HUMERAL SHAFT FRACTURES Vasu Pai

3% of all orthopedic injuries

Definition: Fracture shaft humerus is the fracture of humerus between shaft: from Pect Major insertion to supracondylar ridge.

Types

A Simple fracture: Spiral, short oblique, transverse.

B Wedge fracture

C Complex fracture

Nonoperative management continues as the mainstay for treatment of the majority of these injuries.
Acceptable healing in more than 90% of patients.
Surgical treatment should be reserved for selected cases.

Operative treatment can be performed via external fixation, intramedullary nails, or plate-and-screw constructs, with each method resulting in predictably high union rates.

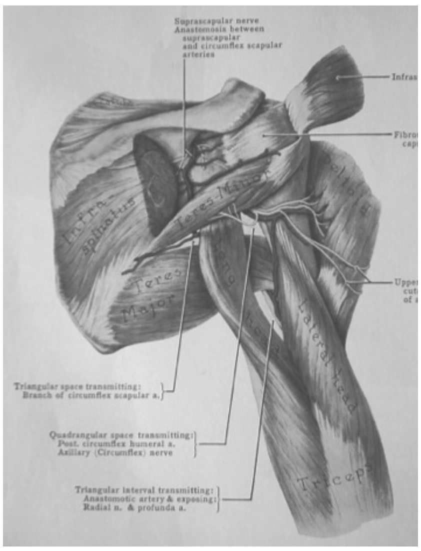
Despite the numerous surgical techniques, plate fixation remains the gold standard for fixation of humeral shaft fractures.

RELEVANT ANATOMY

Important osseous landmarks

a. The deltoid tuberosity is at the mid-anterolateral aspect of the humerus

b. The spiral groove posteriorly, which houses the profunda brachii artery and radial nerve



Deformity is due to differential pull by pectoralis and deltoid muscles.

The nutrient artery, a branch off of the brachial artery that penetrates at the proximal third of the humerus on the medial side of the bone. The periosteum and the surrounding muscle bed also provide vascularity.

The median nerve: Provides no innervation to the muscles proximal to the elbow.

The ulnar nerve travels distally, it pierces the medial intermuscular septum two-thirds the distance down, thus moving from the anterior to the posterior compartment of the arm. It continues in the posterior compartment on its way toward the medial elbow. Like the median nerve, the ulnar nerve provides no

innervation to muscles proximal to the elbow.
The radial nerve: It exits the spiral groove on the lateral aspect of the humerus approximately 10 to 15 cm distal to the lateral acromion; it is there that the nerve is tightly bound by the lateral intermuscular septum and, therefore, highly susceptible to traction injury.

History of humeral shaft treatment

1600 BC, Egyptians	Edwin Smith Papyrus, circa first described treatment: Splints made of cloth, alum, and honey.	
1970	Hanging arm cast [Caldwell]; U slab	No role
1977	Sarmiento first described functional bracing. A major advancement was made and the modern era of splinting was introduced.	

It is important to stress that most transverse to short oblique humeral shaft fractures are amenable to nonoperative management.
Recommendations by some authors for immediate surgical intervention are not supported.
In a level III comparative study of extra-articular distal-third diaphyseal humeral fractures, the authors concluded that although operative treatment resulted in more predictable alignment and a potentially quicker functional return, the operative risks were not insignificant and included loss of fixation (1), infection (1), and postoperative radial nerve palsy (3). Among the 19 patients treated surgically, a 26% complication rate was reported. Comparatively, in the group that underwent brace treatment he end result in each case was a healed fracture with excellent functional outcome, with only minor skin complications due to local brace irritation noted. Advocates for surgical treatment should acknowledge that even in cases in which brace treatment is a challenge, the literature does not support the superiority of operative treatment.

The current strategy for nonoperative management involves the immediate immobilization of the injured extremity via a coaptation splint, sling, and/or swath to provide initial fracture stability, pain control, and resolution of the edema. Once the majority of the soft-tissue swelling subsides, typically after 10 to 14 days, the initial splint is exchanged for a functional brace. This type of bracing is suitable for the majority of humeral shaft fractures and has the benefit of avoiding immobilization of the shoulder and elbow, which can lead to further morbidity including shoulder capsulitis and elbow stiffness.

Gravity allows adequate alignment in majority. Physiologically induced motion at the fracture site favors healing of the fracture. Some amount of varus is acceptable. Rotatory deformities are rarely encountered.

The level of the fracture does not influence the ultimate result. Brace does not fully cover every proximal or distal: but it is not necessary

Fracture with distraction suggest soft tissue interposition and is a contraindication for functional brace.

