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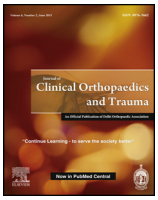

Review article

Best care paradigm to optimize functionality after extra-articular distal humeral fractures in the young patient

Mark S. Ayoub[a,*], Ivan S. Tarkin[b]

[a] UCSF-Fresno, Department of Orthopaedic Surgery, 2823 Fresno Street, Fresno, CA 93721, United States
[b] University of Pittsburgh Medical Center, Department of Orthopaedic Surgery, Kaufmann Medical Building, 3471 5th Avenue, Suite 1010, Pittsburgh, PA 15213, United States

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ABSTRACT

For younger patients with extra-articular distal humerus fractures closed management is plagued with high rates of malunion, suboptimal functional outcomes, extended immobilization with loss of early motion, a delay in return to work, and a general period of lost productivity. Surgical management offers an appealing alternative. Maintaining respect for the triceps musculature and minimizing iatrogenic injury to the radial nerve are primary concerns with operative treatment. Accordingly, use of a triceps-sparing approach and single column plating may be the optimal treatment paradigm in the young patient presenting with an extra-articular distal humerus fracture.

1. Introduction

The goals of care in the young active patient with extra-articular distal humeral fracture include uneventful fracture healing with optimized alignment. Further, return of pre-injury functionality is essential. Elbow motion should be preserved as well as muscle strength and endurance. Although closed management with a Sarmiento brace is an option for care, formal open reconstruction is preferred.

Traditional exposure for the operative treatment of distal humerus fracture is the triceps-splitting approach yet triceps-sparing method is gaining in popularity. Choice of approach is critical to prevent complications of surgery, which include radial nerve injury, stiffness, and muscle weakness. Lastly, fixation can involve single column plating, dual column plating, and even dual plating along one column.[1]

The purpose of this article is to demonstrate the merits of an optimized surgical care plan for these fractures, while also showing the limits of nonoperative treatment. Choice of surgical exposure, reduction technique, and internal fixation strategy can positively affect clinical outcome whilst minimizing complications for the distal humeral fracture in the younger more high demand patient. Best care paradigm for surgical reconstruction includes respect and care for the already traumatized soft tissue envelope, especially the triceps musculature and vulnerable radial nerve. In addition, achieving and maintaining optimal fracture alignment until union with low profile and well-contoured hardware is advisable.

1.1. Conservative treatment for the distal humerus fracture- functional bracing

In order to properly evaluate the relative merits of surgical intervention for this injury, nonoperative treatment and the resultant outcomes must be considered. This requires a thorough review of Sarmiento's original functional bracing outcomes[2], as well as other authors' attempts to replicate his results in the years following.

1.1.1. Sarmiento functional bracing outcomes

Originally described by Sarmiento[2], functional bracing has been shown to have a significant role in the treatment of humeral fractures for the general population[2]. Still, the younger high demand patient with a distal humeral fracture is perhaps not best served with this treatment method. The resultant outcomes of closed management in terms of nonunion, malunion, and adjacent joint function according to Sarmiento and others are typically not acceptable for this patient population. Further, inconvenience and short term morbidity with bracing makes this a less attractive option.

While Sarmiento's series of 85 patients with *distal* third humeral fractures boasted a union rate of 96%, adjacent joint

* Corresponding author.
E-mail addresses: mayoub@fresno.ucsf.edu (M.S. Ayoub), tarkinis@upmc.edu (I.S. Tarkin).

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motion loss and malunion were significant.[3] Malunion was noted in the vast majority of his patients, typically in the form of varus alignment. In active patients with high functional demands the loss of motion and malunion undoubtedly have a significant toll on their daily life and impede their ability to return to pre-injury activity level.

Consistent with these well documented yet infrequently discussed suboptimal outcomes by Sarmiento, newer literature has emerged further reaffirming the prevalence of unsatisfactory outcomes with bracing.

1.1.2. Nonunion with nonoperative treatment, post-Sarmiento

The 96% union rate reported by Dr. Sarmiento unfortunately has not been reproduced in further studies on functional bracing for distal humeral fracture. Ali et al. recently showed a 15% nonunion rate for distal third humerus fractures when treated with conservative treatment in 26 patients.[4] Riera et al., in a larger study on humeral fractures, demonstrated a 12% nonunion rate in 162 patients.[5] Ekholm et al. recently reported on a series of 78 patients treated conservatively with humeral fractures, 10% required secondary operation due to nonunion.[6] Discrepancy in results between Sarmiento and others could be attributable to the substantial loss of follow-up noted in Sarmiento's studies. Indeed, in Sarmiento's largest series there was a 33% loss of follow-up.[7]

