Bracing Versus Casting in Ankle Fractures

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Abstract: Casting and splinting techniques for treating patients with fractures have been used for centuries. Functional bracing after ankle fracture has recently been utilized in an effort to avoid the atrophy and stiffness sometimes associated with casting; functional bracing allows for early mobilization of the ankle joint during recovery. Our review investigated the published literature comparing bracing with casting after ankle fracture. Studies examining both operatively and nonoperatively treated ankle fractures were included. There is minimal evidence supporting the use of functional bracing over cast immobilization to improve functional outcome, range of motion, swelling, or post-traumatic arthrosis after ankle fracture in the long term. The primary benefits of functional bracing are the potential to return to work earlier and bracing may facilitate activities of daily living, such as bathing and dressing. In addition, there may be a decreased patient risk of developing deep vein thrombosis due to immobilization. However, there is an increased risk of wound infection when using a brace after open reduction and internal fixation of an unstable ankle fracture. Functional bracing can be used for treating stable and postoperative ankle fractures in compliant patients to potentially expedite and facilitate the recovery process.

Keywords: brace; cast; ankle fracture; unstable ankle fracture; stable ankle fracture

Introduction

The earliest accounts of treating bone fractures with splinting date back to ancient Egypt. Two wooden splints were laid alongside limb fractures and wrapped in stiff linen bandages to prevent further dislocation and allow healing.[1] In later writings, Hippocrates discussed the management of fractures by applying wooden splints and prescribing early motion exercises to prevent atrophy in affected muscle groups.[1] Plaster of Paris casts were not widely utilized until the mid-19th century when physicians sought better ways to treat maimed persons, particularly soldiers, wounded in war. Limitations of early plaster casts were well recognized, prompting invention of the modern fiberglass and polyurethane casts in the 1970s.

Ankle fractures are one of the most common orthopedic injuries in the general population, with an incidence rate of 100 fractures per 10 000 person-years.[2] Ankle fractures represent a substantial number of emergency room visits yearly, a large burden on both hospitals and patients. Incidence of ankle fracture has been increasing during the last 50 years, especially among patients aged $>$ 75 years, as the prevalence of osteoporosis rises with greater longevity.[3,4] Therefore, it is imperative that efforts be made to improve both short-term and long-term outcomes in patients to help alleviate the associated consequences of casting; such possibilities include decreased range of motion (ROM), pain, post-traumatic arthritis, decreased strength and function, nonunion, malunion, time lost from work and activity, and financial cost to patients and health care systems. Our purpose in this article was to evaluate the current literature

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regarding treatment of both operative and nonoperative ankle fractures with a functional brace compared with cast immobilization.

Fracture Classification

Ankle fractures differ based on the anatomic location of the fracture(s), presence of instability, and associated soft-tissue injuries. The AO-Danis-Weber[5] and Lauge-Hansen[6] ankle fracture classification systems are frequently employed, either separately or in conjunction, in order to standardize ankle fractures into identifiable categories based on radiographic parameters to guide patient treatment. The AO-Danis-Weber classification system segregates ankle fractures into 3 categories (Type A, B, and C) based on the level of the fibular fracture extension in relation to the tibiotalar joint. Type A, B, and C signify a fracture distal to the level of the ankle joint, at the level of the ankle joint, and proximal to the level of the ankle joint, respectively. Each category can be further expanded into subcategories to incorporate associated injuries to surrounding structures. The Lauge-Hansen system classifies ankle fractures into 4 categories (pronation-external rotation [PER], supination-external rotation [SER], pronation-abduction [PA], and supination-adduction [SA]) based on the anatomic position of the ankle and the mechanism of trauma during fracture. Each category denotes a sequence of injuries to the various soft tissues and ligaments that confer stability to the ankle joint. The most common category of all ankle fractures is the SER II fracture, comprising 33% of all ankle fractures (Figure 1).[7,8]

