Timing of initiating manual therapy and therapeutic exercises in the management of patients after hindfoot fractures: a randomized controlled trial*

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ABSTRACT

Study design: Randomized clinical trial.

Background: Patients with fractures to the talus and calcaneus report decreased functional outcomes and develop long-term functional limitations. Although physical therapy is typically not initiated until six weeks after fixation, there's little research on the optimal time to initiate a formal physical therapy program.

Objectives: To assess whether initiating physical therapy including range of motion (ROM) and manual therapy two weeks post-operatively (EARLY) vs. six weeks post-operatively (LATE) in patients with fixation for hindfoot fractures results in different clinical outcomes.

Methods: Fifty consecutive participants undergoing operative fixation of a hindfoot fracture were randomized to either EARLY or LATE physical therapy. Outcomes, including the American Orthopedic Foot and Ankle Society Hindfoot Scale (AOFAS), the Lower Extremity Functional Scale (LEFS), active ROM, swelling, and pain, were collected at three and six months and analyzed using linear mixed-modeling to examine change over time. Adverse events were tracked for 12 months after surgery.

Results: The EARLY group demonstrated significantly larger improvements for the AOFAS ($p = .01$) and the LEFS ($p = .01$) compared to the LATE group. Pairwise comparison of the LEFS favors the EARLY group at 6 months [7.5 (95%CI −.01 to 15.0), $p = .05$]. There were no differences between the groups with regard to ROM, pain, and swelling. The LATE group incurred increased adverse events in this study.

Conclusion: Initiating early physical therapy may improve long-term outcomes and mitigate complications in patients after hindfoot fractures.

Level of Evidence: Therapy, level 2b.

KEYWORDS

Calcaneus Fracture;
talus fracture; outcomes;
rehabilitation

Introduction

Patients sustaining fractures to the hindfoot, including the talus and calcaneus, experience decreases in quality of life and long-term disability. Van Tetering et al. [1] found patients with fractures of the calcaneus reported worse outcomes 2 years after their fractures compared to patients with organ transplants or myocardial infarctions. Although relatively uncommon (11.5/100,000 incidence rate), these fractures often produce a significant socioeconomic burden estimated annually to be between \$28.5 and \$40.5 million [2,3]. Approximately 25% of patients are unable to return to work within one year of their calcaneal fracture [3], and the mean period of work incapacity has been reported to be 260.5 days [4]. Males in their productive working age are often most affected by

calcaneal fractures [4]. These fractures commonly lead to post-traumatic arthritis, continued pain, and long-term disability. Wound complications are common with numbers as high as 25% after open reduction internal fixation (ORIF) [3,5–7]. Previous literature has demonstrated long-term deficits in range of motion (ROM), decreased joint mobility, alterations in gait patterns, and diminished self-reported functional outcomes [8–10].

Talar fractures comprise 0.5% of fractures, and similar to calcaneal fractures, also pose challenges to management due to high rates of avascular necrosis, malunions, and nonunions [11]. These high energy fractures are often associated with additional fractures of the metatarsals, calcanei, and malleoli and frequently result in osteochondral injuries of the talar dome [11]. Complications such as avascular necrosis, early post-traumatic arthritis,

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*This study was approved by Intermountain Healthcare's Institutional Review Board. This trial was initiated prior to 1/1/2013

The supplementary material for this paper is available online at <https://doi.org/10.1080/10669817.2017.1432542>.

impaired joint mobility, malunion, nonunion, infection, soft tissue necrosis, and varus deformities lead to sub-optimal long-term outcomes [11–14]. Like calcaneal fractures, displaced fractures of the talus are associated with a high percentage of permanent disability [12]. The incidence rate of hindfoot arthritis following talar neck fractures ranges from 30 to 90% [15]. Studies suggest a third of patients with a talar fractures will develop a hindfoot deformity [15].