Indicates severe soft tissue damage or soft tissue interposition

Treatment

Initial U slab for 2 weeks. This is followed by a brace. The brace should begin approximately 2.5 cm distal to the axilla and should terminate distally 1 cm proximal to the humeral condyles. Supracromial and condylar extension are not necessary

Patient should above to put it on their own

Pendulum exercise should be encouraged. Active abduction and elevation should be avoided. Leaning on the elbow should be avoided.

Non-union is 1-5%.

Nonoperative management of humeral shaft fractures results in predictably good outcomes, with acceptable alignment and healing occurring in more than 90% of cases. In the largest clinical analysis to date, Sarmiento reported on 922 patients treated with a functional brace for both closed and open humeral shaft fractures. In total, 67% of patients were available for follow-up, and among these patients, 98% of all closed injuries and 94% of all open fractures healed.

Acceptable for fracture reduction

30° of varus angulation

20° of anterior bowing

up to 15° of internal rotation

Indications

1. Open fractures
2. Polytrauma: because of recumbent position, sling not good for chest
3. Floating elbow
4. Bilateral: patient can be independent
5. Associated Vascular or neurological [radial nerve palsy at injury is not an indication for fixation] but Holstein Lewis syndrome is an indication
6. Distraction: 1 cm or angulation >15° in the brace
7. Fracture lower limb with fracture shaft humerus [for mobilisation]
8. Impending pathological fracture
9. Segmental fracture
10. Delayed or NU: >12 wks

Surgical treatment of humeral shaft fractures

1. ORIF by a plate
2. IM Nail
3. External fixation [polytrauma patient]

I Intramedullary nailing

Flexible nails
Rigid locking humeral nails.

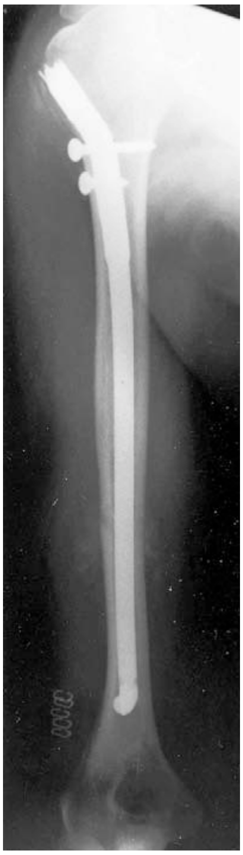
Locking nails were then introduced in hopes of better addressing the pitfalls associated with the preliminary devices and remain the standard intramedullary implant used today.

From a biomechanical standpoint, the intramedullary positioning of these devices places them in line with the mechanical axis of the humeral diaphysis, thereby subjecting the implant to lower bending loads. In turn, by being centrally positioned, the nail functions in a ''load-sharing'' capacity and mitigates the potential effects that stress shielding may play as compared with compression plating.

With regard to surgical benefits, the nail can be introduced through a smaller incision, which allows a smaller surgical approach and less soft-tissue stripping as compared with plating techniques.

Conditions better suited for intramedullary fixation

1. Pathological lesions [metastasis]
2. Segmental injuries,
3. Osteopenic bone.



Contraindications to IMN include concomitant neurologic deficit, as well as open injuries because of the concern for intramedullary contamination.

Modern intramedullary devices can be implanted in either an antegrade or retrograde fashion.

Technique

1. Longitudinal cut inferior to the anterolateral corner of the acromion.
2. The deltoid is split [< 5 cm distal from the acromion]
3. The subdeltoid bursa is excised
4. The supraspinatus tendon split.
5. Starting hole at the medial sulcus of the greater tuberosity
6. Guide wire
7. Retrograde: Triceps splitting; The entry portal located 1.5 to 2 cm proximal to the olecranon fossa.

The incidence of shoulder dysfunction has been reported to range from 6% to as high as a 100%. Much of the problem is believed to be due to either subacromial impingement caused by a prominent nail or scar tissue and/or damage to the rotator cuff in its critical zone of hypovascularity creating chronic tendon tearing.
Proponents of the retrograde technique would safely counter that shoulder dysfunction is avoided with this approach but it is not without its own share of complications, including iatrogenic supracondylar fracture, extension loss of the elbow, and heterotopic ossification.

Another commonly reported concern pertains to the rate of nonunion after intramedullary humeral fixation. Nonunion rates have ranged between 0% and 29% in the literature.