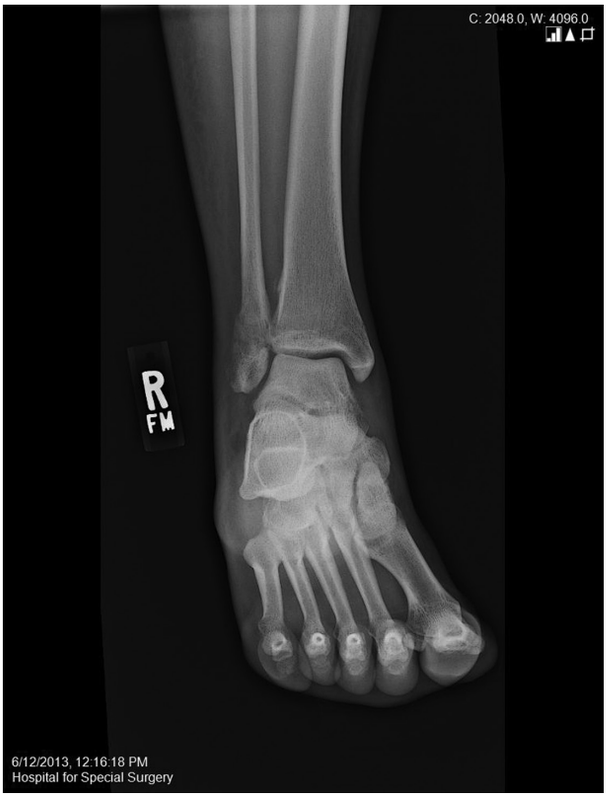
Stable Versus Unstable

Determining the stability of an ankle fracture by placing it into a category based on plain radiographs can help determine which ankle fractures will need surgical intervention. Stable fractures are fractures of the fibula in which there is not a complete disruption of the tibiofibular syndesmosis and medial deltoid ligament leading to anatomic tibiotalar malalignment (Figure 1). Healing of stable fractures can be accomplished nonoperatively with excellent success.[3,9,10] Unstable fractures are defined by a disruption of the tibiofibular syndesmosis and medial deltoid ligament, which leads to displacement of the talus by > 2 mm (Figure 2).[11] Fractures under this definition require open reduction and internal fixation (ORIF) to restore anatomic alignment and minimize the risk of post-traumatic arthritis (Figure 3).

Functional Brace and Cast Definition

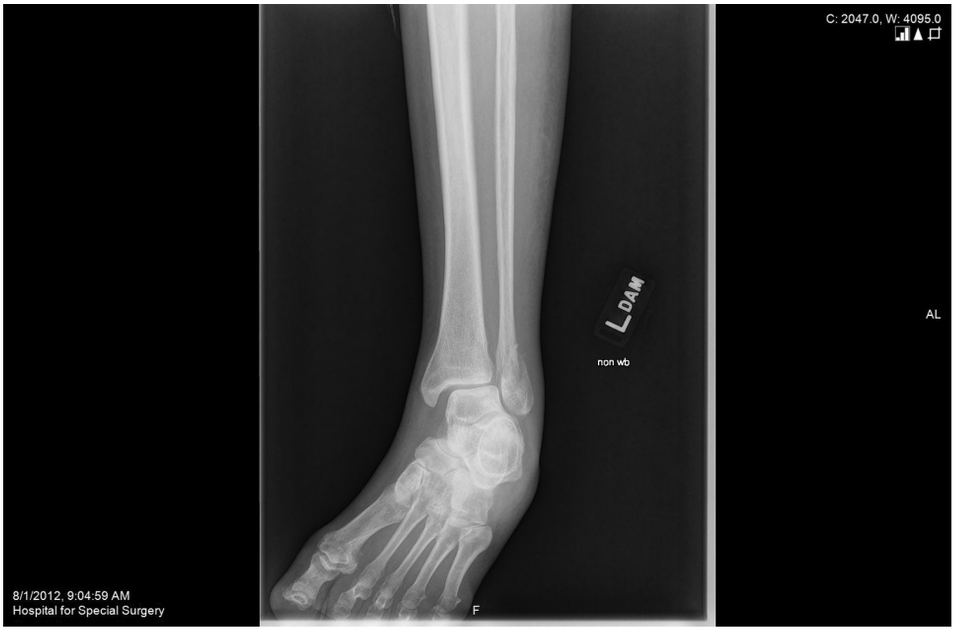
The fractured ankle must be supported after immediate treatment to maintain reduction while healing. Support has traditionally entailed ≥ 6 weeks of immobilization in a below-the-knee plaster or fiberglass cast. However, research on the effects of prolonged lower-limb immobilization has revealed several negative effects of "cast disease," including 17% to 24% calf-muscle atrophy after 6 weeks immobilization, and a 50% decrease in plantarflexion torque and strength after 7 to 8 weeks.[12–14] Studies analyzing outcomes after cast immobilization of ankle fractures found that prolonged periods of immobilization are associated with a significant degree of patient osteopenia and osteoporosis—showing a 5.8% to 31.7% decrease in bone mineral density (BMD) and a 5.2% to 19.4% decrease in bone mineral content immediately after cast removal at 6 weeks[15]; a 15% to 18% decrease in BMD at 6 months[16]; a 3.5% to 9% decreased BMD in the affected limb 2 years after the injury[17]; an 11% decrease in BMD at 3 years[16]; and a 4.7% loss of BMD at 5 years.[18] Functional braces provide ample support of the fractured ankle by limiting rotational forces exerted on the ankle while allowing dorsi- and plantarflexion, which encourages early motion but prevents unwanted displacement of the fracture. Functional braces include the pneumatic Aircast, a stabilizing high-top shoe that only allows flexion and extension at the tibiotalar

Figure 1. Stable SER II ankle fracture without a disruption of the syndesmotic ligaments.



Abbreviation: SER, supination-external rotation.

Figure 2. Unstable SER IV ankle fracture with widening of the tibiotalar joint secondary to disruption of the syndesmotic ligaments.