Historically, patients have not been sent to a formal physical therapy program within the first few weeks after operative fixation of a calcaneal fracture due in part to concerns of wound complications such as delayed healing and infection [16]. Research suggests that a majority of surgeons' protocols recommend physical therapy 6 weeks after operative care [16]. Pfeifer et al. completed an analysis of 213 protocols for the management of patients with ankle, hindfoot, and midfoot fractures [16]. They found in the majority of protocols, patients were immobilized for the first several weeks after operative care of intra-articular calcaneal fractures with active ROM limited to 10 degrees below neutral dorsiflexion (–10 degrees) for the first six weeks after operative fixation [16]. With regard to talus fractures, studies propose that early motion may improve the prognosis after ORIF [12,17]. For patients with calcaneal fractures, research suggests subtalar joint motion is a predictor of clinical outcomes [8] and early ROM after internal fixation may decrease the incidence of post-traumatic arthritis. Conversely, some research suggests that initiating early mobilization in patients with fractures to the ankle may lead to disruption of wound healing [18].

To the authors' knowledge, no study to date has assessed outcomes of patients initiating an early supervised physical therapy program consisting of manual therapy and therapeutic exercise versus those initiating a formal physical therapy program six weeks after operative treatment of hindfoot fractures. Therefore, the primary purpose of this study was to assess whether initiating a formal physical therapy program including range of motion and manual therapy two weeks post-operatively (EARLY) vs. six weeks post-operatively (LATE) in patients with ORIF for talus or calcaneus fractures results in differences in clinical outcomes of disability, active ROM, swelling, pain, or adverse events such as wound complications.

Methods

This study was a longitudinal randomized controlled trial. Intermountain Healthcare's Review Board approved the study protocol and all patients gave their informed consent. This study was not funded.

Participants

Between 2010 and 2014, patients sustaining an ORIF of either a calcaneal or talar fracture were recruited from

two fellowship trained board certified foot and ankle orthopedic surgeons. The reduction of the fracture was determined through intraoperative radiographs. Patients were eligible for this study if they were between the ages of 18 and 70 years. Patients were excluded if they had a previous foot/ankle fracture or surgery, an open fracture, a head injury affecting cognitive function, a fracture not fixed utilizing a standardized later extensile approach, or other fractures impeding normal rehabilitation.

Measures

Intervention

Eligibility was confirmed, and then baseline measures were performed. Fifty patients were then randomized to the EARLY group ($n = 24$), defined as starting a formal supervised physical therapy program within the first two weeks post-operatively, or the LATE group ($n = 26$), defined as initiating a formal supervised physical therapy program after their six week follow-up appointment with their orthopedic fellowship trained foot and ankle surgeon. Randomization was stratified to control for fracture type (talus vs. calcaneus). The treatment allocation was placed in opaque, sealed envelopes prior to enrollment and was not opened until baseline measures were complete. The study design did not allow blinding of the participants; however, an assessor blinded to group allocation performed all measures. In addition, participants were asked not to reveal group allocation to their assessor.

All patients were treated for the same number of visits (10); however, the EARLY group received five supervised treatments including manual therapy prior to their six week follow-up appointment with their orthopedic surgeon and then continued to work on range of motion exercises independently between post-operative weeks six through 12. The LATE group received range of motion exercises to work on independently between prior to their six week follow-up appointment with their surgeon, and then received five supervised treatments including manual therapy between their six and 12 week follow-up appointments with their surgeons. All patients received an additional five visits between the three and six month post-operative timeframe. See Figure 1 for a flow diagram of the study. During time periods when patients were not participating in formal physical therapy, they were given a standardized home program consisting of active ROM of the talocrural and subtalar joints such as ankle pumps, ankle circles, and drawing the alphabet with their foot. In addition, they were given straight leg raises and clam shell exercises in non-weight bearing positions to perform independently every day. Patients were given the standardized home exercise program of the above exercises with specific instructions on the number of repetitions, sets, and times per day to perform each exercise. Supervised physical therapy treatments were provided by the same fellowship trained manual physical therapist for both groups and included

Figure 1. Flow diagram of study treatment.

manual therapy and therapeutic exercise based on an evidence-based model that was individualized based on the patient's fracture pattern. For example, if a participant sustained a talar neck fracture and was lacking active dorsiflexion ROM, the therapist avoided an anterior to posterior talocrural joint mobilization which could place increased stress through the healing talar neck. Instead, the physical therapist may have chosen to mobilize the talonavicular joint, distal tibio-fibular, and/or subtalar joint.

