Review Article

Early Weight Bearing After Lower Extremity Fractures in Adults

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Abstract

Weight-bearing protocols should optimize fracture healing while avoiding fracture displacement or implant failure. Biomechanical and animal studies indicate that early loading is beneficial, but high-quality clinical studies comparing weight-bearing protocols after lower extremity fractures are not universally available. For certain fracture patterns, well-designed trials suggest that patients with normal protective sensation can safely bear weight sooner than most protocols permit. Several randomized, controlled trials of surgically treated ankle fractures have shown no difference in outcomes between immediate and delayed (≥6 weeks) weight bearing. Retrospective series have reported low complication rates with immediate weight bearing following intramedullary nailing of femoral shaft fractures and following surgical management of femoral neck and intertrochanteric femur fractures in elderly patients. For other fracture patterns, particularly periarticular fractures, the evidence in favor of early weight bearing is less compelling. Most surgeons recommend a period of protected weight bearing for patients with calcaneal, tibial plafond, tibial plateau, and acetabular fractures. Further studies are warranted to better define optimal postoperative weight-bearing protocols.

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Lower extremity fractures are among the most common conditions treated by orthopaedic surgeons, and making appropriate recommendations regarding weight bearing is an important clinical issue. Early weight bearing may improve function and speed return to work, thus minimizing the economic impact of an injury.

However, allowing patients to bear weight too soon may lead to loss of reduction or fixation failure, thereby compromising patient outcomes and potentially necessitating further surgical intervention. This article reviews the basic science data on mechanical loading and fracture healing and summarizes the available clinical evidence on early weight bearing after lower extremity fractures.

Basic Science of Mechanical Loading and Fracture Healing

Wolff[1] described the ability of skeletal tissue to remodel and alter its architecture in response to the mechanical forces acting on it. In normal bone, osteocytes reside within a fluid-filled network of widely spaced lacunae. Mechanical loading of bone produces hydrostatic pressure gradients in the bone matrix, leading to interstitial fluid flow within the lacunae. Osteocytes sense these changes in fluid flow and alter gene expression and extracellular signaling accordingly. The predominant mediators of this process are the soluble signaling molecules receptor activator of nuclear factor-κ B ligand and osteoprotegerin. Receptor activator of nuclear factor-κ B ligand acts to stimulate osteoclast precursors to differentiate into mature osteoclasts, whereas osteoprotegerin blocks osteoclastogenesis and decreases the survival of existing osteoclasts.[2]

Cell culture, animal studies, and computer models have been used to explore the role of mechanical factors (ie, strain, shear, axial motion) on fracture healing and callus formation.[3] Animal osteotomy models have shown that controlled or moderate axial loading of the osteotomy site typically leads to a greater volume of callus and a faster time to union compared with no loading or excessive early loading.[4] Efforts to optimize limb-loading protocols have suggested that cyclical or dynamic loading produces osteogenesis superior to that achieved with protocols that use a static strain across the fracture site; however, an ideal protocol has yet to be determined.[4,5] Perfusion at the fracture site appears to be the primary driver of mesenchymal cell proliferation, but local mechanical factors influence cell differentiation and phenotype. Sites of small to moderate strain favor osteoblastic differentiation, whereas larger strains increase the proportion of fibroblastic cells and the likelihood of fibrous union.[6]

Laboratory-based Evaluation of Weight Bearing in Humans

Several studies have been done on postfracture weight bearing in the laboratory setting.[7-9] Although such studies allow precise measurement of fracture loading, displacement, and other parameters, they may not accurately reflect patient behavior outside a controlled setting. In one study, 27 patients with tibia fractures were treated with external fixation and allowed to bear weight as tolerated.[7] Initial axial motion across the fracture site was small at 5 weeks postfracture (mean, 0.28 mm), peaked at 11 weeks (mean, 0.43 mm), then decreased as fracture healing progressed.

Koval et al[8] performed gait analysis testing on 60 elderly patients (average age, 77 years) with femoral neck and intertrochanteric femur fractures that were managed with either internal fixation or hemiarthroplasty. Elderly patients often have difficulty complying with restricted weight bearing, so to facilitate early mobilization, patients were allowed to bear weight as tolerated. Over time, patients voluntarily increased the weight applied to the injured limb, from 51% at 1 week to 87% at 12 weeks compared with that of the uninjured contralateral limb. The authors identified no loss of fixation or other complications associated with immediate weight bearing. However, elderly patients are expected to place lesser physical demands on fixation constructs, and the implications for similar fractures in younger patients remain uncertain.