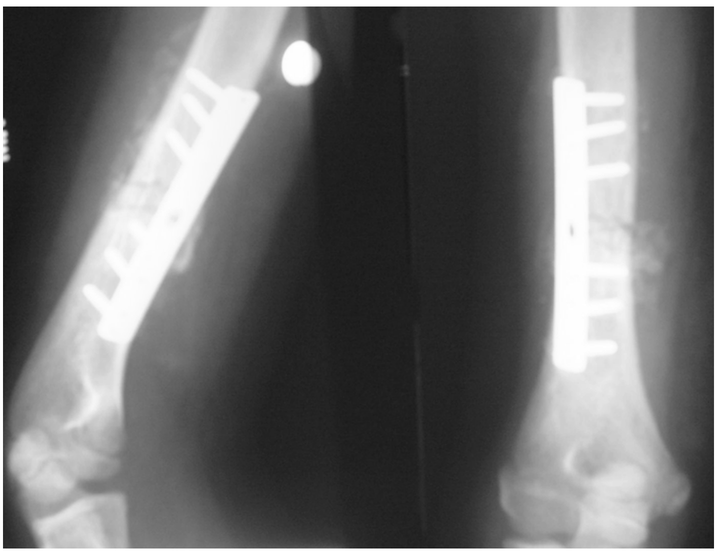
A recent level II prospective study by Putti: comparing modern locked humeral nails with direct compression plating, found no significant difference in union rates or functional outcomes but did note a statistically significantly higher complication rate in the nail group.

II Open reduction/internal fixation

Continues to be the mainstay of operative management
The anterolateral approach is useful for exposure of fractures involving the proximal and middle thirds of the humeral shaft. The benefits of this approach include its extensile nature and its avoidance of the radial nerve.
A posterior approach may be better suited for fractures extending between the olecranon fossa and distal middle-third of the humerus. The triceps tendon can be either split midline (triceps splitting) or released medially and laterally and mobilized (triceps sparing) to allow visualization of the bone. In both techniques, the radial nerve must be dissected and identified to avoid iatrogenic injury from either cutting it during exposure or plating over it during fracture fixation.

Basics

1. Less stripping of periosteum
2. Anatomical reduction

3. Using a longer plate to obtain a greater working length is recommended when bridging a comminuted segment. [Minimum 6 cortices each side; heavy duty 4.5 plate]
4. Do not shorten > 2 cm incurred after removal of comminution may result in significant muscular weakness
5. Plate applied on the tension surface; Lateral or posterior

In a recent study comparing locking plates with non-locking plates for a comminuted midshaft fracture model, no biomechanical advantage was noted with regard to torsion, bending, or axial stiffness between the 2 constructs. Locking screws are also costly, averaging 5 times greater than their non-locking 3.5-mm counterpart.
In comparison, when faced with poor bone quality, the use of locking plates may be advantageous. For most transverse fractures, compression with a broad 4.5-mm dynamic compression plate is recommended to achieve primary bone healing. The broad 4.5-mm plate incorporates staggered screw holes in its design, a feature that helps to prevent splintering of the humerus and propagation of existing fracture lines. The 4.5-mm plate can be used for most humeri of adequate size. However, for smaller patients, a narrow 4.5-mm dynamic compression plate is recommended.

Minimally invasive techniques have been described and used effectively [Zhiquan]. This approach was clinically safe as long as plating occurred with the arm maximally supinated to avoid injury to the radial nerve.

OUTCOME

1. Chapman: JOT 14: 162:
84 patients: ORIF or Rod [Randomized]; At one year: Healing in 93% ORIF and 87% with Rod.
20% Pain in the shoulder in IM nail group

2. Flinkkila: Acta Orthop 70: 133
21/125 Humeral rod, Nonunion
37% Shoulder problem
Good to excellent results in 60%

3. Jupiter: JBJS 81A: 177
22 cases of Osteopenic NU: ORIF with bone graft 90% Good to excellent results

COMPLICATIONS

Interolcking Nail: Non union 5-10% and exchange nailing is successful in only 40% or less
Removal of nail and plating is required.
Shoulder pain : 40%

Nonunion

Nonunion rates as high as 10% of cases

Normal healing 8-10 weeks	
Functional brace	2%
ORIF	6%
Flexi nail	8%
Rigid Nail	10%

Fracture patterns with a high propensity for nonunion

1. Humeral fractures associated with ipsilateral brachial plexopathies and long oblique fractures with proximal extension. [45% of incidence of nonunion]

2. Long oblique fractures with proximal extension. Soft-tissue interposition between the fracture fragments occurs due to buttonholing of the sharp distal fragment through the deltoid muscle belly. Up to 50% nonunion has been reported [Ring]. For this type of injury and supported close observation and possible early intervention if healing is not observed by 2 months.