Patients who had incurred a talar neck or body fracture or a calcaneal fracture were allowed to begin weightbearing at 12 weeks post-operatively. Patients were allowed to weightbear after a lateral process fracture at six weeks after ORIF and remained in a walking boot until 12 weeks post-operatively. Once patients were weightbearing, physical therapy management consisted of gait training, balance and proprioception retraining, continued swelling management, joint mobilizations, and functional strengthening.

Outcome measures

Participants filled out the following self-reported questionnaires: the American Orthopedic Foot and Ankle Score (AOFAS), the Lower Extremity Functional Scale (LEFS), Numeric Pain Rating Scale (NPRS), and the Beck Anxiety Questionnaire. Swelling and active ROM were assessed by a clinician blinded to group allocation. All outcome measures were assessed at baseline, 3 months, and 6 months except for the Beck Anxiety Inventory which was only administered at baseline only.

The AOFAS is a 100-point scale with both a subjective and objective component. It is the most frequently cited outcome score for patients post intra-articular calcaneal fractures and contains nine patient and physician-reported items regarding function and alignment of the ankle and hindfoot [19]. A perfect score of 100 points indicates no disability [20]. Forty points of the AOFAS Ankle-Hindfoot Score is devoted to pain, 50 points to function, and 10 points to alignment [15]. The LEFS is comprised of 20-item questionnaire with rating a patient's difficulty with activities. The patient may choose one of five different responses using a 0–4 scale. Patients rate a 0 for extreme difficulty or unable to perform and a 4 for no difficulty and responses are then totaled. A perfect score of 80 points indicates no disability [21]. The minimal clinically important difference (MCID) for the LEFS is 9 points [21]. The Beck Anxiety Inventory is a 21 question assessment of how a subject has been feeling over the past week. It is designed for subjects' age 17–80 years. Higher scores indicate increases in anxiety, and previous research has demonstrated links between psychosocial factors such as anxiety and foot trauma [22,23]. Pain intensity was measured on an 11-point numeric pain rated scale (NPRS) (0–10) [24]. Current, best, and worst pain intensity was collected at each assessment. The NPRS has been found to be a reliable and valid measure of pain intensity [25]. Ankle swelling, assessed by the figure-of-eight method has been shown to have an intraexaminer reliability (ICC = 0.99) for patients with post-operative ankle swelling [26]. The minimal detectable change (MDC) for the figure-of-eight method is 9.6 mm [26]. Active ROM was assessed with a

plastic goniometer, and has been shown to have good intraexaminer reliability (ICC = 0.89) [27].

For this study, active ROM was measured in a long sitting position with the stationary arm aligned to the fibular head and the moving arm was aligned parallel to the plantar surface of the calcaneus instead of the fifth MT as previously described. This was done in an attempt to capture talocrural joint ROM and alleviate the combination of talocrural and forefoot ROM. An intra-rater reliability of this measure was completed prior to the beginning of this study using 20 participants. The intraclass correlation (ICC) for active dorsiflexion range of motion was 0.96 (95% CI 0.90 to 0.99) and for plantarflexion range of motion, the ICC was 0.94 (95% CI 0.86 to 0.98).

All patients with a calcaneal fracture received a computerized tomography scan (CT) prior to operative fixation. Calcaneal fractures were then classified according to the Sanders classification system by one of two foot and ankle fellowship trained orthopedic surgeons from the CT scan prior to operative fixation.

