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Return to Functionality After Humeral Shaft Fracture – Treatment Strategies

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Abstract

Background Humeral shaft fractures are relatively common injuries of the musculoskeletal system and occur in the general population and among athletes. They may result from high-energy trauma, falls, overuse, or repetitive microtrauma associated with intensive training. Advances in surgical techniques, fixation materials, and rehabilitation methods have led to the development of new therapeutic strategies that compete with traditional conservative management.

Aim The aim of this review is to analyze the available literature on humeral shaft fractures, with particular emphasis on comparing conservative and surgical treatment, as well as evaluating rehabilitation strategies that influence the time to and quality of return to sports activity.

Material and methods Review of the literature was undertaken using PubMed, Scopus, Google Scholar. Publications in English or Polish focusing on different treatment approach and its results in adult patients were included and evaluated using a qualitative approach.

Results In recent years, this topic has gained increasing attention in sports medicine, especially in relation to overuse injuries and the process of returning to training. The aim of this paper is to present current data on biomechanics, epidemiology, treatment options, and the role of rehabilitation, in humeral shaft fractures. Based on the reviewed literature, both conservative and surgical treatments are associated with high rates of bone union and generally good functional outcomes. Surgical management earlier mobilization and a faster return to sports activity, whereas conservative treatment is linked to a lower risk of surgery-related complications. The choice of treatment method should be individualized.

Conclusion The importance of early rehabilitation was emphasized as a key component of the treatment process, influencing the recovery of full limb function.

Keywords : Humeral shaft fracture; surgical approach, athletes, physical rehabilitation

1. Introduction

The humeral shaft is the segment located distal to the surgical neck and proximal to the epicondyles, and its structure and topography are of key importance for the safety of surgical procedures involving the arm [1]. Detailed anatomical knowledge of the neurovascular structures in this region is essential for planning the surgical approach and for preventing iatrogenic complications.

In its proximal part, the shaft has a cylindrical shape, which gradually becomes triangular distally, with three surfaces: anterolateral, anteromedial, and posterior. Two anatomical landmarks are of particular importance: the deltoid tuberosity, which serves as the attachment site for the deltoid muscle, and the radial groove, which runs spirally along the posterior surface of the shaft. The radial nerve and the profunda brachii artery course within this groove, making it a high-risk area in cases of trauma or surgical intervention [2].

The radial nerve, originating from the posterior cord of the brachial plexus, runs along the humeral shaft accompanied by the profunda brachii artery. Approximately 10–14 cm proximal to the lateral epicondyle, it passes from the posterior to the anterior surface of the bone. At this level, the nerve is particularly vulnerable to injury, especially in the setting of so-called Holstein–Lewis fractures [3]. The incidence of post-traumatic radial nerve injury ranges from 4% to 22%, while iatrogenic injuries occurring during surgical treatment are reported in approximately 3% of cases [4].

The humeral shaft is primarily supplied by the nutrient artery, which is usually located on the anteromedial surface, between the attachment of the coracobrachialis muscle and the origin of the brachialis muscle. Preservation of this vessel is important for proper bone healing, particularly in spiral fractures and during osteosynthesis procedures.

Understanding the topography and anatomical relationships of the humeral shaft is not only fundamental to safe surgical practice, but also crucial in the analysis of sports-related injuries, where forces acting on the arm may lead to characteristic radial nerve injuries or impaired fracture healing.

1. Review methodology

This paper is based on a comprehensive narrative review of the existing literature. The objective of the review was to identify, analyze, and synthesize current clinical approach relevant to the research topic. A systematic literature search was conducted using major electronic databases, including PubMed, google scholar. Original research articles, review studies, clinical recommendations published in English or Polish were included. The analysis is focused on publications concerning adult and athlets patients with humeral shaft fracture.

2. Research results

3.1 Classification of Humeral Shaft Fractures – Biomechanical and Clinical Aspects

In addition to the AO classification, which allows understanding of fracture morphology, the literature emphasizes the importance of the fracture level in relation to the attachment sites of the major muscles of the arm. This aspect has significant practical relevance, as the direction of muscular forces determines typical fragment displacement patterns and influences the choice of treatment strategy [2].

