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ORIGINAL ARTICLE

Gait analysis and functional assessment of conservatively treated calcaneal fractures

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ABSTRACT

Objectives: This study aims to compare the functional scores and gait analysis data of patients undergoing conservative treatment after calcaneal fractures with healthy individuals and to evaluate both success of conservative treatment and the applicability and effectiveness of a novel smartphone-based gait analysis method in assessing post-fracture mobility.

Patients and methods: Between January 2017 and December 2022, a total of 30 patients (10 females, 20 males; mean age: 48.6±12.6 years; range, 19 to 65 years) who underwent conservative treatment due to calcaneal fractures and 30 healthy controls (12 females, 18 males; mean age: 45.3±12.7 years; range, 21 to 63 years) were retrospectively analyzed. Patients with completed fracture union and mobilized by full weight bearing on the fractured extremity were evaluated with ankle joint range of motion (ROM), American Orthopaedic Foot and Ankle Society (AOFAS), Short Form-36 (SF-36), Visual Analog Scale (VAS) functional scoring and gait analysis using the smartphone-based Gait Analyzer application, and the results were compared with the control group.

Results: After conservative treatment, there was no statistically significant difference in the ankle ROM values (dorsiflexion p=0.359, plantarflexion p=0.240), AOFAS (p=0.211), and SF-36 scores (physical function p=0.188, pain p=0.483, health change p=0.894) of the patient and control groups. The mean VAS score of the patient group was 2.83±1.80, indicating higher scores than those of the control group (p=0.035). There was a statistically significant change between the groups in terms of all gait parameters (gait velocity p=0.010, step time p<0.001, step length p<0.001, cadence p<0.001, step time symmetry p<0.001, step length symmetry p<0.001, vert-COM p<0.001).

Conclusion: Although the functionality and gait patterns of the patients may be affected after conservative treatment of calcaneal fractures, the fact that there was no significant difference between the patient and control groups indicates that this treatment method can be preferred in this group of patients, particularly in extra-articular and Sanders type 1 intra-articular fractures, with appropriate rehabilitation.

Keywords: Calcaneal fractures, conservative treatment, functional outcome, gait analysis, rehabilitation, smartphone.

Calcaneal fractures are among the most common fractures of the tarsal bones, accounting for 60% of tarsal bone fractures and 1 to 2% of all fractures.[1] After a calcaneal fracture, the physical activity of patients decreases significantly due to immobilization. As a result of pain and limited movement, quality of life of individuals may decrease and changes in gait patterns may occur. Gait disturbances, if persistent, may result in long-term complications such as postural imbalance, increased risk of falls, and degenerative changes in lower extremity joints.

Depending on the direction and effect of the forces acting, and the severity of the trauma, calcaneal fractures may present in various forms, ranging from simple non-displaced fractures to complicated fractures involving the joint surface and adjacent joints. The most optimal treatment method is chosen based on the general condition of the patient, fracture morphology, swelling in the fracture area, patient's expectations and comorbidities.[2] Treatment is mainly classified into two groups as conservative and surgical. Conservative treatment includes elevation, ice, and short-term non-weight bearing period followed by a gradual transition to

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the weight-bearing phase. In surgical treatment, fixation is applied using percutaneous wires, plates and screws with different surgical approaches (i.e., medial, extended lateral, sinus tarsi). The rehabilitation process is of utmost importance in both treatment methods.[3]

Calcaneus plays a critical role in human bipedal biomechanics, as it is the attachment site of many muscles and ligaments. Many factors have been shown to be implicated in the pathogenesis and the difficulty patients experience in mobilizing after calcaneal fractures. Pain which persists after union is one of the main obstacles to normal walking biomechanics. It is usually caused by surface incompatibility and stiffness in the subtalar joint and pain during weight bearing affects all mobility.[4] The range of motion (ROM) in the hindfoot joint is another factor which affects gait after a fracture.[4] Disturbances in the gait pattern also affect the functionality of patients and cause loss of manpower.[5]

Patients with calcaneal fractures may face several difficulties, as the ideal treatment of these fractures is not fully known.[6] Previous studies have mostly compared the results of surgical and conservative treatment of severely displaced intra-articular calcaneal fractures and shown similar functional outcomes.[7] To the best of our knowledge, there is no study in the literature which examines the effect of calcaneal fracture on human gait using smartphone-based gait analysis and compares the results with healthy individuals. In the present study, we, for the first time, aimed to compare the functional scores and gait analysis data of patients undergoing conservative treatment after calcaneal fractures with healthy individuals and to evaluate both the success of conservative treatment and the applicability and effectiveness of a novel smartphone-based gait analysis method in assessing post-fracture mobility.