Analysis

A priori power analysis was performed using GPower 3 [28]. The sample size calculation was based on the primary aims with the AOFAS hindfoot scale being the primary endpoint. Recruiting 25 participants per group was planned to provide an 80% power to detect a difference between groups at 6 months and an MCID in the AOFAS hindfoot scale of 8.9 with a standard deviation of 10, a two-tailed alpha level of .05, and up to a 16% attrition rate [29].

All analyses were performed using SPSS Version 23.0 statistical software (IBM Corporation, Armonk, NY). To evaluate the primary study purpose of EARLY vs. LATE group comparison across time, an intention-to-treat (ITT) analysis was done using linear mixed modeling. Baseline descriptive statistics were assessed for potentially important differences, and were added to the model as co-variables as appropriate. Group, time, and the group by time interaction were modeled as fixed

effects. Treatment effects were estimated using separate, random intercept and slope linear mixed models for each outcome variable. For each model, the co-variance structure (autoregressive, unstructured, scaled identity) was used based on best model fit and ability of the model to reach convergence. Missing data points were estimated in the mixed model analyses using restricted maximum likelihood ratio estimation with 100 iterations; therefore, all participants randomized to a treatment group were included in the analyses of outcome for that group.

Due to a higher than expected dropout rate, a sensitivity analysis was additionally performed which excluded estimated data from analysis. Since linear mixed modeling automatically imputes missing data, the sensitivity analysis was performed using analysis of co-variance (ANCOVA). Baseline outcome scores were used as co-variables, and the primary result of interest was the group (EARLY vs. LATE) by time interaction. The Beck Inventory Scores were also used as co-variables due to differences between the EARLY and LATE group at baseline.

Results

Twenty-four patients were randomized to the EARLY group and 26 patients were randomized to the LATE group. Baseline demographics are listed in Table 1. No clinically important differences were found between the two groups at baseline, except for baseline Beck Anxiety scores, which were used as a co-variate in each analysis. Forty participants (80%) were enrolled in the study which had undergone ORIF for a calcaneal fracture and 10 for a talar fracture. Of the 40 Calcaneal fractures, 28 had a Sanders 2A, 2B, or 2C type fracture, 11 sustained a 3AB, 3 AC, or 3 BC, and one was unknown. Of the 10 participants with talar fractures, three presented with a lateral process fracture, one with a talar head fracture, and six with a talar neck fracture. Of the six patients with a talar neck fracture, one had a Hawkins I classification, four a Hawkins II classification, and one with a Hawkins IV classification. Sixteen patients were smokers prior to the study and two patients were current smokers. Twenty-six (52%) of patients sustained fractures to the right lower extremity. For a majority of patients in this study ($n = 38$), the mechanism of injury was a fall from a height. Sporting activities, such as rock climbing and mountain biking, accounted for an additional 10 fractures, and motor vehicle accidents accounted for only two fractures in this study.

Five subjects were lost to follow-up at 3 months and 18 subjects at 6 months (See Figure 1). The dropout rate was higher for the LATE group than the EARLY group at 6 months (5 in the EARLY vs. 13 in the LATE group). No differences were noted between the patients that completed the study and those that were lost to follow-up at 6 months (See Table 2). In addition, no participant reported dropping out due to any study-related procedures.

Table 1. Baseline demographics

Baseline demographics		
	EARLY ($n = 24$)	LATE ($n = 26$)
Age (years), SD	40.46 ± 13.32	39.65 ± 12.91
Male, n (%)	22 (91.7)	24 (92.3)
Fracture type, Calcaneus, n (%)	20 (83.3)	21 (80.7)
LEFS, SD	17.16 ± 11.67	20.08 ± 10.73
AOFAS Hindfoot, SD	42.14 ± 9.22	41.58 ± 12.85
ROM side-to-side difference (Degrees), SD	29.3 ± 9.29	30.61 ± 7.68
Swelling side-to-side difference (cm), SD	3.43 ± 1.6	3.88 ± 1.49
Pain intensity worst (0–10), SD	5.17 ± 2.17	4.0 ± 2.63
Beck Anxiety Score, SD	13.67 ± 8.07	7.34 ± 7.18
Previous smoker, n (%)	8 (33.3)	10 (38.4)
Injury to operative treatment (days), SD	13.23 ± 5.16	15.17 ± 8.33

Abbreviations: LEFS, Lower Extremity Functional Scale; AOFAS, American Orthopedic Foot and Ankle Society Hindfoot Scale; ROM, range of motion; cm, centimeters.