Classical studies describe three characteristic fracture levels [5,8]:

A) above the insertion of the pectoralis major muscle,

B) between the insertions of the pectoralis major and deltoid muscles,

C) below the insertion of the deltoid muscle.

In the proximal segment, where abducting and rotating muscles force predominate (mainly the supraspinatus and deltoid muscles), fractures tend to settle in abduction and rotational displacement of the fragments. In contrast, in the middle and distal segments, the influence of adducting and extending muscles (including the pectoralis major, coracobrachialis, and triceps brachii) is more dominant, favoring anterior displacement and shortening of the limb axis [6].

Understanding these biomechanical relationships is particularly important in athlets population, in whom injuries often result from high-force overload, sudden abduction movements, or direct impact to the arm. Knowledge and awareness of typical displacement patterns allows more adequate plan of fracture reduction, immobilization, and rehabilitation, thereby minimizing the risk of delayed union and axial malalignment of the limb [7].

3.2 Epidemiology and Mechanisms of Injury

Humeral shaft fractures account for approximately 3% of all long bone fractures and 5–8% of all limb fractures [9]. Their incidence is estimated at about 13 cases per 100,000 persons per year, with two characteristic peaks in occurrence [10]:

- in men age : 20–30 years, most commonly resulting from high-energy trauma,
- individuals over 70 years old, typically following a low-energy fall from standing height.

In epidemiological analyses, open fractures account for approximately 10% of all cases [10]. According to the AO classification, type A fractures are the most common (63%), followed by type B (23%) and type C (10%), reflecting the predominance of simple injury mechanisms over comminuted fractures [11].

In younger and physically active populations, humeral shaft fractures are usually a result of traffic-related injuries, falls from height, contact sports, or sudden high-load forces during strength-based activities [12].

In athletes, an increasing number of cases described as the so-called *spiral humeral fracture of the thrower* have been reported. This is a spiral fracture of the humeral shaft caused by a sudden, explosive rotational movement of the upper limb, typically occurring during the throwing phase in sports such as baseball, handball, or javelin throw [13]. This mechanism involves a combination of external rotation and abduction, accompanied by eccentric contraction of the pectoralis major and deltoid muscles. The resulting torsional stresses may exceed the mechanical strength of the bone, particularly in the presence of fatigue, repetitive microtrauma, or insufficient training adaptation [14].

Understanding these injury mechanisms is crucial for sports injury prevention. Appropriate strength conditioning, stabilization of the shoulder girdle, and careful control of training volume may significantly reduce the risk of stress-related fractures in this region.

3.3 Clinical and Imaging Diagnostics

The initial patient assessment includes examination of the skin, vascular status, and radial nerve function as its injury is one of the most common complications of humeral shaft fractures. Any neurological or vascular deficit should be documented prior to the treatment. The authors emphasize that standard plain radiographs in two views (anteroposterior and lateral) are sufficient to establish the diagnosis in the majority of cases [1]. In doubtful or more complex situations—particularly in athletes—computed tomography or magnetic resonance imaging may be useful, as they allow for a more detailed assessment of fracture fragments and associated musculotendinous structures.

