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Rehabilitation after plate fixation of upper and lower extremity fractures

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ABSTRACT

Post-operative rehabilitation and weight-bearing protocols are important to fracture fixation outcomes, yet there is a dearth in the literature concerning universal treatment guidelines following plate fixation of extremity fractures. There are controversies regarding time to allow weight-bearing and range of motion for most fractures of the upper and lower extremity. This lack of a consensus has led to varying practice guidelines and differing anecdotal protocols between treating surgeons. This review attempts to establish consensus guidelines for the post-operative rehabilitation required for patients following plate fixation of common upper and lower extremity fractures.

Introduction

Many fractures of the upper and lower extremity require open reduction and internal fixation with plate constructs. Plate fixation can be utilized to surgically manage fractures involving the shaft, metaphyseal or periarticular regions in the upper and lower extremities. While appropriate reduction, fixation, and stability of the construct are imperative, post-operative rehabilitation management and timing to weight-bearing and range of motion may be just as important and affect patient outcomes. Balancing appropriate weight-bearing status with early therapy and range of motion activities are vital, yet there is a paucity of evidence regarding rehabilitation after plate fixation.

Rehabilitation instructions following surgical treatment include weight-bearing status (early vs. delayed, full vs. partial, protected or unprotected), immobilization (cast immobilization, removable brace, or no immobilization), and range of motion (early vs. delayed, restricted vs. unrestricted, passive vs. active). In lower extremity fractures, a non-weight-bearing regime should be avoided, and patients should be allowed to at least toe touch-weight-bear, which assists with balance, reduces the pressure on muscles supporting the affected hip, and allows the ground to act as the leg support.

Accelerated rehabilitation involving early weight-bearing and early range of motion/mobilization is thought to expedite recovery with earlier return to function [1] and prevent complications of joint immobilization such as stiffness and muscle atrophy [2]. It has also been shown to improve bone mineral density [3]. However, a potential risk of accelerated rehabilitation is that early weight-bearing and/or range of motion may increase the risk of wound complications, fracture displacement, and fixation failure [4].

Basic science of fracture healing

Initially described by Julius Wolff in 1892, skeletal tissue is able to remodel and change architecture in response to mechanical stress acting upon it. This initial concept explained by Wolff has been reiterated today and helped to develop three important rules to post-operative rehabilitation. First, that bone remodeling is triggered by mechanical strains. Secondly, that repetitive dynamic loads initiate bone remodeling while static loads do not. Third, dense bone tends to develop on the concave side of a stress, while bone becomes more fragile on the tension, convex side [5].

The understanding of these principles has developed our practice of allowing early weight-bearing and compressive forces to allow for remodeling. Optimum loading is the key. Animal studies have revealed that axial loading at an osteotomy site leads to high volume of callus, and faster time to union compared to no loading [6–8]. However, while minimal micro motion leads to improved callus and bone formation, larger strains lead to fibrous tissue creation [9,10]. It is important to implement this principle of active loading early in a patients' care to maximize bone growth, but this must be done appropriately as to not jeopardize the stability of fixation.

Rehabilitation considerations

Following appropriate reduction and plate fixation, there are several fracture and patient specific characteristics to consider when determining appropriate rehabilitation protocols. In terms of fracture specific variables, is important to consider the location of fracture, and whether it is a weight-bearing bone of the lower extremity (which may require more caution to allow full activity).

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Likewise, proximity to the joint and intra-articular involvement is paramount, as more restraint may be required in allowing immediate full weight-bearing in periarticular fractures [11]. Fractures with extensive comminution may be the result of higher energy trauma, and are generally treated with bridge plating techniques, which may affect the post-operative rehabilitation regime.

Patient specific variables can also confound rehabilitation practices. Pre-injury activity and ambulatory status should be incorporated into rehabilitation guidelines. Early weight-bearing and mobilization in elderly patients is imperative, as studies have shown the benefits of early ambulation which mitigate post-operative comorbidities in this population [3]. A more accelerated weight-bearing protocol is also vital for poly-traumatized patients, who may have injuries to multiple extremities. Patients with lower extremity fractures may require the use of crutches/walker for mobility, and hence must weight-bear on the upper extremities. The percent of body weight placed on an upper extremity is 25% with a standard cane, 45% with a single forearm crutch, and 80% with axillary crutches [12,13]. Such patients may benefit from immediate weight-bearing after internal fixation of upper extremity fractures and may otherwise be restricted to a wheelchair until their lower extremity fractures have healed.

Some patient factors, such as diminished protective sensation due to diabetes mellitus or severe neuropathy, may impact weight-bearing protocols towards being more conservative. Likewise, the compliant nature of a patient must be considered. It is important to note that despite extensive patient education and feedback, patients will habitually overstep weight-bearing and rehabilitation restrictions [14]. Patients who are suspected of being non-compliant, and likely to bear weight against medical advice, may require more secure immobilization or delayed rehabilitation protocols.

