patients with an opportunity to improve shoulder function over non-operative treatment. Patients should be counselled that their post-operative rehabilitation may be long and arduous, and that their compliance with rehabilitation will influence their outcome. Fractures which may benefit most from primary replacement of the humeral head. Despite the numerical increase in fractures amenable to head-conserving treatment, there is a minority of fractures in which reduction and fixation is impractical or ill-advised. Replacement of the humeral head is therefore usually reserved for fractures in which the head is cleaved into two or more fragments and is unreconstructable (the true Neer ‘head-splitting’ fracture), those in which the humeral head is found to be devoid of soft-tissue attachments at surgery (‘Type 1’ anterior fracture-dislocation).

<table>
<thead>
<tr>
<th>Technique</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-operative treatment</td>
<td>Functionally as good as operative treatment for many fractures, low risk of infection and other operative complications</td>
<td>Malunion inevitable: Cuff dysfunction/stiffness more likely Later salvage surgery is more difficult Risk of nonunion increased</td>
<td>Nonunion, malunion, osteonecrosis, rotator cuff tear, subacromial impingement, neurologic injury, osteoarthritis</td>
</tr>
<tr>
<td>Minimally invasive techniques</td>
<td>Reduced injury to soft-tissue envelope, lower infection risk</td>
<td>Deep learning curve, risk of axillary nerve/vascular injury, less stable fixation</td>
<td>Nonunion, malunion, superficial infection, deep infection, avascular necrosis, subacromial impingement, stiffness, neurologic injury, movement of fixation, osteoarthritis</td>
</tr>
<tr>
<td>Open reduction and plate fixation</td>
<td>Anatomical fracture reduction is possible: Improved functional outcome Later revision surgery easier Most stable method of fixation in multi-part fractures: Rigid implants Adjuvant bone grafting techniques possible</td>
<td>Open surgical approach required: Increased risk of infection osteonecrosis Top of plate may cause mechanical impingement</td>
<td>Nonunion, malunion, superficial infection, deep infection, osteonecrosis, subacromial impingement, tendinitis of biceps, stiffness, neurologic injury, fixation failure, osteoarthritis</td>
</tr>
<tr>
<td>Intramedullary nailing</td>
<td>More stable fixation technique in osteoporotic bone, minimal dissection required for insertion</td>
<td>Rotator cuff dysfunction after antegrade insertion, poor results in multi-part fractures, high rate of late metalwork removal</td>
<td>Nonunion, malunion, superficial and deep infection, avascular necrosis, fracture, stiffness, neurologic injury, movement of fixation, osteoarthritis</td>
</tr>
<tr>
<td>Hemiarthroplasty</td>
<td>Risk of nonunion, osteonecrosis, and symptomatic malunion removed Low rate of re-operation</td>
<td>Poor functional outcome Later arthroplasty complication difficult to treat in the elderly</td>
<td>Superficial and deep infection, rotator cuff tear or insufficiency, subacromial impingement, dislocation, heterotopic ossification, reflex sympathetic dystrophy, periprosthetic fracture, loosening, greater tuberosity pull-off, non-union</td>
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necrosis are avoided. Conservative treatment of displaced and multi-part fractures is more controversial, but may be more appropriate in the very elderly, cognitively-impaired or debilitated and alcoholic patients. Although some authors have documented good overall outcomes, it is generally accepted that the risk of non-union, symptomatic malunion and osteonecrosis is higher in this group. Secondary salvage surgery is also likely to be more complex, and the anticipated outcome is likely to be worse than after primary operative treatment.

**Humeral head conserving techniques**

**Closed/minimally invasive reduction and percutaneous fixation.** Closed and minimally invasive techniques have potential advantages over more invasive techniques in improving cosmesis and reducing blood loss, post-operative pain and the risk of infection. Unimpacted two-, three- and four-part fractures in which the shaft has translated or separated from the head fragment and impacted valgus fractures are most amenable to these techniques, whereas fracture-dislocations are not suitable.

**Planning treatment.** Where surgical intervention is appropriate, most patients can be treated on a semi-elective basis within the first week after injury. Computed tomography with three-dimensional reconstruction (3D-CT) makes it much easier to understand the fracture pattern, and plan the operative procedures. In particular 3D-CT enables an accurate assessment of the degree of subluxation and angulation of the humeral head, the extent of separation of the shaft from the head, the degree of separation of any marginal fragments of tuberosity and the presence of any marginal fragments of the articular surface attached to the tuberosities.

**Technique and results.** Reduction is achieved using closed manipulation and instruments or pins to ‘joystick’ fragments into position guided by fluoroscopy. Fixation is achieved by passing end-threaded Kirschner (K-) wires or cannulated screws across the major fracture fragments (Fig. 3). Where bone quality is poor a ‘humerus block’ can be inserted percutaneously to link the wires and improve stability.