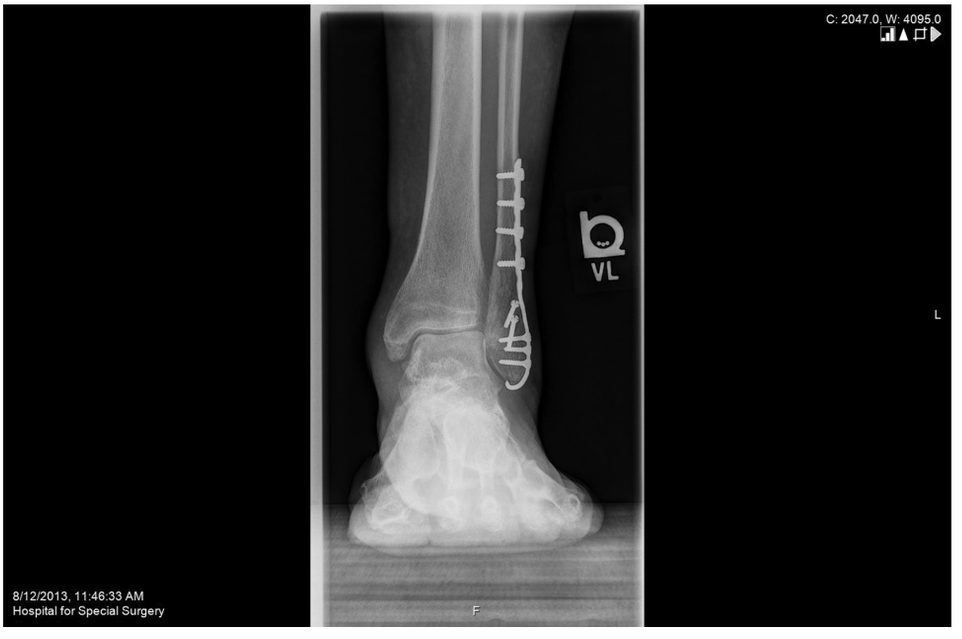
Abbreviation: SER, supination-external rotation.

joint; a Cam Walker Boot; and customized ankle-foot orthosis (AFO) braces. Evidence has shown that outcome is not influenced by the specific type of functional brace used to treat a stable fracture.[19] Patients are able to mobilize the injured ankle in the brace at an earlier stage to counteract the aforementioned effects of immobilization. The fact that the braces are removable allows the wearer access to the injured limb. Brace use may decrease the need for frequent follow-up appointments reserved for cast changes as well.

Cast Immobilization and Deep Vein Thrombosis

The association between cast immobilization and the development of deep vein thrombosis (DVT) has been investigated

Figure 3. Open reduction and internal fixation of an unstable ankle fracture.



by several authors,[20–25] but few studies have directly analyzed the incidence of DVT after cast immobilization in patients with isolated ankle fractures. Patil et al[20] found a 5% rate of DVT after performing ultrasound examination on 100 patients who experienced an isolated stable lateral malleolus fracture and were treated with cast immobilization for 6 weeks. None of the patients were given prophylactic treatment to prevent thromboembolism.[20] Several studies have examined the incidence rate of DVT in larger patient populations, including patients who had only lower-extremity bony and soft-tissue injuries and/or surgical procedures that required treatment with cast immobilization. Lassen et al[22] found a 19% DVT rate identified with venography in 188 patients with a variety of lower-extremity injuries treated with 5 weeks of cast immobilization. Jorgensen et al[23] demonstrated a 17% DVT rate in a similar population of 106 patients at an average of 5.5 weeks of cast immobilization. In studies with similar patient populations but shorter durations of cast immobilization—ranging from 10.55 days to 15.8 days—DVT rates were comparable at 4.3%,[21] 3.5%,[25] and 16.5%.[24] These incidence rates of DVT are significantly higher compared with the 0.1% DVT incidence rate in the general population.[26]

Materials and Methods

A PubMed search was performed with the keywords: *ankle fracture*, *stable ankle fracture*, *unstable ankle fracture*, *casting*, *cast immobilization*, *functional brace*, and *early mobilization*. The search identified a total of 257 publications, which were then screened for relevance in pertaining only to isolated ankle fractures treated with cast immobilization or functional bracing. Studies published in a language other than English, those focussing on ankle soft-tissue injuries, and studies with < 5 patients were not included in our review. Only studies directly comparing conservative or postoperative ankle fracture management with cast immobilization and functional bracing were included in our analysis. Studies were further stratified based on stable ankle fractures, unstable ankle fractures, and weightbearing status of the subjects. All references from each of the 16 reports chosen for inclusion were examined in an effort to reveal any additional studies not discovered in the initial PubMed search. No upper or lower limit was placed on date of publication for inclusion criteria.

Included studies were analyzed with emphasis on clinical outcome scores, calf muscular atrophy, ankle swelling, incidence of wound infection, incidence of DVT, need for surgical reintervention, delay until return to work or athletic activity, range of ankle motion, and ankle strength. Not all studies included in our analysis reported data on every variable of interest.

Results

Our results were segregated into 3 sections based on the subject populations included. The first group was comprised of all studies analyzing outcomes in patients with stable ankle fractures who were permitted full weightbearing in the cast or functional brace as soon as tolerated. The next group included studies addressing treatment with a functional brace compared with cast immobilization in patients with surgically repaired, unstable ankle fractures, who were then further subdivided into 2 groups: those allowed full weightbearing initially in the cast or brace; and those prohibited full weightbearing until removal of the cast or functional brace.