One study demonstrated that 10 of 12 patients who were permitted to bear weight as tolerated after external fixation of diaphyseal tibia fractures progressively increased the weight applied across their injured leg, reaching 85% of the weight placed across the uninjured leg by 6 weeks postoperatively and approaching 90% at the time of external fixator removal (mean, 15.9 weeks [range, 11 to 23 weeks]).[9] In the two patients who progressed to delayed union, weight bearing in the injured leg remained approximately 40% that of the contralateral limb at 20-week follow-up, and both patients ultimately required further surgical intervention to achieve healing. The authors of that study suggested that inability to advance weight bearing as expected may be an early sign of nonunion or delayed union.

Restricted Weight Bearing and Patient Compliance

Restricted weight bearing comes at a high physiologic cost. In healthy subjects, non–weight bearing or touch-down weight-bearing restrictions result in a fourfold increase in the energy expended for ambulation compared with full weight bearing.[10] Patients who are restricted to touch-down weight bearing perceive their ambulation to be less tiring than that of persons who are restricted to non–weight bearing.

Available data suggest that patient compliance with physician restrictions on weight bearing is poor.[11-13] Hurkmans et al[11] collected underfoot load data 7 and 21 days postoperatively in 50 patients who had undergone total hip arthroplasty with trochanteric osteotomy. The patients routinely exceeded the prescribed amount of partial weight bearing, even when closely observed in a laboratory setting. Investigations of compliance in other populations found similar results, with subjects uniformly exceeding the prescribed amount of weight bearing even when they believed themselves to have been compliant.[12,13]

In an effort to improve compliance, investigators have evaluated the use of devices that provide real-time feedback on weight bearing.[12-15] In a trial performed in 1975, auditory feedback was found to be ineffective in preventing overloading of the limb due to a lag between auditory perception and motor response.[13] In a more recent study, patients who were trained to partially bear weight with audio feedback during their hospital stay were unable to replicate the prescription when walking unsupervised in the hospital or at home 21 days postoperatively.[14] Winstein et al[15] demonstrated that although device-based real-time audio feedback for weight-bearing training was more accurate and consistent at the time of training, delayed verbal feedback by a physical therapist was more beneficial in achieving compliance with partial weight bearing 2 days after training.

Clinical Results

There are few well-designed published studies comparing early and delayed weight bearing after fixation of lower extremity fractures. In the absence of high-quality comparative studies, we provide the recommended weight-bearing protocols of authors with extensive experience treating a particular fracture type. In most of the studies cited in this article, patients with neuropathy, psychiatric disease, or other barriers to weight-bearing compliance were excluded from early weight-bearing protocols. Instances in which these patients are included are highlighted.

Calcaneus Fractures

External Ring Fixation

Acceptable results were noted in two small series of intra-articular calcaneus fractures managed with open reduction and ring external fixation followed by immediate weight bearing as tolerated. Paley and Fischgrund[16] treated seven patients with ring fixators for a mean of 10 weeks; in all cases, the frame was dynamized 2 weeks before removal. Reduction was maintained in six patients, and all patients ambulated with a cane or crutches for the duration of treatment. No patient had heel pain at 2-year follow-up, which the authors attributed to desensitization from early weight bearing. Talarico et al[17] described 23 patients with 25 fractures (17 Sanders type II, 6 type III, and 2 type IV fractures) treated similarly. At a minimum follow-up of 2 years, there was no loss of reduction, and 92% good or excellent results were reported as measured using the Maryland Foot Score.

Calcaneal Plate Fixation

A retrospective comparison of patients with intra-articular calcaneal fractures treated with open reduction and locking plate fixation showed no difference in pain or American Orthopaedic Foot and Ankle Society scores between the 58 patients restricted to 10-kg (22-lb) weight bearing for 12 weeks and the 78 patients who were restricted to 10 kg for 6 weeks and then increased to 20 kg after 6 weeks and to 40 kg after 8 weeks, with full weight bearing allowed after 10 weeks.[18] Hyer et al[19] reported on 17 calcaneus fractures managed with open reduction and locking plate fixation. Progressive weight bearing in a walking boot was allowed beginning at an average of 4.8 weeks postoperatively. The average Böhler angle was 30.1° at the first postoperative visit and 28.5° at final follow-up. No patients demonstrated significant loss of calcaneal height, loss of reduction, or implant failure.

In a trial of 424 patients with displaced intra-articular calcaneal fractures, Buckley et al[20] recommended 6 weeks of non–weight bearing followed by physical therapy and progressive weight bearing as tolerated for both surgically and nonsurgically managed fractures.