PATIENTS AND METHODS

Study design and study population

This single-center, retrospective study was conducted at Department of Orthopedics and Traumatology of a tertiary care center between January 2017 and December 2022. Initially, patients who were conservatively treated due to calcaneal fractures were screened. Inclusion criteria were as follows: age between 18 and 65 years, having unilateral calcaneal fracture, having no history of fracture or surgery in the lower extremity other than unilateral calcaneal fracture, having no neurological or musculoskeletal disease that can cause gait disturbance, and having at least 18-month follow-up data. Patients younger than 18 and older than 65 years of age, those with a history of previous surgery in the same or contralateral lower extremity, patients with a history of malignancy or neurological disease that can affect the gait pattern, those with open fractures or a history of spinal trauma or hereditary-acquired disorders of the spine were excluded from the study. Finally, a total of 30 patients (10 females, 20 males; mean age: 48.6±12.6 years; range, 19 to 65 years) who underwent conservative treatment due to calcaneal fractures and 30 age- and sex-matched healthy controls (12 females, 18 males; mean age: 45.3±12.7 years; range, 21 to 63 years) were included. Of the 30 patients included in the study; 15 (50%) had extra-articular fractures, five (16.66%) had nondisplaced (Sanders type 1) intra-articular fractures. The remaining 10 (33.33%) patients had Sanders type 2, 3, and 4 fractures, and five of these patients had a high risk of developing soft tissue problems after surgery, three of them could not tolerate surgery due to comorbidities, and two of them voluntarily refused surgical treatment and, thus, conservative treatment was decided. The majority of the patients had extra-articular fractures or Sanders type 1 intra-articular fractures, which were the primary focus of conservative treatment.

The control group consisted of age- and sex-matched healthy volunteers without a history of lower extremity trauma, surgery, or chronic musculoskeletal and neurological disease. Individuals with minor complaints (pre-existing minimal osteoarthritis, VAS <3) were not excluded to reflect a realistic healthy population sample.

After the inclusion and exclusion criteria were determined, a sample size calculation was performed to ensure adequate statistical power. Using the "Means: Difference between two independent means" test and "Two-tailed", an effect size (d) of 0.80 was determined. With a statistical power of 80% and a significance level of 0.05, it was calculated that at least 26 participants would be needed per group. The sample size analysis performed using the G*Power 3.1.9.2 software.

Written informed consent was obtained from each participant. The study protocol was approved by the University of Health Sciences, Gülhane Training and Research Hospital, Non-Interventional Scientific Research Ethics Committee (Date: 10.10.2024, No: 2024-17). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Treatment protocol

The conservative treatment protocol included short leg circular cast with the ankle in a slightly equinus position. In the presence of severe edema, since compartment syndrome may develop after the circular cast, a short leg splint was applied, and elevation and ice were recommended. If the edema decreased, short leg cast treatment was started after five to seven days. Elevation, ice, non-weight bearing, and rest were recommended to all patients. Appropriate antithrombotic, analgesic and proton pump inhibitor medications were prescribed.

All patients were scheduled for follow-up on a weekly basis. During follow-up visits, the fracture was evaluated and an appropriate exercise program was tailored with a physiotherapist. Our goal for the first week was to reduce edema with elevation and ice and to control the pain. After two to four days, all patients were allowed to mobilize with crutches or walkers without putting any weight on the broken foot. Toe movements were recommended to prevent contractures in the toes and to help reduce edema, and isometric strengthening exercises were recommended to prevent muscle atrophy which may develop in the calf and upper leg due to disuse.

The cast was removed after two weeks and the patients were instructed to use a hinged ankle brace which allowed controlled mobilization while maintaining ankle stability. Active ankle joint movements were started. Exercises help to regress edema, prevent deep vein thrombosis, and contracture development, and also make it easier for the patient to be ready for mobilization. All patients were prescribed a standard rehabilitation protocol including range-of-motion exercises, calf stretching and strengthening, proprioceptive training and gradual weight-bearing exercises with sessions scheduled three times per day, for 12 weeks, and they were controlled weekly. Strengthening exercises with TheraBand were started as of Week 6.

After Week 8, considering the union findings as evidenced by the radiographs and pain tolerance status of the patient, the controlled weight bearing phase was initiated with crutches or a walker. The controlled weight-bearing phase was supported by ankle strengthening and closed chain exercises. This phase was started with 25% of the body weight in the first week, continued with 50% in the second week, 75% in the third week, and the phase was completed when the patient was able to bear full weight on the fractured side in the fourth week. Patient adherence to the treatment protocol was monitored through regular follow-up appointments.

We aimed for the patients to walk with full weight bearing at the end of Week 12. At the end of Week 12, patients who could put full weight on the fractured side without using an assistive device were allowed to drive.