3.4 Conservative Management of Humeral Shaft Fractures

The humerus, due to its rich blood supply and surrounding muscular envelope, has a high potential for fracture healing, which allows for a relatively wide acceptance of displacement in conservative treatment. Clinically acceptable alignment includes up to 20° of anterior or posterior angulation, up to 30° of varus or valgus angulation, and shortening of up to 3 cm [15]. Sarmiento et al. conducted one of the largest studies on functional bracing in humeral shaft fractures, including 620 patients. The authors reported fracture union in 98% of patients with closed fractures and in 94% of those with open fractures. In 87% of cases, the residual angulation did not exceed 16°, and only 2% of patients presented with deformity greater than 25° [15].Similar outcomes were reported by Papasoulis et al., who analyzed available clinical studies and found a mean union rate of 94.5%, ranging from 77.4% to 100% [16]. With regard to functional recovery, which is particularly important for physically active patients, numerous studies have demonstrated comparable results between conservative and surgical treatment. Shields et al. found no significant differences in functional outcomes between patients treated operatively and non-operatively [17]. Likewise, Koch et al. reported a 95% rate of complete recovery among 67 fractures treated with functional bracing, with only minimal limitations in range of motion and no relevant impact on limb function [18]. In a large retrospective study, Denard et al. compared 150 patients treated surgically with 63 patients managed non-operatively. The rate of nonunion was 20.6% in the non-operative group and 8.7% in the surgical group, while radial nerve palsy was observed in 9.5% and 2.7% of patients, respectively. However, no differences were found in the time to achieve full union (mean 4.8–4.9 months) or in the final range of motion between the two groups [19].

Conclusions drawn from these studies indicate that conservative treatment remains an effective option for the majority of humeral shaft fractures, including in physically active individuals. However, in athletes, the choice of treatment should also take into account sport-specific demands and the expected time to return to training, as surgical management may, in selected cases, facilitate faster functional rehabilitation.

3.5 Risk Factors for Impaired Bone Healing

One of the key challenges in the conservative management of humeral shaft fractures is the risk of nonunion. Neuhaus et al. analyzed 79 patients with simple AO/OTA type A2 and A3 fractures. Successful bone union following non-operative treatment was achieved in 80% of cases [2,8]. That study also evaluated factors associated with an increased risk of persistent fracture site mobility after 6 weeks of treatment. The strongest independent predictors of treatment failure were:

- smoking, which increased the risk approximately sixfold,
- female sex, associated with a fivefold increase in risk,
- and the width of the fracture gap, with each additional millimeter of initial diastasis increasing the risk by about 40%.

3.6 Surgical Treatment – Principles and Indications

Surgical management of humeral shaft fractures is indicated in cases where acceptable alignment of fracture fragments cannot be achieved or maintained with conservative treatment, or when absolute indications for operative intervention are present.

Absolute Indications include the following [20–22]:

- open fractures with extensive soft tissue damage,
- high-velocity gunshot injuries,
- vascular injuries requiring reconstruction,
- pathological fractures,
- and associated injuries to the brachial plexus.

In cases of low-energy gunshot injuries, as well as closed fractures associated with radial nerve palsy, conservative management may be considered, as spontaneous recovery of the radial nerve is common and usually does not require early surgical exploration [21].

However, early surgical intervention involving nerve exploration combined with osteosynthesis is justified in the presence of an open fracture, vascular injury, high-velocity gunshot trauma, or secondary iatrogenic nerve injury [15,22]. Polytrauma, as well as complex, segmental fractures or fractures associated with other injuries of the upper limb (such as the so-called *floating elbow* or *floating shoulder*), are considered relative indications for surgical treatment. It has been shown that immediate functional loading of the limb after plate fixation does not increase the risk of nonunion or delayed union [20].

In athletes and physically active individuals, the decision to proceed with surgical treatment should be individualized. Indications may be broadened when a rapid return to training and restoration of full range of motion are considered critical.

3.7 Operative Methods – Comparison

Among surgical treatment options, both external and internal fixation can be distinguished. Internal fixation provides earlier mechanical stability and allows for early functional rehabilitation, which is particularly important in sports involving throwing, weightlifting, or physical contact [23].

In operative management of humeral shaft fractures, two stabilization techniques are most commonly used: plate fixation (ORIF, open reduction and internal fixation) and intramedullary nailing (IMN). The choice of technique depends on fracture pattern, soft tissue condition, surgeon experience, and—in physically active patients—the expected time to return to full function. In recreational athletes, however, conservative treatment remains a safe and effective option.

3.7.1 Plate Fixation (ORIF)

Plate fixation is considered by many authors to be the preferred surgical method for the treatment of humeral shaft fractures [24,25]. It allows for anatomical reduction of fracture fragments, stable compression, and precise control of rotational alignment. In clinical practice, the anterolateral and posterior approaches are most commonly used. The anterolateral approach enables exposure of the proximal and middle portions of the shaft while maintaining radial nerve safety, whereas the posterior approach is favored for distal fractures and allows for direct visualization of the nerve [25].