Stable Ankle Fractures With Full Weightbearing

Several studies have evaluated functional bracing for stable fractures that do not require surgery.[19,27–32] Stuart et al[27] designed a prospective, randomized controlled trial comparing a below-the-knee walking plaster and a pneumatic Aircast brace for the treatment of stable Lauge-Hansen SER fractures. The brace group patients were allowed to remove the brace only for bathing, itching, etc, but otherwise were instructed to wear the brace night and day. Patients in both groups were followed up at 24 hours, 1 week, 4 weeks, and at 6 weeks (if the fracture was not clinically united at 4 weeks) and finally, at 3 months. Specific follow-up parameters included comfort at 24 hours, rated on a linear analog 1–10 scale; swelling, measured in millimeters; time to union, ROM at union; symptomatology at 3 months; and complications. Final results indicated that patients in the brace group reported more comfort at 24 hours. Swelling averaged 6.6 mm in the brace group and 11.5 mm in the casted group at 1 week follow-up. Brace group patients exhibited a 16.6° greater average arc of motion at 4 to 6 weeks, the average time of fracture union among all subjects. The difference is clinically relevant to patients wishing to continue athletic activity. Whereas only 5° of dorsiflexion is required for unhindered performance of activities of daily living, $\geq 15°$ of dorsiflexion is required for athletic activity.[33] Subjective patient reports indicated a statistically significant decrease in pain, increase in ROM, and increase in level of activity for patients in the brace group. All fractures in the studies were united clinically by 6 weeks. Two patients in the cast group developed

symptomatic DVT, confirmed by venography, and were admitted for systemic anticoagulation.

Port et al[28] achieved similar results when studying treatment outcomes of an elasticated support bandage compared with cast immobilization in stable ankle fractures of Weber B1 or Lauge-Hansen SER fractures. All patients enrolled in the study were initially treated with a plaster backslab for 1 week until primary swelling subsided. They were then randomized to either early mobilization with an elastic support, or cast immobilization. Patients were evaluated at 1 week and then at monthly intervals until 6 months Of patients in the early mobilization group, 33% were walking unassisted at 1 week compared with 15% in the immobilized group.[28] Olerud and Molander scores[34] were significantly higher for up to 3 months in the mobilized group before normalizing between the 2 groups. Mean arc of movement was 17% greater in the mobilization group at 1 month and 9% greater at 2 months. The differences were not clinically significant as differences in ROM beyond the 2-month mark were not significant when patients were able to return to full pre-injury levels of activity. There were no significant differences in pain, calf, and ankle swelling, or analgesic usage between the treatment groups at any point. One patient fracture in the cast group was clinically united at 6 weeks but at 6 months still exhibited radiographic evidence of nonunion. There were no other complications reported.

These findings have also been supported in studies examining the treatment of stable Lauge-Hansen SER fractures with a functional brace and no comparison group. The protocols did not result in increased rates of dislocation, nonunion, or malunion compared with reported values after cast immobilization. There were no observed decreases in ROM and patients were able to return to full weightbearing without difficulty.[29,30]

Unstable Fractures With Non-Weightbearing

Sondenaa et al[35] randomized 43 patients to receive plaster cast immobilization for 6 weeks or undergo an early mobilization treatment plan following ORIF. The early mobilization group exhibited greater ROM only at 6 weeks postoperatively, reported a deficit of 10° of dorsiflexion compared with 15° in the casted group, 18° of plantarflexion compared with 9°, and 14° of supination compared with 27° loss in the immobilization group. The differences in ROM were not clinically relevant as differences quickly resolved between the 2 groups at the next follow-up. There was decreased swelling up to 12 weeks, and decreased subjective pain reports up to 18 weeks. All 3 parameters, ROM, swelling, and pain, had normalized between the 2 groups at 1 year. There was never a significant difference in ankle strength or rates of osteoporosis and osteoarthritis between the 2 groups at any point during follow-up. There was only 1 complication in the early mobilization group, a temporary superficial wound infection that resolved with oral antibiotics. The exact timing of the wound infection was not specified in the study. No complications were reported in the cast immobilization group.[35]