Functional assessment and gait analysis

In the present study, patients who completed the treatment process and mobilized by giving full weight to the fractured extremity were evaluated in terms of functionality and pain with the American Orthopaedic Foot and Ankle Society (AOFAS), Visual Analog Scale (VAS), and Short Form-36 (SF-36). In addition, ankle joint ROM (dorsiflexion-plantar flexion angles) and gait parameters of these patients were measured and recorded.

Gait analysis was performed using the Gait Analyzer version 0.9.95.0 (Control One LLC, NM, USA) smartphone application compatible with the Samsung Galaxy Note 10 Plus (143.3×71.1×6.3 mm; 141 g) smartphone as described previously.[8] A waist belt with a pocket on it was attached to the waist of the subjects. The smartphone was placed vertically in the pocket so that it was in line with the midline of the body and the L3 spinous process (Figure 1).[9] To ensure calibration of the application, the patients first walked on a flat surface for 30 sec and then for 25 m walkway at a self-selected walking speed to mimic their natural

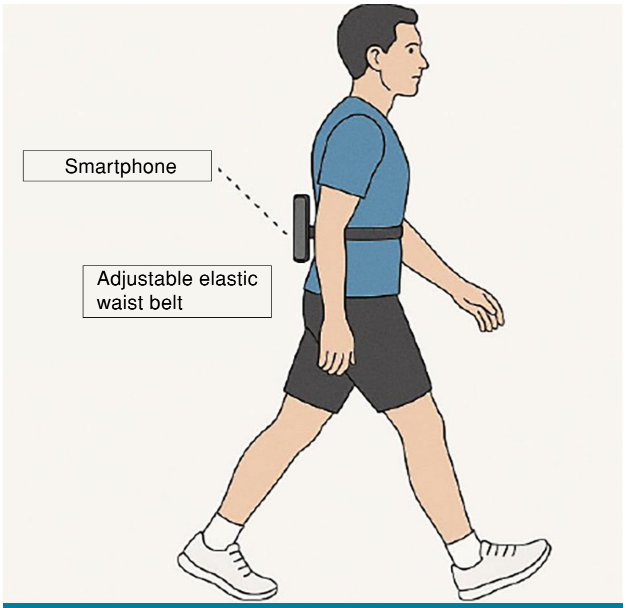

FIGURE 1. Placement of smartphone on waist of the subject.

walking pattern in real-life settings which leads to more accurate and natural data, thus better reflects their true gait pattern. Walking speed, step time, step length, cadence, step time symmetry, step length symmetry and vertical-COM (vert-COM) parameters were recorded.

Statistical analysis

Statistical analysis was performed using the SPSS for Windows version 20.0 software (IBM Corp., Armonk, NY, USA). Continuous variables were presented in mean ± standard deviation (SD) or median (min-max), while categorical variables were presented in number and frequency. The normality of distribution of variables was checked using the Shapiro-Wilk test. In the comparison of continuous variables and scale scores between two groups, the independent samples t-test was used for data that conformed to normal distribution, and the Mann-Whitney U test for data that did not conform to normal distribution. The relationships between scale scores and gait analysis values were tested with the partial correlation coefficient which was selected to eliminate the effect of age in correlation analyses. A *p* value of <0.05 was considered statistically significant.

RESULTS

The demographic data of the patients and healthy subjects are shown in Table I. There was no statistically significant difference in the demographic data between the groups (p>0.05).

There was no statistically significant difference in ankle dorsiflexion (p=0.359) and plantarflexion (p=0.240) angle/degree between the groups.

There was no statistically significant difference in the mean AOFAS (p=0.211), SF-36 physical function (p=0.188), SF-36 pain (p=0.483) and SF-36 health change (p=0.894) scores between the groups. However, the mean VAS scores of the patients were higher than those of healthy individuals,

TABLE I
Demographic data of the patients and healthy individuals

	Patient group (n=30)			Control group (n=30)				
	n	%	Mean±SD	n	%	Mean±SD	*p*	Cohen's d
Age (year)			48.6±12.6			45.3±12.7	0.308[a]	0.265
Length (cm)			170.40±8.55			173.33±9.85	0.223[a]	–0.318
Weight (kg)			75.83±14.45			78.37±14.95	0.507[a]	–0.173
Body mass index (kg/m²)			26.03±4.20			25.93±3.48	0.923[a]	0.026
Sex							1.000[b]	-
Female	10	33,3		12	40.0			
Male	20	66,6		18	60.0			
Broken side							-	-
Right	12	40		-	-			
Left	18	60		-	-			

SD: Standard deviation; a: Independent samples t-test; b: Chi-square test.