Satisfactory results have been reported using closed or minimally invasive reduction and percutaneous pin or screw fixation. However, these procedures have a protracted learning curve and carry substantial rates of complications including failure of fixation, malunion, nonunion and osteonecrosis.

**Open reduction and internal fixation (ORIF).** Recent innovations in surgical approach, techniques of reduction, implants and the use of bone graft or substitutes have greatly increased the range of fractures of the proximal humerus which are amenable to fixation.

**Technique.** The extensile anterior deltopectoral approach remains the benchmark procedure. However, the limited access which this provides posteriorly may compromise the surgeon’s ability to reconstruct multi-part fractures, where the greater tuberosity is markedly displaced, and in posterior fracture-dislocations. This has led to the extended delto-pectoral approach, using either a straight lateral or a shoulder strap incision. This provides better access for reconstruction, provided the anterior terminal branch of the axillary nerve is identified and protected throughout the procedure. The ‘surgical window’ above the nerve allows access for reduction and stabilisation of the fracture, whereas the window below allows access to the humeral shaft and creates a safe area for insertion of screws into the lower part of the plate. Although concerns regarding the risk of intra-operative
injury to the axillary nerve and late deltoid pull-off have been expressed, these complications have not been encountered in practice,\(^{18,47}\) with cadaver studies also suggesting that the nerve is protected.\(^{48,49}\)

**Fracture reduction.** In order to achieve this, a clear understanding of the anatomy of the more complex fracture patterns is essential. This is aided greatly by the use of preoperative 3D-CT. If the humeral head is dislocated it must be reduced and stabilised along with any fracture involving the articular surface. Varus and valgus deformities of the head can then be corrected using K-wires, elevators or osteotomes inserted eccentrically into the humeral head and used as joy-sticks. Particular attention should be paid to complete correction of varus deformity, to prevent instability and re-displacement.\(^{50,51}\) Anatomical reduction can then be achieved by correcting the translation of the shaft under the head, and then correcting any residual rotational deformity. **Adjuvant fracture stabilisation.** In three- and four-part impacted valgus fractures, after reduction there is usually a substantial defect in the metaphysis which should be filled with autograft bone, allograft or bone substitutes, in order to assist healing and reduce the risk of re-displacement.\(^{52,53}\) Structural autograft or allograft may also be used as a 'strut' to improve the stability of fractures in which the humeral head is displaced into varus, or if there is instability due to loss of the postero-medial calcar.\(^{16,54}\) and also as a space-filler in anterior and posterior fracture-dislocations, where there is a Hill-Sachs defect.\(^{55}\)

**Fixation of fracture.** Cloverleaf, buttress and simple semitubular plate fixation have been extensively used in the past, but have been superseded by site-specific locking plates, which provide more secure fixation in osteoporotic bone (Fig. 4).\(^{56-59}\) Both fixed (mono-axial) and poly-axial plates are now available.\(^{60,61}\) It is important for these to be positioned below the apex of the greater tuberosity to prevent later impingement. None of the screws placed in the humeral head should penetrate the articular surface. In fractures in which the humeral head is displaced into varus, it is essential to insert locking screws in a low position in the head along the area of the calcar. These screws are under compression rather than tension and act to buttress the area of bony instability in the deficient postero-inferior calcar.\(^{16,54,62}\)

**Results of treatment.** Objective comparison of the latest results of the newer techniques with other techniques is impractical due to a lack of clinical trials in this area.\(^{63}\) The functional results for both conventional and locking plates are satisfactory with a relatively low rate of the major complications of osteonecrosis, nonunion and malunion.\(^{64-67}\) Recent series reporting higher rates of fixation failure and screw cut-out have highlighted the importance of achieving a stable reduction in varus displaced fractures.\(^{68}\) The increased use of structural bone grafts and calcar-supporting screws to enhance stability may improve the results from this form of surgery. However, the learning curve is steep and complications are common.

**Closed or open intramedullary nailing.** The concept of statically locked intramedullary nailing is based on preserving the periosteal blood supply by achieving reduction of fracture and fixation without substantial damage to the soft-tissue envelope. Antegrade insertion places the entry point close to the rotator cuff and may lead to pain and stiffness of the shoulder and dysfunction of the rotator cuff. For this reason, many surgeons are reticent to use this technique in younger patients. The current ideal indication would be an elderly patient with a displaced two-part surgical neck fracture (Fig. 5)\(^{69-71}\) despite the reduced options for fixation within the humeral head compared with plate fixation. Three- and four-part fracture configurations are difficult to treat using this technique.