Intention-to-treat analysis

Results of the intention-to-treat analysis are listed in Table 3. The hypothesis of interest was the group by time interaction which was examined with pairwise comparisons of the estimated marginal means. A significant group by time interaction was found for both the AOFAS hindfoot score ($p = .01$) and the LEFS ($p = .01$) favoring the EARLY group (See Figures 2 and 3, respectively). For the LEFS, the mean difference for the pairwise comparison at 6 months was 7.5 (95%CI -0.1 to 15.0), $p = .05$ favoring the early group. No significant difference was found between the EARLY and LATE group ($p = .07$) for active ROM at 6 months; however, the trend was for a greater improvement in total ROM for the EARLY group (See Figure 4). There was no difference between the EARLY and LATE groups over time for the outcomes of swelling ($p = .30$) or pain ($p = .73$).

Sensitivity analysis

Due to the high dropout rate a sensitivity analysis was performed. Repeated measures ANCOVA analyses were performed with the Beck Anxiety Questionnaire and baseline scores as co-variables to assess group by time interactions. Similar to the ITT analysis, a significant difference favoring the EARLY group was found for the AOFAS hindfoot scale ($p = .03$). Pairwise comparisons at six months were not significant for the AOFAS [1.80 (95% CI -4.26 to 7.86), $p = .54$]. Repeated measures ANCOVA analysis demonstrated no significant interaction for the groups over time with regard to the LEFS ($p = .30$). Pairwise comparisons at six months for the LEFS were also not significant [2.68 (95% CI -3.14 to 8.40), $p = .35$]. However, pairwise comparisons at six months for side-to-side differences in ROM were significant favoring the EARLY group [4.62 (95% CI .359 to 8.89), $p = .04$].

Main effects

For the main effect of the AOFAS hindfoot scale, all participants in the study improved 28.75 (95% CI 25.39, 32.10), $p < .01$. Utilizing the ITT analysis, the mean change

score in the AOFAS hindfoot score between baseline and 3 months was 8.09 (95% CI 5.13, 11.06), $p < .01$, and between 3 and 6 months was 25.13 (95% CI 21.74, 28.52), $p < .01$. All participants in the study improved over time as reported with the LEFS, with a mean change score between baseline and six months of 39.57 (95% CI 36.45, 42.68), $p < .01$.

All participants had improved total active ROM of the talocrural joint. From baseline to six months follow-up, side-to-side ROM differences decreased by 14 degrees (95% CI 12.05, 16.77). At baseline, the total side-to-side difference in active ROM of the talocrural joint between the affected and unaffected side was 30.0 degrees (95% CI 27.6 to 32.5). At 3 months, the total talocrural side-to-side difference in active ROM decreased to 13.3 degrees (95% CI 11.3 to 15.2), and at 6 months, it decreased to 8.0 degrees (95% CI 5.9 to 10.1). The EARLY group started with a greater overall side-to-side loss of motion compared to their unaffected side, however, at six months, they had a decreased overall deficit in ROM compared to the LATE group.

Pain and swelling improved for all participants in the study from the initial visit to the one year follow-up period. At baseline, the mean reported pain was 4.6 ± 2.5 (range 0–10) and by the six month follow-up, the mean reported pain was 1.7 ± 1.9 (range 0–7). The mean difference between the affected and unaffected side at baseline for swelling was 3.7 cm (95% CI 3.2 to 4.1), and by six months, the mean side-to-side difference of swelling decreased to 1.1 cm (95% CI 0.8 to 1.4) which fell below the MDC of 9.6 mm.