Ankle Fracture

A Cochrane meta-analysis of early versus late weight bearing after ankle fractures showed no difference between groups in range of motion (ROM), functional scores, or radiographic outcomes 1 year after injury.[21] This analysis was based on three studies that directly compared early and late weight bearing after ankle fractures without other confounding variables; all three studies were published before 1990.[22-24]

Finsen et al[24] reported on 56 patients with ankle fractures (24 lateral malleolar, 10 bimalleolar, 22 trimalleolar) that were managed with plate fixation of the fibula and tension-band wiring or screw fixation of the medial malleolus. The syndesmosis was stressed intraoperatively under fluoroscopy, and 22 patients who were found to have disruption were treated with a single transsyndesmotic screw. Postoperatively, patients were randomized to one of three groups: early ROM and weight bearing at 6 weeks with no immobilization; late ROM and immediate weight bearing as tolerated in a plaster of paris cast; or late ROM and weight bearing at 6 weeks in a cast. At follow-up of 9, 18, 36, 52, and 104 weeks, there were no consistent differences in the functional outcomes between the three groups on an author-derived scoring system that incorporated pain and patient-perceived function. Radiographic widening of the ankle mortise was noted in three patients from each group.

van Laarhoven et al[25] reported on 81 patients with ankle fractures (33 lateral malleolar, 48 bi- or trimalleolar) treated with surgical fixation utilizing one-third tubular plating of the fibula with syndesmotic, medial malleolar, and posterior malleolar fixation as indicated. Patients were randomized to either weight bearing at 2 to 5 days in a plaster cast or non–weight bearing for 4 weeks without a cast. Follow-up measurements were taken at 10 days to 2 weeks, 6 weeks, 12 weeks, and 1 year postoperatively. In the immediate weight-bearing group, the authors found sig-

Table 1

Evaluation of Early Versus Late Weight Bearing After Ankle Fractures

Study	Study Type	Treatment Group (No. of Pts)	Control Group (No. of Pts)	Outcomes Measured	Results	Fracture Pattern
Ahl et al[23]	Prospective RCT	ORIF and immediate WB in plaster cast (24)	ORIF and WB in plaster cast at 4 wk (22)	Swelling, ROM, and self-assessment at 12 and 24 wk. XR at 3, 7, and ≥12 wk.	No difference. No loss of reduction in either group.	Isolated fibular
Ahl et al[22]	Prospective RCT	ORIF and immediate WB in plaster cast (25)	ORIF and WB in plaster cast at 4 wk (28)	Swelling, ROM, and self-assessment at 12 and 24 wk. XR at 3, 7, and ≥12 wk.	No difference. No loss of reduction in either group.	Bimalleolar and trimalleolar
Finsen et al[24]	Prospective RCT	ORIF and immediate WB in plaster cast (19)	ORIF and WB in a plaster cast at 6 wk (19)	Functional score, ROM, and swelling at 9, 18, 36, 52, and 104 wk. XR at 6 and 36 wk. Other outcomes: LoS and RTW.	No difference. Mortise widening was noted in 3 pts in each group.	All
Gul et al[26]	Retrospective cohort	ORIF and immediate WB without an orthosis (25)	ORIF and NWB in a plaster cast for 6 wk (25)	Pain, functional scores, and XR at 2, 6, 12, and 52 wk. Other outcomes: RTW and LoS.	Treatment group: faster RTW (~37 d earlier), loss of reduction in 1 patient at 1 wk	Isolated fibular and bimalleolar
van Laarhoven et al[25]	Prospective RCT	ORIF and WB in a plaster cast at 2–5 d (41)	ORIF and NWB for 6 wk; plaster cast for first 2–5 d, then early ROM (40)	Pain, QoL, functional scores, and XR at ~2, 6, 12, and 52 wk. Other measure: RTW.	Improved QoL and functional scores at 10 d and 6 wk in the treatment group	All

LoS = length of stay, NWB = non–weight bearing, ORIF = open reduction and internal fixation, QoL = quality of life, RCT = randomized controlled trial, ROM = range of motion, RTW = return to work, WB = weight bearing, XR = X-ray

nificantly higher scores on the linear analogue scale at 10 days and 6 weeks as well as in the Olerud and Molander score at 6 weeks. No difference was found at 3 months and 1 year.

Taken together, multiple comparative studies using both historical and modern implants and fixation techniques have shown minimal difference in functional and radiographic outcomes of surgically managed ankle fractures, regardless whether patients were allowed to bear weight immediately or were restricted to non–weight bearing for 4 to 6 weeks. A single study reported faster return to work in patients who were allowed to bear weight immediately,[26] but this was not a consistent finding (Table 1).