**Results of treatment.** Evaluation of the published results suggest that this technique can be used satisfactorily for two-part fractures but it is associated with variable results in three- and four-part fractures.\(^{72-74}\) Satisfactory functional results have been reported in case series for both locked and unlocked nails.\(^{75-77}\) However, substantial rates of rotator cuff dysfunction requiring secondary nail removal and high rates of fixation failure and malunion, especially for more unstable two- and multipart fractures, have resulted in a high rate of revision surgery.\(^{72}\)

**Replacement of the humeral head**

Neer popularised the use of humeral head replacement to treat acute fractures in the 1970s because of the high rates of osteonecrosis and nonunion associated with...
complex three- and four-part fractures. The improved results achieved by head-conserving reconstructive techniques recently have reduced the requirement for this technique.

**Technique and results.** Hemiarthroplasty is generally preferred to total shoulder replacement in acute fractures, and aims to restore the anatomical relationship of the humeral head to the tuberosities and shaft, by achieving proper component height, off-set and version (Fig. 6). Modular implants are now available that are specifically designed to treat these fractures. They have jigs for judging insertion, porous coating, and fenestrations to encourage tuberosity healing. In view of the poor potential for osseous integration in these osteoporotic fractures, cemented implants are generally used. The high rate of tuberosity pull-off and non-union has generated renewed interest in enhanced suturing techniques to promote tuberosity healing.

The reported outcomes following primary replacement of the humeral head for fractures are varied. Although satisfactory prosthetic survival rates with a low rate of revision have been reported, few studies have been able to replicate the good functional results reported by Neer. A good functional outcome can be anticipated for younger individuals if the tuberosities heal and the rotator cuff is functional. The results are poorer in elderly patients, particularly if they have a neurological deficit, a post-operative complication requiring re-operation, or an eccentrically located prosthesis with retracted tuberosities.

The poor outcomes associated with traditional replacement of the humeral head have led to the extended use of the reverse shoulder arthroplasty, which had previously been used to treat rotator cuff arthropathy (Fig. 7). The joint lateralisation dictates that an intact cuff is not required and healing of the tuberosities is therefore less important. The provisional results of this technique in acute fractures have been encouraging. However, larger studies are required to properly assess the outcome. In addition to the risks associated with conventional replacement of the humeral head, reverse shoulder arthroplasty may also be complicated by the development of notching of the scapular neck, early loosening and acromial stress fracture.

**Complications of proximal humeral fractures**

Complications may occur as an inevitable consequence of the original injury, or as a result of errors in treatment. Osteonecrosis, nonunion, and malunion of the tuberosities causing rotator cuff dysfunction are the most common complications, and a satisfactory outcome is generally achieved if they are avoided. Osteonecrosis. Osteonecrosis may be an inevitable complication of an injury which damages the blood supply of the humeral head, and is thus more common in multi-part fractures and fracture-dislocations. It may also be the result of poor operative technique, with excessive manipulation of the fracture and stripping of soft tissues.
The pathophysiology is poorly understood as osteonecrosis does not necessarily develop, even if the head is denuded of blood supply,\(^{31,88,89}\) whereas some cases occur after relatively innocuous injury. It presents with pain, stiffness and loss of function, typically after a latent period of satisfactory function. Radiologically, the changes vary from patchy and segmental sclerosis of the head to complete resorption and collapse, and MRI is useful in the evaluation of the extent and severity. Osteonecrosis may be relatively asymptomatic and amenable to non-operative treatment.\(^{90}\) Core decompression can help in patients with early radiological changes,\(^{91}\) but most patients have symptomatic advanced collapse requiring replacement of the humeral head.\(^{92}\) If there are reciprocal glenoid changes, a conventional total joint replacement may be more successful,\(^{93}\) and if there is a severe associated malunion of the tuberosities or cuff tear, reverse shoulder arthroplasty may be a better option.

Osteonecrosis may also occur in one or both tuberosities after fracture, regardless of the viability of the humeral head. The patient usually has debilitating shoulder pain and loss of function, with signs of rotator cuff weakness and dysfunction. At present, there is no known treatment for this complication. **Nonunion.** Head-shaft nonunion is a rare but debilitating complication.\(^{94}\) There are usually associated identifiable patient-, fracture- or treatment-related risk factors. Patient factors include osteoporosis, existing inflammatory or degenerative joint disease of the shoulder, poor physiological state, medical comorbidities and drug treatment, smoking and alcohol abuse.\(^{95-98}\) The fractures most at risk are those with no residual cortical contact between the humeral head and shaft, and those with marked comminution.\(^{94}\) Complete disruption of the periosteal sleeve leads to instability and soft-tissue interposition may inhibit callus formation.\(^{99}\) Hanging casts, which distract the fracture, overzealous shoulder mobilisation, poor surgical technique with extensive soft-tissue stripping, and mechanically unstable fracture reduction and fixation may also cause nonunion. Patients complain of severe pain, stiffness and loss of function, and there is usually ‘pseudoparalysis’ of the deltoid, rotator cuff, and periscapular muscles, and a flail arm. Radiologically, there is resorption and fracture line widening, often with massive bone resorption.