In a randomized controlled trial by Vioreanu et al,[36] patients treated with a removable fiberglass AFO after ORIF of a closed ankle fracture experienced 2.5 cm less calf muscular atrophy 6 weeks postoperatively, as measured circumferentially at 10 cm distal to the tibial tuberosity. Two patients in the cast immobilization group with DVT and some degree of calf swelling were included in the comparison analysis. There was no difference in ankle swelling between the cast immobilization and early mobilization groups at any point during follow-up. Total range of plantarflexion and dorsiflexion was 13° greater on average in the early mobilization group up to 9 weeks postoperatively. Significantly higher Olerud and Molander[34] and American Orthopaedic Foot and Ankle Score (AOFAS)[37] functional scores were reported in the early mobilization group up to 12 weeks. The 36-item short form health survey (SF-36) scores representing patient satisfaction and quality of life were not significantly different between groups at 6 months postoperatively. All patients were treated postoperatively with a plaster of Paris splint for 10 to 14 days to ensure wound healing and closure. The cast or AFO was continued for 6 weeks postoperatively—but patients treated with the AFO had a 10% postoperative wound infection rate compared to a 0% infection rate in the cast group. One patient experienced a superficial wound infection requiring a week-long course of oral antibiotics. Two patients developed deep soft-tissue infections requiring eventual re-operation for hardware removal; 1 needed a procedure 5 months postoperatively for an unresolved infection, persisting since the fifth week despite adequate medical therapy; and the other patient, at 10 weeks postoperatively, after developing a *Staphylococcus aureus* infection postoperatively at week 8. Both subjects recovered fully without development of osteomyelitis or long-term sequelae. The cast immobilization group experienced 2 cases of DVT identified with Doppler ultrasound. Doppler ultrasound was not routinely performed and reserved only for patients exhibiting symptoms of lower-extremity DVT during clinical and functional assessment.

Farsetti et al[38] also employed the AOFAS functional scoring system[37] to evaluate long-term outcomes of patients treated with early mobilization or a nonremovable cast. At a 10- to 20-year follow-up, patients treated with early mobilization had statistically significant higher scores than those treated with cast immobilization and showed less radiographic evidence of osteoarthritis. The difference in ankle and hindfoot ROM values was not found to be significant.

DiStasio et al[39] found comparable functional results utilizing the Maryland Foot Score[40] as an index. Patients treated with a functional brace had higher subjective functional scores up to 6 months postoperatively but no statistically significant difference was found between the 2 groups with respect to swelling, ROM, and strength at 6 weeks postoperatively or after completing a full physical therapy regimen. Only 3 patients in total developed superficial wound infections, 2 in the casted group and 1 in the group treated with functional bracing. The infections resolved with local wound care and oral antibiotics.

Egol et al[41] designed a prospective, randomized controlled study to evaluate functional outcome of patients, using the Mazur[42] ankle grading system. All patients were treated with a plaster backslab for 2 to 3 days before being randomized to receive cast immobilization for 6 weeks or functional bracing in an Aircast with physiotherapy beginning immediately. Results continued to show higher scores among patients treated with functional brace at 6, 12, 26, and 52 weeks, but the difference was only significant at 6 weeks. The patients also had higher average SF-36 scores at 1 year but the differences were only statistically significant for 2 of 8 categories. The high rate of wound complications seen in other studies was not demonstrated in our study. There was only 1 postoperative complication reported. An elderly woman in the cast immobilization group developed a pulmonary embolus on the third postoperative day that resolved uneventfully with intravenous heparin therapy, followed by warfarin therapy for 3 months.

Unstable Fractures With Full Weightbearing

In a study by Lehtonen et al,[43] 100 consecutive patients with an unstable Weber A or Weber B ankle fracture were randomly allocated into 2 equal-sized treatment groups: early mobilization in a functional brace or immobilization in a below-the-knee cast for 6 weeks, after ORIF according to Association for Osteosynthesis/Association for the Study of Internal Fixation (AO/ASIF) methods. Follow-up at 2, 6, 12, and 52 weeks showed no differences in ROM, swelling, atrophy, Olerud and Molander scores,[34] or Kaikkonen scores between patient groups.[44] All fractures healed with no loss of reduction. Alarmingly, 33 of 50 patients in the brace group experienced postoperative complications, most of the adverse events related to wound healing. There were 16 superficial wound infections, 4 deep wound infections, and 3 patients had wound dehiscence. All patient wound complications resolved with appropriate treatment and did not require further surgeries. In contrast, patients in the cast group developed 4 superficial wound infections, 2 DVTs, 1 case of chronic skin irritation and 1 case of chronic dysesthesia. The 2 patients with DVT were treated uneventfully with subcutaneous heparin injections followed by oral warfarin for 3 months. All fractures in both groups united clinically by 6 weeks, and, as confirmed by radiograph, by 12 weeks. One patient in the brace group experienced loss of internal fixation but no further displacement of the fracture at the 2-week follow-up. The hardware was subsequently removed at 7 weeks without complication.

Ahl et al[45–48] collaborated data from 4 sequential studies to compare the effects of weightbearing compared with nonweightbearing and early mobilization, beginning the second postoperative week versus casting in patients with isolated lateral malleolar fractures and bimalleolar/trimalleolar fractures. In lateral malleolar fractures, when early ankle mobilization was allowed, regardless of weightbearing status, patients experienced greater range of loaded dorsiflexion at 3 months postoperatively and greater plantarflexion out to 6 months. There were no differences in subjective ankle scores. In the cases of bimalleolar and trimalleolar fractures, early ankle mobilization resulted in significantly greater subjective ankle scores and loaded dorsi- and plantarflexion out to 3 months postoperatively. Within the initial 3 months postoperatively, all patients included in the 4 studies except 1 were able to achieve $\geq 10°$ of dorsiflexion and 15° of plantarflexion, the ankle ROM required for normal ambulation. There were no disparities in subjective ankle scoring, ROM, ankle and calf circumference, complications, or the presence of arthrosis between the study groups at the final follow-up.[45–48]

Finsen et al[49] randomized 56 patients after surgical fixation of an unstable ankle fracture to 1 of 3 6-week treatment regimens: non-weightbearing early mobilization; non-weightbearing plaster cast immobilization; or a full-weightbearing plaster walking cast. All patients were followed at 9, 18, 36, 52, and 104 weeks. Patient outcome was evaluated based on return to work, complications, and a specific demerit scale constructed for the purpose of the study.