Tibial Plafond Fracture

There is limited literature on early weight bearing after tibial plafond fracture. In one series of eight patients (four acute fractures, two subacute, two chronic) treated with the Ilizarov technique and allowed to immediately bear weight, bony union was achieved in all patients.[27] One patient malunited in 10° of varus. A nonrandomized series compared 28 patients with AO/OTA type C plafond fractures treated with locking plate fixation followed by non–weight bearing until fracture healing was demonstrated clinically and radiographically (range, 8 to 12 weeks) with 14 patients treated with the Ilizarov technique who were allowed to bear weight immediately.[28] The investigators found nonsignificant trends toward a faster time to union with higher associated rates of nonunion, malunion, and soft-tissue infection in the Ilizarov group. Mean time to union was 24 weeks in the

Figure 1

Preoperative (**A**) and 12-week postoperative (**B**) AP radiographs of a pilon fracture in an elite athlete who was treated with delayed open reduction and internal fixation. Against recommendations, the patient returned to sport within 1 month of surgery. The patient maintained adequate fracture reduction and went on to heal uneventfully.

Ilizarov group and 39 weeks in the plate fixation group. The current literature is not adequate to enable confident comparison of early versus late weight bearing after tibial plafond fractures. However, most surgeons restrict weight bearing for at least 8 to 12 weeks after ORIF (Figure 1).

Tibial Shaft Fracture

Closed Treatment With Cast or Orthosis

Early weight bearing following management of tibial shaft fractures with fracture orthoses or patellar tendon bearing casts is well described. In a representative series published in 1979, weight bearing at zero to 6 weeks (mean, 22 days) after closed management of tibial shaft fractures was associated with a faster time to union and no increase in complications compared with delayed weight bearing of ≥6 weeks (mean, 211 days).[29]

External Fixation

Historically, good results have been reported with immediate weight bearing after external fixation of tibial shaft fractures.[9,30] Because of the widespread adoption of intramedullary (IM) nailing as the treatment of choice for diaphyseal tibia fractures, we could not identify any recent reports of weight-bearing recommendations for tibia fractures managed definitively with external fixation.

Bridge Plating

Adam et al[31] reported on 25 tibial shaft fractures that were managed with minimally invasive locked bridge plating; immediate weight bearing was allowed as tolerated. The authors provided little detail on fracture pattern or comminution, but plating was selected in most cases because the fracture was thought to be either too proximal or too distal to adequately control with IM nailing. Radiographic union was achieved at an average of 9.1 weeks. They reported one nonunion, one implant failure, one infection, and six cases of valgus malalignment >5°. These six cases of malalignment were attributed to inadequate initial reduction. No loss of reduction or progression of initial malalignment was seen in any patient compared with radiographs obtained immediately postoperatively.

Intramedullary Nailing

The largest pool of comparative data on weight bearing after tibial shaft fracture comes from the Study to Prospectively Evaluate Reamed Intramedullary Nails in Patients with Tibial Fractures (SPRINT) trial, in which 1,226 tibial shaft fractures at 29 trauma centers were prospectively randomized to reamed or unreamed IM nailing.[32] Post hoc analysis found that immediate full weight bearing conferred an increased risk for a postoperative adverse event (odds ratio, 1.63; 95% confidence interval, 1.00 to 2.64 [$P = 0.048$]). Among the defined adverse events were intentional surgical dynamization caused by locking screw removal and autodynamization caused by locking screw breakage. When dynamization was excluded from the analysis, immediate weight bearing was no longer a significant predictor of other adverse events, including malunion, nonunion, and wound complications.

The strength of this conclusion is tempered by the fact that this aspect of the study was nonrandomized, with the weight-bearing prescription determined by the treating surgeon. More than 90% of patients were restricted to partial or non–weight bearing postoperatively, so the immediate weight-bearing comparison group was much smaller. Furthermore, it seems likely that the immediate weight-bearing group might contain a disproportionate number of patients with transverse, noncomminuted, or otherwise favorable fracture patterns that would make the treating surgeon more comfortable with permitting immediate fracture loading. Despite some encouraging findings with regard to immediate weight bearing of diaphyseal tibia fractures, the fact remains that >90% of surgeons in the SPRINT trial restricted weight bearing in the immediate postoperative period, which indicates that this was the preferred method of treatment of most surgeons.[32]

Tibial Plateau Fracture

Most surgeons recommend ≥6 to 8 weeks of restricted weight bearing postoperatively to prevent fracture displacement in patients with tibial plateau fracture. However, several studies suggest that for partial articular fractures managed with buttress plating, early weight bearing may not carry the risk of fracture displacement that is traditionally presumed.