Evidence in the literature

Upper extremity fractures (Table 1)

Clavicle

As mentioned, not all fracture locations/patterns have good clinical evidence to guide treatment protocols, which is the case with clavicle fractures. For patients who meet operative indications, plate fixation is a reliable and effective treatment method for both midshaft and distal third fractures [15,16]. Traditional clavicle post-operative protocol recommends arm sling immobilization for 2–6 weeks followed by physical therapy [17]. There is a paucity of data regarding immediate safe mobilization after clavicle fixation for both acute fractures and nonunions [18].

It is imperative to note that the type of plate utilized can impact the stability of the construct. Compared to compression plates, the use of pelvic reconstruction plates has been shown to be associated with a higher rate of fixation failure and malunions. The use of such plates can affect outcomes, as well as delay post-operative weight-bearing protocols, and should be avoided [19].

In our practice, a pre-contoured clavicular plate is utilized for internal fixation. The injured arm is placed in a sling post-operatively, while allowing pendulum exercises to begin immediately. At 2 weeks post-operatively, the sling is discontinued, and range of motion exercises are initiated, while strengthening is commenced at 6 weeks post-operatively. Most patients can return to unrestricted activity at 3 months post-operatively. In the setting of poly-traumatized patients with mid-shaft clavicular plate fixation, our practice has been to allow immediate use of crutches/walker for mobilization. While the deforming force on clavicle fractures is inferior displacement of the distal fragment, the use of crutches counteracts this by creating a superior force, therefore "balancing" the deforming forces (Fig. 1).

Humeral shaft

The vast majority of humeral shaft fractures can be treated non-operatively, however plate osteosynthesis can be achieved in fractures that meet surgical indications. Studies have shown that immediate post-operative weight-bearing can be safely performed in humeral shaft fractures treated with appropriate plate fixation. Tingstad et al. [20] reported on 83 humeral shaft fractures treated with plate fixation. The majority of fractures were treated with 4.5-mm dynamic compression plating (DCP), with a minimum of 6 cortices of fixation proximal and distal to the fracture. The

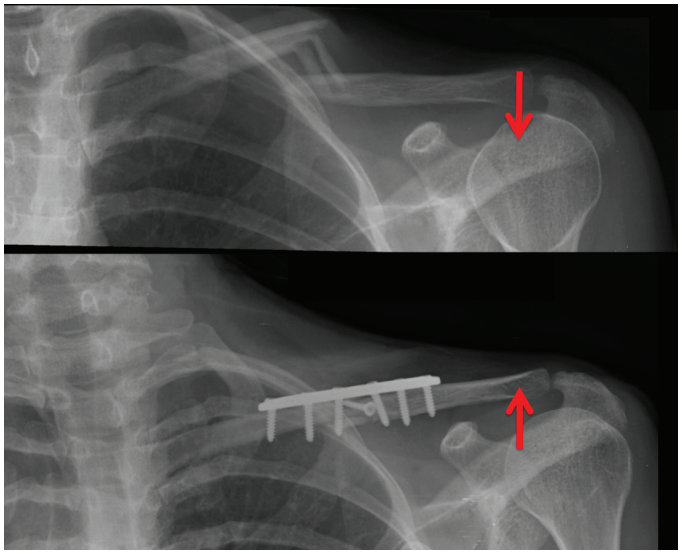

Fig. 1. Deforming forces on midshaft clavicle fracture. (A) Inherent inferior displacement forces on the distal fragment post fracture. (B) Superior forces on the distal fragment from use of crutches/walker, counteracting the inherit inferior forces.

Table 1
Recommended weight bearing and rehabilitation practice by fracture in the upper extremity treated with plate fixation

Fracture type	Weight-bearing status	Immobilization	Range of motion	Source	Level of evidence
Clavicle	CCWB for 2 weeks, strengthening at 6 weeks	Sling for comfort 2 weeks maximum	Immediate	–	Level 5
Humeral shaft	Immediate WBAT	None	Immediate	[20]	Level 4
Elbow					
Distal humerus	CCWB initially, WBAT at 6 weeks	Maximum 2 weeks	Immediate or within 2 weeks	–	Level 5
Olecranon	CCWB initially, WBAT at 6 weeks	Maximum 2 weeks	Immediate		
Forearm	Immediate WBAT	None	Early; unrestricted	–	Level 5
Distal radius	CCWB, initiate strengthening at 2–6 weeks	2 weeks maximum	Immediate or at 2 weeks	[27]	Level 1

CCWB, coffee cup weight-bearing; WBAT, weight-bearing as tolerated