Overall, no significant clinical or radiographic differences were found between any of the 3 treatment arms throughout the 2-year follow-up. There was 1 case of deep and 2 cases of superficial infections, all treated successfully with antibiotics, but it was not stated to which treatment group each of the patients belonged.

Hedstrom et al[50] randomly selected 53 patients after surgical fixation of an unstable ankle fracture to undergo postoperative treatment either with early ankle physiotherapy in an orthosis with weightbearing or a walking cast with ankle immobilization. Follow-up evaluation at 3, 6, and 18 months postoperatively focused on ROM, a linear analog functional scale, and the Olerud and Molander scoring system.[34] No differences were found between the 2 groups with respect to ROM or Olerud and Molander scores[34] at any point. A significant difference was found in the linear analog score in favor of the orthosis group but only at the 3-month follow-up. All differences beyond 3 months were not significant. There were 3 cases of superficial wound infection, 1 in the cast group and 2 in the orthosis group, all of which healed without complications. Although not statistically significant, there were 4 cases of ankle arthrosis, 1 Grade III and 3 Grade I, all in the orthosis group at 18-month follow-up.

In a prospective, randomized trial by Tropp et al,[51] patients were randomized after ORIF of an unstable ankle fracture to either postoperative immobilization in a walking cast or full weightbearing in an ankle brace with an at-home exercise program for 6 weeks. Evaluation at 10 weeks, 12 months, and 3 years entailed radiographic assessment, Olerud and Molander score,[34] measurement of atrophy and ankle swelling, active and passive plantar- and dorsiflexion ROM, and isokinetic dorsiflexion strength. Increased range of dorsiflexion in the brace group at 10 weeks and 12 months was the only significant difference between the 2 groups in any designated parameter. Four patients in each group showed inadequate reduction postoperatively but there were no differences in future fracture displacement or healing between the 2 groups at any point during follow-up. The inadequate reduction did not statistically correlate with any change in ankle score or ROM. No other complications were mentioned.

In a study by Cimino et al,[52] 51 patients with surgically stabilized ankle fractures were postoperatively randomized to full weightbearing in an AFO with early ankle exercises or a plaster cast for 6 weeks. Plantar- and dorsiflexion ROM using a roentgenogram were evaluated at 6, 10, and 14 weeks postoperatively, and then at monthly intervals. Seventy-two percent of subjects in the AFO group compared with 37% in the casted group were able to dorsiflex the ankle $> 15°$ at 6 weeks postoperatively. However, this result did not carry substantial clinical significance as $> 15°$ of dorsiflexion is not required to perform daily living activities unhindered and is only needed for more rigorous athletic activity.[33] There were 4 wound complications in the study by Cimino et al, 2 in each treatment group; all resolved with appropriate therapy except for 1 patient in the AFO group with preexisting peripheral vascular disease and venous stasis, who developed a superficial wound dehiscence eventually requiring hardware removal at 6 weeks. One patient in the casted group developed painful bursitis over her screw that resolved with hardware removal 23 months postoperatively.

Discussion

Clinical Significance

When analyzing treatment options for ankle fractures it is also vital to address factors beyond the scope of direct outcome measurements and examine the feasibility, economic implications, and lost time from work or other activities. Long-term studies have shown that the majority of ankle fractures treated conservatively or surgically heal well with minimal development of post-traumatic arthrosis and chronic symptomatology.[7–10] Patients have been able to return to work and daily activities without difficulty, pain, stiffness, or significant morbidity. When treated with a functional brace, opposed to cast immobilization, patients were able to return to work and daily activities an average of 28 to 53 days sooner.[17,36,41]

Data detailing return to competitive sports after unstable ankle fracture have been less predictable. There have been no studies directly comparing functional bracing with cast immobilization with respect to return to competitive sporting activities. Colvin et al[53] specifically looked at return to sports following ORIF in 243 unstable ankle fractures. All patients were treated postoperatively in a plaster backslab to allow wound healing before transitioning to a non-weightbearing functional brace and early mobilization for 6 weeks. Only 3% of patients had returned to their self-reported baseline preoperative athletic activity at 3 months; 15.4% at 6 months, and 24.5% at 1 year. Preoperative level of participation was not a predictor of return to athletic activity before 1 year. At 12 months, however, 88% of recreational athletes had returned to play but only 11.6% of competitive athletes had returned to their previous level of activity. The type of sport that each athlete participated in was not controlled in Colvin et al's study. The best predictors of return to activity in the study were younger age, male gender, no mild systemic disease, and less severe ankle fracture.