Participants were also dichotomized based on calcaneal of talus fractures. There were significant differences in the LEFS self-reported outcome favoring the talar fracture group over the calcaneal fracture group. The mean difference in the LEFS at the six month follow-up was 12.2 (95% CI 2.2 to 22.3), $p = .02$.

Adverse events were tracked for one year after the study by means of chart review. Few adverse events occurred throughout the course of the study, with more events noted in the LATE group than the EARLY group (See Table 4). One patient in the EARLY group required an additional surgery, while three in the LATE group required an additional surgical procedure throughout the course of the study. The patient in the EARLY group with an additional operation underwent a subtalar joint arthrodesis. The three operative procedures for patients in the LATE group included: a hardware removal, a hardware removal with a peroneal tendon repair and a lateral wall take down, and a hardware removal and lateral wall take down. Due to the few number of adverse events, differences between groups were not analyzed statistically.

Discussion

Patients sustaining fractures to the hindfoot can be difficult and challenging to manage. It is unknown when the

Table 2. Baseline characteristics of participants lost to follow-up at six months and those completing the study*.

Variable	Lost to follow-up 6 Months ($n = 18$)	Completed study
Age (years)	39.5 ± 12.66	40.34 ± 13.34
LEFS (0–80)	16.78 ± 11.39	19.75 ± 11.09
AOFAS (0–100)	43.17 ± 10.98	41.03 ± 11.48
ROM side-to-side difference	29.53 ± 9.43	30.23 ± 7.97
Swelling side-to-side difference (cm)	3.74 ± 1.69	3.64 ± 1.51
Pain intensity (0–10)	5.0 ± 2.74	4.32 ± 2.31
Beck Anxiety Score	9.5 ± 6.71	10.88 ± 8.98

Abbreviations: LEFS, Lower Extremity Functional Scale; AOFAS, American Orthopaedic Foot and Ankle Society Hindfoot Scale; ROM, range of motion; cm, centimeters.

*Values are mean $\pm$ SD.

Table 3. Outcome measures for EARLY and LATE groups.

	EARLY group			LATE group			Mean diff between groups	p value
	Unadjusted mean	Adjusted mean	Mean change from baseline	Unadjusted mean	Adjusted mean	Mean change from baseline		
<i>AOFAS</i>								
Baseline (SD/CI)	41.58 ± 12.85	53.19 (49.47 to 56.92)		42.14 ± 9.22	57.13 (52.86 to 61.41)			
3 Month (SD/CI)	63.74 ± 13.38	64.42 (60.19 to 68.65)	11.23 (6.83 to 15.62)	62.76 ± 9.59	61.25 (56.88 to 65.62)	4.12 (−0.55 to 8.78)	3.17 (−2.91 to 9.25)	.31
6 Month (SD/CI)	84.46 ± 9.07	85.58 (80.83 to 90.32)	32.95 (27.49 to 37.27)	81.1 ± 12.48	82.49 (78.06 to 86.93)	25.36 (20.6 to 30.12)	3.08 (−3.41 to 9.58)	.35
<i>LEFS</i>								
Baseline (SD/CI)	20.08 ± 10.73	22.39 (17.77 to 27)		17.17 ± 11.68	25.13 (20.13 to 30.12)			
3 Month (SD/CI)	34.22 ± 13.59	34.74 (30 to 39.5)	12.36 (8.49 to 16.23)	29 ± 14.1	28.6 (23.65 to 33.56)	3.48 (0.63 to 7.58)	6.14 (−0.72 to 13)	.08
6 Month (SD/CI)	64.54 ± 8.76	67.24 (61.84 to 72.65)	44.86 (40.19 to 49.52)	60.05 ± 12.11	59.95 (54.85 to 65.05)	34.82 (30.53 to 39.12)	7.29 (−0.14 to 14.72)	.05
<i>ROM</i>								
Baseline (SD/CI)	30.62 ± 7.68	23.77 (21.12 to 26.42)		29.3 ± 9.3	29.3 ± 9.3			
3 Month (SD/CI)	13.25 ± 4.49	13.07 (10.34 to 15.8)	10.7 (7.93 to 13.47)	12.8 ± 7.28	12.8 ± 7.28	5.32 (2.18 to 8.46)	0.3 (−3.76 to 4.36)	.88
6 Month (SD/CI)	8.46 ± 5.77	7.22 (3.88 to 10.56)	16.55 (13.17 to 19.93)	7.22 ± 6.01	7.22 ± 6.01	11.26 (8.02 to 14.49)	0.39 (2.87 to 6.54)	.44