1.1.3. Malunion with nonoperative treatment

Although rates of nonunion with functional bracing are varied, malunion or deformity is commonplace, which is typically both functionally and cosmetically unacceptable for the young active patient. Sarmiento et al. reported varus malunion in eighty one percent of distal humerus fractures.[3] In another study by Jawa et al. comparing conservative to operative management, distal humeral fractures treated in a brace had an average twelve-degree varus deformity.[8] This was in contrast to their operative cohort that had minimal residual deformity after union. In a study of 21 patients treated with functional bracing for distal humeral fractures, Pehlivan found 38% of patients had varus angulation.[9] Further, Riera et al. reported an 18% deformity rate in 162 humeral fractures treated in a functional brace.[5]

1.1.4. Functional outcomes with conservative treatment

Perhaps of greater importance to the young active patient is the ultimate functionality achieved after treatment and subsequent rehabilitation after distal humeral fracture. A concern with functional bracing is "cast disease" resulting in stiffness of adjacent joint especially the elbow but also the shoulder as well. Using a functional brace, specifically for distal humeral fractures, Sarmiento reported both shoulder and elbow dysfunction in a subset of his patients. At the shoulder, 45% of patients had a decrease in external rotation (range: 5 to 45° loss), and more than 15% lost abduction (range: 10 to 60° loss). At the elbow, 26% lost flexion (range: 5 to 25° loss) and 24% lost extension (range: 5 to 25°).[3] In Ekholm's study of 78 patients, 50% did not self-assess themselves as 'fully recovered' from their injury at final follow- up.[6] Koch et al. reported on 67 patients and found that only 50% of their patients had 'excellent' functional outcomes defined as 'normal, symmetric range of motion of shoulder and elbow; no pain'.[10]

1.1.5. Brace inconvenience

Beyond objective musculoskeletal data on the limitations of usage of the functional brace for the management of distal third humeral fracture, patient satisfaction can be compromised. Short term morbidity in terms of comfort, convenience, and early return to activity should be considered in the younger patient. Further, maturity and compliance as it relates to brace use is integral to its effectiveness, which can be especially challenging in the younger patient that potentially lacks the discipline and patience needed with this treatment. Sarmiento noted that compliance was the single most important factor leading to success with functional bracing.[11,12] Woon described some of the common pitfalls with brace wear including the tendency to remove the brace frequently, moving the arm excessively, loosening the straps for comfort and losing the intended sleeve-compression effect of the brace, as well as resting the elbow when upright and not allowing gravity to restore alignment.[12] Jawa et al. reported that nearly 10% of patients with extraarticular distal humerus fractures treated with functional bracing had skin breakdown requiring brace discontinuation and transition to a sling.[8]

Other authors have reaffirmed these challenges associated with brace wear, as Jawa wrote:

> 'With a fracture brace and sling, the pain and instability of the fracture make the arm relatively useless for at least 4 weeks . . . and up to 8 weeks . . . Even basic daily tasks are difficult on one's own...Shoulder and elbow motion return but it can take weeks to months of uncomfortable stretching exercises. Some people have skin problems in the brace-particularly in hot, humid weather.'[13]

Clearly, the difficulties with brace wear and the younger patient's desire to get back to a meaningful state of life in a timely manner can make bracing a less attractive if not inferior option compared to surgical fixation.

1.1.6. Secondary intervention after failed brace treatment

With these challenges of brace treatment comes the need to consider the significant consequences to failed brace management. Typically, operation is the only meaningful solution to correct nonunion, deformity, and stiffness (Fig. 1). As compared to operation in the acute setting, the rate of complication is higher and the functional result is less desirable.

Working in scarified soft tissue envelope makes dissection more challenging and puts the radial nerve at increased risk for injury. In addition, callus can encase the nerve or place it under tension, putting the nerve at high risk.[14] The incidence of radial nerve palsy after humeral shaft nonunion surgery has been reported from 4% to nearly 20%.[14–18] Specifically for distal humerus nonunion surgery, Kakazu et al. noted a nearly 20% iatrogenic radial nerve palsy, whether patients initially were treated conservatively or with surgery.[14]

For the patient with loss of motion at the elbow after brace treatment several options exist. Static progressive and dynamic elbow splinting can be considered for a patient presenting within the first 6 months.[19] For those who fail nonoperative treatment for their posttraumatic elbow stiffness, surgical contracture release is the next option. While this is met with good results, there is no doubt that it involves a demanding and long course of rehabilitation.[19]

The potential morbidity and ultimate functional result of operation in delayed fashion for the distal humeral fracture is certainly life altering. Aside from radial nerve concerns, the lost productivity, excess time off work, stiffness, and muscle wasting that occur during the extended course of a nonunion are difficult to quantify but certainly significant. This is especially true for the young patient that would otherwise be active, working, and productive.

1.2. Surgical treatment for the distal humerus fracture- patient selection

As compared to the limitations of functional bracing for extra-articular distal humeral fractures in the young patient, operation has been met with largely positive outcomes. Rigid fixation with

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