Hong et al[54] retrospectively reviewed 47 bimalleolar and trimalleolar fractures treated with ORIF to assess any disparities in union rate, Olerud and Molander scores,[34] patient satisfaction with surgery, and return to sports participation. Postoperatively, patients were placed in a splint and remained non-weightbearing until adequate wound closure was achieved. It is unclear whether patients were treated thereafter in a hard cast or functional brace. Thirty-three of the 47 patients reported involvement in sports activity prior to injury. At the final 1-year follow-up, only 9 of 33 (27.3%) patients were able to return to their previous level of sports participation without any difficulty or hindrance. Six of 33 (18.2%) patients were unable to return to sports at all. There was no statistically significant difference between bimalleolar and trimalleolar fractures for any of the parameters investigated. Longer-term data have shown similar results. Shah et al[55] retrospectively reviewed the functional outcome of 69 patients who underwent surgical fixation of an unstable ankle fracture 5 years previously. All patients in the study were treated postoperatively in a non-weightbearing cast for 6 weeks before beginning physiotherapy. Forty-two of the patients claimed to be involved in athletic activities before their injury. At 5 years postoperatively, 26 patients (62%) were able to return to their pre-injury level of competition, whereas 16 (38%) were unable to return to previous levels of activity. However, 4 patients in the study, who did not report involvement in athletic activity before the injury did claim to participate in some sports after surgery.[55]

Other data show that athletes do not experience difficulty returning to previous levels of competition after ankle fracture. Donley et al[56] published a case series of an unstable ankle fracture requiring ORIF in 3 professional football players. All 3 athletes were treated postoperatively in a non-weightbearing short leg cast for 6 weeks with prescribed physiotherapy for the upper extremities, hip, quadriceps, and hamstring before transitioning to a removable boot with graduated weightbearing over a course of 3 weeks. At 12 weeks postoperatively, all syndesmosis fixation screws were removed. All 3 players were able to return to preinjury levels of competition in the National Football League at 24 to 30 weeks postoperatively without limitation, pain, or stiffness after aggressive rehabilitation. Porter et al[57] examined functional outcome in a younger population of 27 recreational or competitive athletes with a large variety in type of ankle fracture, all requiring surgical fixation. With the exception of 1 patient who experienced a pilon fracture, the postoperative regimen for all patients included 6 weeks in a functional brace with weightbearing and early-motion exercises. Final follow-up ranged from 12 months to 3.7 years. Patients with isolated lateral malleolar fractures were able to return to competition at an average of 6.8 weeks. Patients with isolated medial malleolar fractures took the longest to return to athletic activity, at 17.0 weeks. All subjects were able to return to previous levels of competition except 1, who had a bimalleolar fracture and feared reinjury, despite the absence of objective evidence suggesting the ankle had not healed completely.

The financial benefits of treatment in a functional brace with early mobilization are also evident. The cost of repeated radiographs, follow-up clinic visits, and cast changes creates a substantial financial burden for hospitals and patients.[58,59] In stable ankle fractures, the utility of repeated radiographs to assess ankle mortise stability after treatment in a brace or cast has not led to alterations in treatment plan or improvements in outcome.[58] Additionally, treating stable ankle fractures with a functional brace instead of casting has been shown to decrease the recovery period, number of follow-up appointments, repeat radiographs, and cast changes leading to thousands of dollars in potential savings annually.[59]

Conclusion

The optimal treatment of ankle fracture continues to be debated. The ankle is unique in that it is a weightbearing structure requiring a precise restoration of anatomic congruity and integrity to function properly without pain or biomechanical deficit after injury.[11,60] Moreover, blood supply to the skin surrounding the ankle is poor compared with other distal musculoskeletal structures, thus increasing the risk for wound complications.[61] The dependent position of the lower extremity also predisposes it to increased swelling and vascular compromise. These physiologic factors play a large role in determining treatment protocol and outcomes for patients with ankle fractures. Primary or postoperative treatment of ankle fractures with a functional brace rather than cast immobilization suggests many theoretic benefits that could lead to better patient outcomes with regard to clinical symptoms, lost time from work or activity, and financial burden.

There is evidence based on the published literature that treating a stable ankle fracture with a functional brace provides some benefit to the patient. Data show that patients experience better ROM, strength, functional scores, and decreased atrophy at short-term follow-up (Table 1 and 2). There are few data showing that these benefits extend beyond 6 months. There is also a demonstrable lower risk of DVT when cast immobilization is avoided (Table 3). Moreover,

Table 1. Measured Atrophy (mm)

Source	Atrophy at First Follow-Up[a]		Atrophy at Final Follow-Up[b]	
Study	**Cast**	**Early Mobilization**	**Cast**	**Early Mobilization**
Vioreanu et al (mm ± SD)	35 ± 5.4	10.16 ± 9.64	NA	NA
Lehtonen et al (mm ± SD)	10 ± 24	4 ± 12	0 ± 7	1 ± 8
Tropp et al (mm ± SD)	11 ± 7	13 ± 12	4 ± 9	3 ± 5
Ahl et al (1986, 1988)[c] (%)	97.5%	96%	98.5%	98.5%
Ahl et al (1987, 1993)[c] (%)	96.5	NA	97.5%	NA

[a]Initial follow-up ranged from 6 weeks to 3 months.
[b]Final follow-up ranged from 6 months to 2 years.
[c]Values expressed as percentage of uninjured limb.
Abbreviation: NA, not applicable.

no significant difference in fracture union rates has been observed between the 2 treatment options. In all studies of both stable and unstable fractures, patients treated with a brace or cast have shown comparable clinical and radiographic union rates with no significant loss in reduction or need for reoperation to achieve adequate reduction and fixation. We recommend the use of a functional brace over cast immobilization for the management of stable ankle fractures to decrease patient risk of DVT and potentially expedite recovery.