Abbreviations: Diff, Difference; Betw, Between; AOFAS, American Orthopaedic Foot and Ankle Society Hindfoot Scale; LEFS, Lower Extremity Functional Scale; ROM, range of motion.

Figure 2. Patient self-reported AOFAS hindfoot scale adjusted mean scores.

optimal time is to initiate a formal physical therapy program. The primary purpose of this study was to examine if initiating an early (within two weeks post-operatively) formal physical therapy program improves outcomes for patients with hindfoot fractures. With regard to the ITT analyses, both the AOFAS and LEFS self-reported outcomes favored the group initiating an early supervised program. However, the ITT analysis imputes data for participants that miss a follow-up session. In contrast, when comparing this to the sensitivity analysis where

patients that were lost to follow-up were excluded from the analyses, the results differ. Like the ITT analysis, the sensitivity analysis also demonstrated a significant group by time interaction for the AOFAS; however, there was not a significant interaction for the LEFS. The ITT analysis demonstrated no group by time interaction for ROM between the EARLY and LATE group; however, the sensitivity analysis demonstrated a significant group by time interaction. The purpose of doing a sensitivity analysis is to determine if the study results are contingent upon

Figure 3. Patient self-reported LEFS adjusted mean scores for EARLY and LATE groups.
Abbreviations: LEFS, Lower Extremity Functional Scale; Mo, Month.

Figure 4. Side-to-side differences in talocrural joint range of motion between EARLY and LATE groups.
Abbreviations: ROM, range of motion.

Table 4. Complications for the EARLY and LATE groups.

Complications	EARLY	LATE
Superficial Wound Complications	3	4
Deep wound complications	0	0
DVTs	0	1
STJ Early post-traumatic arthritis	2	7
Additional surgeries	1	3

Abbreviations: DVTs, Deep Vein Thrombosis; STJ, Subtalar Joint.

the analytic strategy utilized creating less confidence in the results, which was the case of this study. Our primary results suggest that either early physical therapy results in superior outcomes than standard-practice late physical therapy, or that there are equivocal outcomes with early vs. late physical therapy. Either way, we can conclude there does not appear to be any adverse effects by initiating an early supervised physical therapy program as some previous literature has suggested [18].

All patients demonstrated significant improvements in all clinical outcomes for this study. AOFAS scores were rated according to Dudkiewicz: 90–100 points

– excellent, 70–89 points – good, 40–69 points – moderate, and below 40 – poor [30]. At six months post-operatively, the mean AOFAS hindfoot score was 84.0 (95% CI 80.8 to 87.3) indicating good outcomes for this patient population.

At 6 months after operative repair of a hindfoot fracture, patients continued to demonstrate limitations in active range of motion of the talocrural joint compared to the contralateral side. Although the limitation of active ROM compared to the contralateral side was 8.0 degrees, this was still a 17% decrease compared to the unaffected side. This is consistent with previous literature in which significant long-term side-to-side differences have been reported for both the talocrural and subtalar joints after intra-articular calcaneal fractures and talar fractures [9,31,32].

Patients sustaining talar fractures achieved better self-reported outcomes than those patients sustaining calcaneal fractures. However, patients with lateral process fractures were included in this study and typically

report better clinical outcomes than those patients with talar neck, head, or body fractures. Therefore; these improved outcomes may not be a true reflection of talar neck or body fractures.