Nonlocked Buttress Plating

Segal et al[33] reported on a consecutive series of 86 lateral tibial plateau fractures (ie, Schatzker types I, II, and III) that were managed surgically or nonsurgically based on a fracture displacement cutoff of 5 mm. Surgical treatment consisted of buttress plating of the proximal lateral tibia with repair of any associated meniscal or ligamentous injury, followed by fracture bracing. Nonsurgical management consisted of 7 to 10 days in a compressive dressing, followed by application of a fracture brace. Both groups were permitted to bear weight as tolerated once the brace was applied. The authors reported 86% satisfactory outcomes (ie, occasional mild pain, knee ROM ≥10° to 90°, and return to previous activity level without the use of walking aids) in the surgical group and 76% satisfactory outcomes in the nonsurgical group. No patient in either group had radiographic fracture displacement >2 mm.

Locked Buttress Plating

In a more recent study, 32 patients with partial articular proximal tibia fractures (AO type 41B) were treated surgically with locking plate fixation.[34] Twelve patients were allowed to bear weight immediately, and the other 20 were kept non–weight bearing until 6 to 8 weeks postoperatively and then allowed progressive weight bearing as tolerated. The study was not randomized, but the reported demographic and fracture characteristics were similar between groups. The authors did not assess functional outcomes. No implant failure or radiographic fracture displacement was seen in either group at 6 to 8 weeks.

Solomon et al[35] reported similar findings in seven patients with Schatzker type II tibial plateau fractures managed with subchondral screws and locking plate fixation. Patients were permitted partial weight bearing (20 kg [44 lb]) for the first 6 weeks postoperatively and then were instructed to progress to full weight bearing as tolerated. At the time of surgery, tantalum beads were implanted into the largest depressed fragment and the adjacent intact metaphysis. Radiostereometric analysis was performed at 2, 6, 12, 18, 26, and 52 weeks. Non–weight bearing images of the affected knee were compared with images obtained with the knee under load. Displacement of the fracture fragments under loaded and unloaded conditions was measured, and negative inducible displacements indicated displacement in a caudad direction. The mean inducible fragment displacement was −0.30 mm at 2 weeks (range, −0.73 to 0.02 mm) and 0.00 mm at 1 year (range, −0.12 to 0.15 mm). At final follow-up of 52 weeks, the fracture fragment had displaced by a mean of −0.34 mm (range, −1.64 to 1.51 mm) in the craniocaudal direction and 0.11 mm (range, −2.03 to 1.35 mm) in the mediolateral direction on weight-bearing radiographs. On subjective radiographic analysis by the authors without the use of stereoisometry, no depression was seen on any radiograph, and plateau widening averaging 0.86 mm (range, −2 to 3 mm) was noted.

Femoral Shaft Fractures

Nonlocked Plating

We found no studies in which immediate weight bearing was allowed after plating of femoral shaft fractures. Zlowodzki et al[36] reported on 40 femoral shaft fractures in 37 patients treated with open or submuscular plating. Patients were restricted to toe-touch weight bearing immediately postoperatively and were advanced at the discretion of the treating surgeon based on symptoms and radiographic findings. The average time to full weight bearing was 15.5 weeks. One patient required revision surgery for a nonunited fracture and a broken plate.

Intramedullary Nailing

Good results were reported in two studies of immediate weight bearing following statically locked IM nail fixation to manage comminuted diaphyseal femoral fractures.

Brumback et al[37] described 28 patients with comminuted diaphyseal femur fractures (ie, Winquist types

III and IV) treated with reamed IM nailing utilizing a statically locked 12-mm nail, one oblique 6.4-mm proximal locking screw, and two 6.4-mm distal locking screws. Patients were allowed to bear weight as tolerated postoperatively. Twenty-six patients progressed to full weight bearing by 6 weeks (93%). All fractures united, with one patient requiring surgical dynamization of the nail at 5 months to promote union.

Similarly, Arazi et al[38] treated 30 patients with comminuted diaphyseal femur fractures (ie, Winquist types II, III, and IV) with IM nailing consisting of a statically locked 12- to 14-mm nail, one oblique 6.4-mm proximal locking screw, and two 6.4-mm distal locking screws. Six patients were lost to follow-up. All patients were allowed to immediately bear weight as tolerated; however, no patient began weight bearing on the injured extremity prior to 1 week. Twenty-three patients were fully weight bearing without an assistive device by the second month postoperatively (96%). All fractures healed without complication. No construct failures were reported.

Weight-bearing recommendations for fractures of the calcaneus, ankle, tibia, and femoral shaft are summarized in Table 2. Weight-bearing recommendations for fractures of the hip, acetabulum, and pelvis are listed in Table 3.

Hip Fracture

As early as 1961, Garden[47] advocated immediate weight bearing after surgical fixation of femoral neck fractures in elderly patients. His recommendation has gained considerable support in the literature and is widely accepted as the standard of care.