3. Relative indications for surgery also include the cases of ''**floating elbow**'' with concomitant fractures of the humerus and both forearm bones, morbidly obese patients whose bracing is uncomfortable or not feasible because of the impediments of the surrounding soft tissues, and cases in which closed management has failed.

The most common type of nonunion is the atrophic nonunion, which is essentially a failure of biology at the fracture site. Treatment for this type of nonunion is aimed at enhancing the biologic milieu of the fracture site to make it more hospitable for fracture healing. Strategies include bone grafting and the use of bone morphogenic protein compounds to enhance healing.

A hypertrophic nonunion is a problem of mechanical stability, where the bone is trying to heal but the mechanical instability at the fracture site prevents complete osseous union.

The final type of nonunion is the infected nonunion. Treatment of this problem requires debridement of necrotic tissue, treatment of the infection, and establishment of a stable mechanical construct to aid in fracture healing.

With an atrophic nonunion of the humeral diaphysis; each patient was treated by compression plating and an intramedullary allograft strut. A union rate of 95% was observed in our series.

2.**Malunion**: described as angular deformity greater than 16° in any plane, occurred in a varus position and apex-anterior angulation 13% and 19% of the time, respectively. Only 2% of patients reported loss of shoulder motion exceeding 25° as compared with the uninjured side.

With regard to angular deformities, given the mobility afforded by the shoulder and elbow, malunions of the humeral shaft are well tolerated with minimal functional impairment.

3. Shoulder pain

The incidence of shoulder dysfunction has been reported to range from 6% to as high as a 100%. Much of the problem is believed to be due to either subacromial impingement caused by a prominent nail or scar tissue and/or damage to the rotator cuff in its critical zone of hypovascularity creating chronic tendon tearing. Usually is about 35%

4. Radial nerve injury

18% of closed injuries.

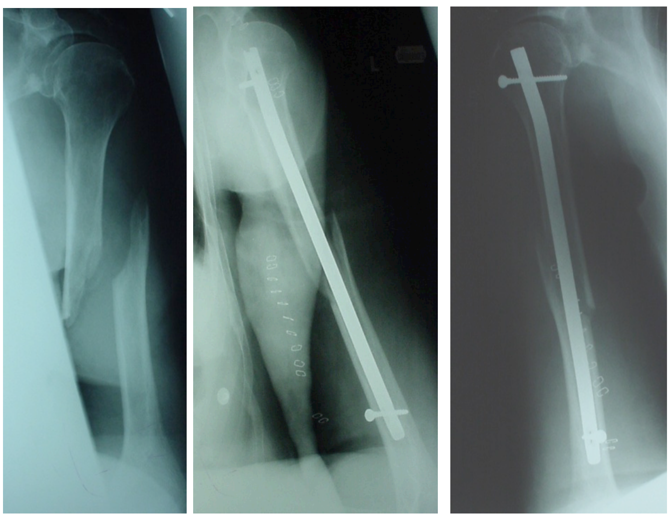
Associated with middle one-third spiral humeral shaft fractures.

90% at 4 months after injury.

Indications for surgical exploration of the radial nerve

1. Neurologic compromise after closed reduction of a humeral shaft fracture, open fractures with associated radial nerve palsies, radial nerve palsy after a penetrating injury, and spiral or oblique fracture patterns in the middle to distal one-third of the humeral shaft (ie, Holstein-Lewis fracture)

2. Without objective clinical signs of radial nerve recovery 6 weeks after the injury (ie, return of brachioradialis, extensor carpi radialis longus, and brevis muscle function), electromyography (EMG) and nerve conduction studies should be performed. In the presence of muscle action potentials on EMG testing, observation of the radial nerve for recovery should be continued. However, in the presence of denervation where fibrillation potentials will be observed, EMG and nerve conduction studies should be repeated at 12 weeks after the injury. In the absence of recovery at 12 weeks, as indicated by clinical examination and neurophysiologic testing, surgical exploration of the radial nerve is recommended. Should the radial nerve not recover, tendon transfer procedures have shown success for the treatment of radial nerve palsy.



1. Pathological fracture and Nailing

2. Nonunion following nailing

Summary

The treatment for the majority of humeral shaft fractures continues to be nonoperative management.

Compression-plate fixation gives predictably good results but necessitates an extensive exposure and requires expertise
in plate-application techniques.

Interlocking intramedullary nails are an attractive alternative for humeral fracture stabilization, primarily because of the limited surgical exposure and secure fixation provided.

However, these advantages must be weighed against a high rate of postoperative shoulder problems with antegrade insertion.

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