Gerwin et al. demonstrated that even without mobilization of the radial nerve, visualization of 55% of the distal humeral surface is possible, increasing to 76% after nerve mobilization, supporting the effectiveness and safety of this surgical approach.

3.7.2 Intramedullary Nailing (IMN)

Intramedullary nailing allows preservation of the biological environment for fracture healing by minimizing soft tissue disruption and maintaining periosteal blood supply [24]. Meta-analyses have shown that rates of bone union, radial nerve palsy, and infection are comparable to those observed with plate fixation [26,27]. However, IMN is more frequently associated with complications such as shoulder pain and the need for reoperation, which may be related to injury to the rotator cuff insertions [24,26].

The use of rotator cuff–sparing techniques and tenodesis of the long head of the biceps tendon may significantly reduce these complications [28]. A retrograde approach allows avoidance of shoulder-related damage but is associated with slower recovery of elbow joint function.

3.7.3 External Fixation

Although external fixation is less commonly used in athletic populations due to functional limitations and discomfort associated with the presence of pins, it remains a valuable treatment option in selected clinical situations. It is particularly useful in cases of open fractures, high-energy trauma, extensive soft tissue damage, and in polytrauma patients, where the general condition of the patient or local factors preclude immediate plate or intramedullary osteosynthesis [29].Scaglione et al. reported a fracture union rate of 97.6% after a mean of 12 weeks, with no cases of iatrogenic radial nerve injury [29]. The use of techniques based on direct visualization of the radial nerve during pin placement significantly reduces the risk of neurological complications [1,5].

3.7.4 Choice of Treatment Method in Physically Active Patients

In physically active individuals, including athletes, the choice of treatment method should be individualized. Plate fixation allows for early mobilization and provides superior rotational stability, which facilitates faster rehabilitation and an earlier return to strength training and throwing activities. Intramedullary nailing, on the other hand, may be preferred in acute sports-related injuries where minimizing soft tissue damage and reducing overall healing time are particularly important [25,28].

3.7.5 Rehabilitation as Postoperative Care

Rehabilitation is an integral component of the treatment of humeral shaft fractures and plays a decisive role in the final functional outcome, particularly in physically active individuals and athletes. In conservative management, early mobilization of the shoulder and elbow joints—usually initiated 1–2 weeks after immobilization—helps prevent stiffness and contractures while maintaining fracture stability [25]. In postoperative protocols, passive and active-assisted shoulder exercises are typically introduced between the 2nd and 4th week, whereas active resisted exercises are started after radiological signs of bone union are observed [7]. In athletes, early rehabilitation focuses on preserving range of motion of the shoulder girdle, scapular stabilization, and gradual restoration of muscle strength, enabling a safe and faster return to physical activity [19]. Individualization of the physiotherapy program according to the treatment method, activity level, and type of sport is essential to achieve full limb function and to prevent overload-related complications

3. Conclusions

Analysis of the available literature and clinical data indicates that there is no single universal treatment method for humeral shaft fractures. Conservative management remains effective in most cases due to favorable biological conditions for bone healing; however, its limitations include the risk of delayed rehabilitation and joint stiffness. Surgical treatment, although more invasive, allows for precise fracture reconstruction, earlier limb mobilization, and a faster return to activity, which is particularly important in younger patients and athletes.

Current literature suggests comparable outcomes in terms of fracture union and functional results between plate fixation and intramedullary nailing, with differences mainly related to complication profiles and recovery time. Regardless of the stabilization method used, appropriately planned and staged rehabilitation remains a key component of treatment, determining full restoration of limb function.

Available evidence indicates that optimal management should combine adequate mechanical stabilization with preservation of the biological environment for healing and early physiotherapy. Future research should focus on evaluating the impact of rehabilitation protocols on the time and quality of return to full function, as well as on long-term outcomes in patients with different levels of physical activity.

After conclusions:

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