Sliding Nail-plate

In 1968, Graham[39] reported on 273 patients aged 56 through 95 years with displaced femoral neck fractures (Garden types III or IV) who were treated surgically with a sliding nail-plate. Patients were randomized to either early weight bearing at 2 weeks or late weight bearing at 12 weeks postoperatively. Infection and mortality rates were similar between groups at 1- and 3-year follow-up, with a trend toward lower rates of segmental collapse in the early weight-bearing group at both follow-up times; however, the authors attributed this to a higher incidence of poor reductions and more proximal fractures in this group.

Sliding Hip Screw

In 1996, Koval et al[40] reported the outcomes of a large cohort of elderly patients (average age, 79.8 years) who were treated surgically for femoral neck or intertrochanteric femur fractures, allowed to bear weight immediately, and followed for ≥1 year. Two hundred eight patients had stable or unstable intertrochanteric femur fractures, all of which were managed with sliding hip screws. The rate of revision for loss of fixation was 2.9%, in all cases because of femoral head lag screw cutout.

Cancellous Screws or Knowles Pins

Koval et al[40] also evaluated 69 patients with nondisplaced femoral neck fractures (ie, Garden types I and II) and 26 patients with displaced fractures (ie, Garden types III and IV) who were treated with either cancellous screws (56 patients) or Knowles pins (39 patients). The revision rate for loss of fixation or nonunion was 4.3% for nondisplaced and 7.7% for displaced femoral neck fractures. Two patients in each group developed osteonecrosis (nondisplaced, 2.9%; displaced, 7.7%). In a study by Conn and Parker,[41] 375 patients with nondisplaced femoral neck fracture underwent internal fixation with three parallel 6.5-mm cannulated screws and were allowed to bear weight as tolerated without restriction. Nonunion was detected in 24 patients (6.4%), and avascular necrosis occurred in 15 patients (4%). Five additional patients (1.3%) experienced penetration of the screws into the acetabulum. No studies permitting immediate or early weight bearing in "young" patients with femoral neck fractures were identified.

Cephalomedullary Nailing

Herrera et al[42] described their experience with 551 intertrochanteric femur fractures in elderly patients (average age, 82.8 years) who were treated with a short cephalomedullary nail and allowed to bear weight immediately after the procedure. In this group, 40.4% and 65.2% of patients were ambulating with an assistive device at 1 week and 3 weeks after surgery, respectively. The authors reported a 1.4% rate of screw cutout and a 4% rate of collapse into secondary varus >10° at final follow-up.

Although surgeons must make the decision on a case-by-case basis, in general the literature supports immediate weight bearing after internal fixation of appropriately selected intracapsular and extracapsular hip fractures in elderly patients. Immediate weight bearing has demonstrated benefits in patient balance and mobility, which may decrease morbidity and promote greater independence. In situations in which there is concern regarding the strength of a potential fixation construct and the patient cannot comply with restrictions on weight bearing, both hemiarthroplasty and total hip arthroplasty can reliably allow immediate weight bearing. We found no authors who recommended early weight bearing after fixation of displaced hip fractures in young patients.

Table 2

Weight-bearing Recommendations by Fracture Type and Fixation Construct: Calcaneus, Ankle, Tibia, and Femoral Shaft

Fracture Type	Fixation Construct	Recommendation	LOE	Comments
Calcaneus	External ring[16,17]	Immediate WBAT	IV	Small studies: 7 fractures,[16] 25 fractures[17]
	Plate[18-20]	4–6 wk NWB, then progressive WB	I,[20] IV[18,19]	Large study: 424 fractures[20]
Ankle (malleolar)	Pins/staples/cerclage[22,23]	Immediate WBAT[a]	II	No difference between immediate WBAT and NWB for 4 wk followed by WBAT[22,23]
	Plate and screws[24-26]	Immediate WBAT[a]	II,[24,25] IV[26]	Faster RTW in immediate WB.[26] Improved QoL and functional scores at 10 d and 6 wk in the treatment group.[25] No long-term differences.[24-26]
Ankle (plafond)	External ring[27,28]	Immediate WBAT	III,[28] IV[27]	Faster time to union, but greater rate of complications with Ilizarov and WBAT compared with plate fixation and NWB[28]
	Plate and screws[28]	8–12 wk NWB, then progressive WB	III	Faster time to union, but greater rate of complications with Ilizarov and WBAT compared with plate fixation and NWB[28]
Tibial shaft	Cast/orthosis[29]	4 wk NWB, then progressive WB[b]	II	—
	External[9,30]	Immediate WBAT	IV	—
	Plate and screws[31]	Immediate WBAT in simple patterns. 6–8 wk TDWB in comminuted patterns.	IV	This study supports WBAT. Little detail is provided on fracture pattern.
	Intramedullary nail[32]	Immediate WBAT in simple patterns. 6–8 wk TDWB in comminuted patterns.	II	WB recommendations were not randomized. >90% of surgeons restricted WB initially.
Tibial plateau	Nonlocked buttress plate[33]	WBAT in Schatzker I–III;[c] 6–12 wk PWB then progressive WB in Schatzker IV–VI.	IV	WBAT is described with good results only in lateral unicondylar fractures (Schatzker I–III)
	Locked buttress plate[34,35]	WBAT in Schatzker I–IV;[c] 6–12 wk PWB then progressive WB in Schatzker V and VI.	III,[34] IV[35]	Level III study describing good results with WBAT in AO type 41B fracture.[34] Level IV study describing PWB of 20 kg (44 lb) for 6 wk in Schatzker type II fracture.[35]
Femoral shaft	Nonlocked plate[36]	6–8 wk TDWB, then progressive WB	III	—
	Intramedullary nail[37,38]	Immediate WBAT	IV	Two level IV studies with immediate WBAT and good results for Winquist type III and IV fractures[37,38]