CT can be used to confirm the nonunion and assess the feasibility of reconstruction. If ORIF has been performed as a primary treatment, infection should be excluded by culture of an ultrasound-guided aspirate.\(^{100}\) All medically fit patients should be offered reconstruction if the pain is debilitating. Nonunion may be treated either by ORIF and bone grafting, or replacement of the humeral head. The decision as to which form of treatment is most appropriate is individualised, but absence of infection, osteoarthrosis and osteonecrosis, adequate humeral bone stock, and lack of severe malunion of the tuberosities are mandatory for ORIF.

**Malunion.** Some degree of malunion is inevitable in displaced fractures of the proximal humerus treated non-operatively. Head-shaft and head-tuberosity malunion are both common, and usually well-tolerated in older patients. However, in younger patients, debilitating symptoms may be produced by a head-tuberosity malunion causing dysfunction, impingement or tears of the rotator cuff tendons. It is important to determine the cause of the symptoms by careful clinical examination as postoperative shoulder stiffness, dysfunction of the acromio-clavicular joint, tendinopathy of the biceps and complex regional pain syndromes may all contribute to symptoms. If infection is suspected, joint aspiration and bacteriological examination is warranted. The complex anatomy of a malunion is best appreciated using 3D CT reconstruction. Symptoms may be improved by an osteotomy and correction of the deformity, or more commonly by replacement of the humeral head.

**Post-traumatic shoulder stiffness.** Although capsular contracture is the main cause of refractory stiffness, there may be other factors including malunion of the fracture, complex regional pain syndrome, thoracic outlet syndrome, impingement of implants, and rotator cuff dysfunction from impingement or tears. The initial treatment is non-operative with rehabilitation in an attempt to regain movement of the
shoulder using stretching exercises. Although distension arthrography is useful in stretching the capsule in idiopathic adhesive capsulitis, it is the authors’ experience that the procedure is less effective in the post-traumatic shoulder. In patients with refractory post-traumatic stiffness without malunion, treatment by manipulation under anaesthesia and by arthroscopic arthrolysis often helps.

**Infection.** Infection is relatively rare after fractures of the proximal humerus, even after ORIF, because of the rich vascularity and good soft-tissue cover. 101,102 However, most infections associated with these fractures follow operative intervention. Superficial infections are common and invariably resolve with antibiotic therapy, whereas deep infections may occur early, or be delayed. Early sepsis with a stable implant should be treated with debridement and prolonged antibiotic therapy. Removal of the implant may be required to eradicate infection. Deep infection can occur several years after arthroplasty and may result from a transient bacteremia caused by a range of organisms. 103 The removal of metalwork, debridement, the insertion of a spacer, and parenteral antibiotic therapy should form the basis of treatment. eventual reimplantation can be achieved if the organism can be eradicated.103,104

**Complications unique to arthroplasty.** Rotator cuff dysfunction from early tuberosity redisplacement or non-union is the major complication resulting in an unsatisfactory outcome following replacement of the humeral head. Many patients are also unable to comply with an aggressive rehabilitation program after surgery, and this may result in symptomatic peri-articular adhesions and capsulitis. Other complications associated with arthroplasty include instability, dislocation, prosthetic loosening, late infection and peri-prosthetic fracture. Most elderly patients do not survive long enough to develop these complications; those who do should be treated according to the same protocols used for primary arthroplasty for degenerative joint disease.105-107

**Conclusion**

The majority of fractures of the proximal humerus are stable injuries in the elderly and can be successfully treated non-operatively. The challenge for the future is to select those patients who are going to be at increased risk of developing complications or a poor functional result after non-operative treatment. Well-designed trials will be required to evaluate whether the outcome in these patients is improved by operation. Current systems serve the surgeon poorly in both classifying these fractures and evaluating their outcome after treatment. More robust and reliable systems are required to enable more objective comparison of different methods of treatment in future studies. For the present, it is the authors’ belief that the treatment of most fractures of the proximal humerus should be individualised, and based upon an assessment of the personality of that particular fracture.

**Supplementary material**

Tables summarising published results with the use of non-operative treatment, plate fixation, intramedullary nailing and humeral head replacement in fractures of the proximal humerus are available with the electronic version of this article on our website at www.jbjs.org.uk

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**References**