For unstable fractures requiring surgery, evidence suggesting the use of functional bracing is less definitive. Physicians should be mindful and use clinical judgment when choosing a functional brace for postoperative treatment, as this option may not be advisable in patients where wound healing is compromised, especially in patients with diabetes.[62–64] In several studies, rate of wound complications after ORIF in an unstable ankle fracture was significantly greater with brace treatment (Table 3); this was particularly evident with weightbearing. Patients who experienced the greatest number of wound infections typically included those whose primary incision had not healed before application of the brace,[43] patients who were not compliant, or patients who had a preexisting condition that hindered wound-healing capability.[36] Adequate wound healing must be established before considering transition to a functional brace for further recovery. Patients who smoke, have diabetes, those taking immunosuppressive medications, and the functionally impaired may benefit more from cast immobilization to ensure adequate fracture and wound healing without complication. The decision must be balanced against increased risk of DVT with cast immobilization. In certain cases, DVT thromboprophylaxis may be advisable. Although the effects of treatment with functional bracing compared with cast immobilization on final patient functional outcomes are minimal, the ability to remove the brace allows patients to access the leg for hygiene and take an active role in recovery by performing at-home ankle exercises. The financial benefits of eliminating repeat cast changes and minimizing follow-up clinic visits are also of note. Patient compliance may be difficult to assess but must be considered in all cases as well. As such, we recommend protection of the ankle with immobilization until wound healing has been established before advancing the patient to a brace and partial weightbearing activities.

Table 2. Clinical–Functional Outcome Scores[a]

Data Source	Functional Score at First Follow-Up[b]		Functional Score at Final Follow-Up[c]	
Stable Ankle Fractures	**Cast**	**Early Mobilization**	**Cast**	**Early Mobilization**
Port et al	50 ± 2.4	60 ± 3.2	89 ± 3.8	93 ± 1.2
Veldhuizen et al	NA	51.9	NA	92.3
Unstable Ankle Fractures				
Vioreanu et al	63.75 ± 9.19	79.92 ± 11.32	81.07 ± 9.56	93.17 ± 8.76
Lehtonen et al	54 ± 13	52 ± 14	87 ± 8	87 ± 9
Ahl et al (1987, 1993)	50.5	59.5	82.5	88
Hedstrom et al[d]	70 (range 35–90)	80 (range 5–100)	88 (range 55–100)	100 (range 80–100)
Tropp et al	70 ± 21	77 ± 19	88 ± 22	92 ± 10

[a]Only studies that utilized the Olerud and Molander scoring system are presented here.
[b]First follow-up ranged from 4 weeks to 3 months.
[c]Final follow-up ranged from 12 weeks to 2 years.
[d]Values are stated as median with range in parentheses.

Table 3. DVT and Wound Complication Rates

DVT Rate	Cast, n/N (%)	Early Mobilization, n/N (%)
Study		
Stuart et al[27]	2/18 (11.1)	0/19 (0)
Vioreanu et al[36]	2/29 (6.9)	0/33 (0)
Farsetti et al[38]	1/22 (4.5)	0/22 (0)
Egol et al[41]	1/28 (3.6)	0/27 (0)
Lehtonen et al[43]	2/50 (4.0)	0/50 (0)
Tropp et al[51]	0/?	0/?
Total:	**7/147 = 4.8**[a]	**0/151 = 0**[a]
Wound Complication Rate		
Study		
Sondenaa et al[35]	0/25 (0)	1/20 (5.0)
Vioreanu et al[36]	0/29 (0)	3/33 (9.1)
Farsetti et al[38]	2/22 (9.1)	1/22 (4.5)
Distasio et al[39]	2/31 (6.5)	1/25 (4.0)
Egol et al[41]	0/28 (0)	0/27 (0)
Lehtonen et al[43]	6/50 (12.0)	30/50 (60.0)
Ahl et al (1986[45], 1988[47])	0/46 (0)	0/51 (0)
Ahl et al (1987[46], 1993[48])	8/53 (15.1)	5/40 (12.5)
Hedstrom et al[50]	1/25 (4.0)	2/28 (7.1)
Cimino et al[52]	2/19 (10.5)	2/32 (6.3)
Total:	**21/328 = 6.4**	**45/328 = 13.7**

[a]Excludes values from Tropp et al.
Abbreviation: DVT, deep vein thrombosis.

Conflict of Interest Statement

Mark Drakos, MD, and Conor Murphy, BA, disclose no conflicts of interest.

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