LOE = level of evidence, NWB = non–weight bearing, PWB = partial weight bearing, QoL = quality of life, RTW = return to work, TDWB = touch-down weight bearing (weight of leg), WB = weight bearing, WBAT = weight bearing as tolerated

[a] Studies included patients with syndesmotic injuries; however, surgeons should be cautious about permitting immediate weight bearing in patients with syndesmotic injury.

[b] When placed in a patellar tendon bearing cast or Sarmiento style fracture brace

[c] Surgeons should be cautious about permitting immediate weight bearing in patients with tibial plateau fractures and should do so only in patients unable to tolerate protected weight bearing.

Table 3

Weight-bearing Recommendations by Fracture Type and Fixation Construct: Hip, Acetabulum, and Pelvis

Fracture Type	Fixation Construct	Recommendation	LOE	Comments
Hip (extracapsular)	Sliding hip screw[40]	WBAT in elderly patients. TDWB for 6–12 wk for patients aged <65 y.	IV	208 fractures. Avg patient age, 79.8 y.
	Cephalomedullary nail[42]	WBAT in elderly patients. TDWB for 6–12 wk for patients aged <65 y.	IV	551 fractures. Avg patient age, 82.8 y.
Hip (intracapsular)	Cancellous screws/Knowles pins[40,41]	WBAT in elderly patients. TDWB for 6–12 wk for patients aged <65 y.	IV	—
	Sliding nail-plate[39]	WBAT in elderly patients. TDWB for 6–12 wk for patients aged <65 y.	I	—
Acetabulum	Percutaneous screw fixation[43,44]	WBAT in elderly patients with simple, minimally displaced fracture patterns in those unable to comply. TDWB for 6–12 wk for compliant patients aged <65 y.	IV	Good results with immediate WBAT after percutaneous fixation in elderly patients[43] and in those who are unable to comply[44]
	ORIF	6–12 wk TDWB, then progressive WB	Expert opinion	—
Pelvic ring	Sacroiliac screws	WBAT in vertically stable fractures. 6–10 wk TDWB, then progressive WB in vertically unstable fractures.[a]	Expert opinion	—
	External/internal fixator for anterior ring injury	6–10 wk TDWB, then progressive WB	Expert opinion	—
	Symphyseal plating[46]	WBAT in vertically stable fractures. 6–10 wk TDWB, then progressive WB in vertically unstable fractures.[a]	IV	Describes WBAT in vertically stable fractures
	Triangular osteosynthesis[45]	Immediate WBAT	IV	—

LOE = level of evidence, ORIF = open reduction and internal fixation, TDWB = touch-down weight bearing (weight of leg), WB = weight bearing, WBAT = weight bearing as tolerated

[a] Surgeons should be cautious about permitting immediate weight bearing in patients with vertically stable fractures and should only do so in patients unable to tolerate protected weight bearing.

Acetabular and Pelvic Fractures

The literature on early weight bearing after acetabular and pelvic fractures is limited. Most surgeons would recommend touch-down weight bearing for 6 to 12 weeks postoperatively, and few authors have reported weight bearing any earlier than that following surgical management of these fractures.