Keene et al. performed a systematic review of early ankle movement vs. immobilization in ankle fractures and found increased odds of wound complications in patients that initiated early ROM, however, they did not look specifically at patients who had incurred hindfoot fractures [18]. In our study, there were no deep wound infections requiring surgical intervention. Although one major concern of initiating an early supervised physical therapy program for this patient population was wound complications, there was no difference between the EARLY and LATE groups with the EARLY group experiencing three superficial wound complications and the LATE group incurring four superficial wound complications. All of these complications resolved with a course of oral antibiotics. There was only one reported deep venous thrombosis (DVT) which occurred in the LATE group. This is similar to other literature which has reported increased events of DVT in patients who are immobilized vs. those who begin early ankle motion after ankle fracture [18]. Of the nine patients that demonstrated early post-traumatic arthritis as evidenced by radiograph within one year after operative fixation, only two were in the EARLY group. Therefore, initiating an early supervised physical therapy program may be valuable in this patient population from a standpoint of facilitating joint nutrition through joint mobilization in combination with range of motion.

One limitation of this study was the high drop-out rate, and therefore, the results of this study must be interpreted with caution. Approximately 35% of patients dropped out of the study by the six-month follow-up period (50% in the LATE group and only 21% in the EARLY group). Patients were not compensated for participating in the study, which may have been a factor in the high attrition rate. In addition, patients sustaining these fractures are typically laborers and experienced greater difficulty in returning to their previous line of work. One such patient was on a temporary work visa and returned to his native country before completion of the study. Several other patients went through vocational rehabilitation, and were unavailable to attend long-term follow-up visits. In addition, there were no baseline differences between those that completed the study and those that did not complete the study at the six-month follow-up visit. Further, Younger has previously commented on the risk of 'participant fatigue' in orthopedic studies with long-term outcomes [33].

To our knowledge, there are no studies examining the effects of a supervised physical therapy program on the long-term outcomes of patients with hindfoot fractures. Therefore, additional research is needed in this area to

help guide the management of patients with these challenging and complex fractures. Future research should include cost analyses as our study suggests initiating a formal physical therapy program six weeks after post-operative treatment may lead to more complications than those who begin a formal physical therapy program earlier.

We recognize that an early supervised rehabilitation program may not be advantageous for every patient, as many other factors related to healing such as co-morbidities, patient compliance, and tissue integrity play a critical role in achieving successful patient outcomes. Nevertheless, the assumption that an early rehabilitation program can lead to complications such as disruption of wound or bone healing was not observed in this study. Furthermore, there may be some significant benefits to initiating an early rehabilitation program including minimizing complications such as early post-traumatic arthritis and additional surgical procedures; however, further research is needed.

Conclusion

Initiating an early supervised physical therapy program consisting of manual therapy and therapeutic exercise may improve long-term outcomes in patients after hindfoot fractures; however, this conclusion should be tempered due to the high drop-out rate in this study. Additionally, there appears to be no downside to initiating early therapy and starting early supervised physical therapy management of patients after hindfoot fractures may help mitigate other complications such as early onset post-traumatic arthritis and additional surgical procedures.

Key points

Findings

There appears to be a benefit for initiation and EARLY supervised physical therapy program for patients undergoing operative fixation for hindfoot fractures, as patients reported improved self-reported outcomes.

Implications

Patients historically do not initiate a formal physical therapy program until six weeks after operative fixation due to concerns with wound complications; however, we did not find any increased wound issues in this study for patients that initiated EARLY physical therapy and these patients also presented with less adverse events such as additional surgical procedures and early onset post-traumatic arthritis compared to the LATE group.

Caution

Due to a significant loss to follow-up at 6 months after operative fixation, the results of this trial should be interpreted with caution.

Disclosure statement

We affirm that we have no financial affiliation or involvement with any commercial organization that has a direct financial interest in any matter included in this manuscript, except as disclosed in an attachment and cited in the manuscript.

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