Percutaneous Screw Fixation of Acetabular Fracture

In 21 elderly patients (average age, 81 years), Mouhsine et al[43] permitted weight bearing as tolerated at 4 weeks after percutaneous fixation of nondisplaced or minimally displaced (<2 mm) transverse, T-type, or associated both-columns acetabular fractures. All patients in the study were able to walk prior to injury, but none was able to comply with restricted weight bearing. Eight patients presented with compromised baseline mental status, four patients had a persisting trauma-related confusional state, six patients suffered from a balance disorder, and three patients had Parkinson disease. Two patients died within 4 months of surgery, and one patient was lost to follow-up. Eighteen patients were evaluated at a mean follow-up of 3.5 years (range, 2 to 5 years). There were no fixation failures, and 17 (94%) of 18 surviving patients had satisfactory clinical results according to the modified Merle-d'Aubigné score. The authors cautioned against applying their protocol in the setting of widely displaced fractures or compliant patients.

In a group of 28 patients that included younger patients (mean age, 49 years [range, 18 to 83 years]), Kazemi and Archdeacon[44] managed anterior-column and anterior-column posterior-hemitransverse acetabular fractures with percutaneous screw fixation and immediate full weight bearing. Six fractures were nondisplaced or minimally displaced, and 22 were displaced >2 mm but were felt to be amenable to closed reduction. Six patients were lost to follow-up, and the remaining 22 were followed for a mean of 39 months (range, 12 to 74 months). Radiographic union was achieved in all cases, with outcomes graded as excellent in 19 patients, good in 2, and fair in 1. The mean modified Merle-d'Aubigné score was 17.4 (range, 11 to 18).

Triangular Osteosynthesis for Vertically Unstable Sacral Fractures

Schildhauer et al[45] described a series of 34 patients with vertically unstable sacral fractures that were managed with triangular osteosynthesis, which consisted of iliosacral screws and bilateral vertebropelvic stabilization with a pedicle screw–iliac bolt construct. Twenty-eight patients were polytraumatized. Average patient age was 35 years. One patient died during postoperative care, 12 were unable to begin early weight bearing because of associated lower extremity trauma, 1 was not permitted to bear weight due to the severity of the fracture, and 1 developed an early infection requiring hardware removal prior to bearing weight. Of the 19 patients who were able to immediately bear weight, 17 (89%) were able to progressively bear weight, achieving full weight bearing after an average of 23 days (range, 8 to 70 days). Three patients required reoperation because of implant failure or loss of reduction, two of which were then made non–weight bearing. The remaining 16 fractures healed without incident.

Symphyseal Plating for Pelvic Ring Injuries

There are several case series describing immediate weight bearing after pelvic ring injury; however, to our knowledge, no study has directly compared weight bearing with non–weight bearing in patients with surgically treated pelvic ring fractures. In one of the largest published series, Tornetta et al[46] reported on 29 patients with rotationally unstable pelvic injuries that were managed with symphyseal plating followed by immediate weight bearing. Patients were followed for an average of 39 months postoperatively. At final follow-up, one patient had a limp with ambulation (3.4%), four (13.8%) showed radiographic failure of the symphyseal plate, and three (10.3%) had widening of the pubic symphysis compared with the immediate postoperative films. No patient required reoperation, and outcomes for patients with and without radiographic changes did not differ significantly.

Summary and Future Directions

High-quality clinical data comparing immediate with delayed weight bearing after lower extremity fractures is not universally available. However, for certain fracture patterns, there are well-designed studies suggesting that patients with normal protective sensation can safely bear weight sooner after surgical fixation than traditional protocols permit. In particular, several randomized controlled trials of surgically managed ankle fractures have shown no difference in clinical and radiographic outcomes between patients who are allowed to bear weight immediately and those whose weight bearing is limited for the first 6 weeks postoperatively. Retrospective series have also reported low complication rates with immediate weight bearing following IM nailing of comminuted femoral shaft fractures in younger patients, and in elderly persons treated with surgical fixation of femoral neck and intertrochanteric femur fractures.

The data in favor of early weight bearing after other lower extremity fractures, particularly periarticular fractures, are less compelling. Most surgeons recommend a period of protected weight bearing for calcaneal, tibial plafond, tibial plateau, and acetabular fractures, and they similarly protect younger patients with hip fractures.

Further investigations focused on patient compliance with weight-bearing prescriptions and higher-quality prospective, randomized studies comparing weight-bearing protocols after fracture fixation would enable surgeons to more confidently make recommendations to their patients about optimal weight bearing following fracture.

References

Evidence-based Medicine: Levels of evidence are described in the table of contents. In this article, references 20, 21, and 39 are level I studies. References 10-15, 22-25, 29, and 32 are level II studies. References 28 and 36 are level III studies. References 8, 9, 16-19, 26, 27, 30, 31, 33-35, 37, 38, and 40-47 are level IV studies. References 3-5 are level V expert opinion.

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