TABLE II
AOFAS, SF-36, and VAS scores

	Patient group (n=30)	Control group (n=30)		
	Mean±SD	Mean±SD	*p*	Cohen's d
AOFAS	80.23±13.51	83.97±8.89	0.211[a]	–0.327
SF-36 Physical function	74.67±19.33	79.83±20.32	0.188[b]	–0.26
SF-36 Pain	71.66±18.21	76.833±12.79	0.483[b]	–0.329
SF-36 Health change	60.83±23.38	61.66±23.42	0.894[b]	–0.035
VAS	2.83±1.80	1.87±1.45	**0.035**[b]	0.587

SD: Standard deviation; AOFAS: American Orthopaedic Foot and Ankle Society; SF-36: Short Form-36; VAS: Visual Analog Scale; a: Independent samples t-test; b: Mann-Whitney U test.

TABLE III
Gait analysis results

	Patient group (n=30)	Control group (n=30)		
	Mean±SD	Mean±SD	*p*	Cohen's d
Gait velocity (m/sec)	0.99±0.30	1.33±0.61	0.010[a]	–0.707
Step time (sec)	0.71±0.15	0.56±0.04	<0.001[b]	1.366
Step length (m)	0.88±0.42	0.56±0.19	<0.001[a]	0.982
Cadence	91.50±14.86	107.19±7.28	<0.001[a]	–1.341
Step time symmetry	17.75±10.21	9.31±6.46	<0.001[b]	0.988
Step length symmetry	18.72±8.39	9.59±5.32	<0.001[b]	1.3
Vert-COM	2.74±0.58	1.89±0.69	<0.001[a]	1.334

Vert-COM: vertical-COM: a: Independent samples t-test; b: Mann-Whitney U test.

indicating a statistically significant difference (p=0.035) (Table II).

Gait analysis of the patients and healthy subjects are shown in Table III. A statistically significant difference was observed between the groups in terms of gait velocity (p=0.010), step time (p<0.001), step length (p<0.001), cadence (p<0.001), step time symmetry (p<0.001), step length symmetry (p<0.001) and vert-COM (p<0.001) values.

The correlation between the VAS scores and gait analysis is presented in Table IV. Accordingly, there was a negative correlation between the VAS scores and gait velocity (r=–0.451, p=0.014) and cadence (r=–0.390, p=0.036) values. There was a positive correlation between the VAS scores and step time (r=0.427, p=0.021), step time symmetry (r=0.300, p=0.011) and step length symmetry (r=0.138, p=0.047) values. However, there was no significant correlation between the VAS scores and step length (r=0.345, p=0.067) and vert-COM values (r=0.317, p=0.093).

No dropouts occurred during follow-up period. All participants completed the full evaluation.

TABLE V
Correlation analysis results of VAS scores and gait analysis

Variables	r*	*p*
Gait velocity	**–0.451**	**0.014**
Step time	**0.427**	**0.021**
Step length	0.345	0.067
Cadence	**–0.390**	**0.036**
Step time symmetry	**0.300**	**0.011**
Step length symmetry	**0.138**	**0.047**
Vert-COM	0.317	0.093

Vert-COM: Vertical-COM; * Partial correlation coefficient.

DISCUSSION

Following the injury, patients cannot bear weight on their lower extremities for weeks, their physical activity is restricted, and return to daily activities and work life is delayed. Buckley et al.[10] showed that approximately 20% of these patients could not return to work even one year after the injury. In addition, some authors have suggested that individuals with these injuries can be incapacitated for up to three years and afterwards partially impaired for several years. Calcaneal fractures, which cause serious morbidity and socioeconomic effects, also cause loss of workforce and productivity.[5]

In the present study, to bridge the gap in the literature on this subject, we compared the functional scores and gait analysis data of patients who underwent conservative treatment after calcaneal fractures with healthy individuals. Our study results showed that there was no significant difference in the functionality and gait patterns between the patients and healthy individuals and that conservative treatment could be preferred in this patient group, particularly in extra-articular and Sanders type 1 intra-articular fractures, combined with appropriate rehabilitation. There is no definitive consensus in the literature for the treatment of calcaneal fractures. While some authors recommend surgical treatment, others suggest that there is no significant difference between surgical and conservative treatment. In their study, Catani et al.[11] showed that even if the articular surface was anatomically reduced, the original function of the foot could not be regained for daily living activities and walking. This is further proven by an experimental study suggesting that the profound and probably irreversible damage to the cartilage during high-energy trauma was the main culprit.[12]

In addition to individual efforts, there are many randomized-controlled trials conducted to establish a definitive consensus on the treatment of these fractures.[13] In a multi-center, prospective, randomized-controlled study comparing surgical and non-surgical treatment of displaced intra-articular calcaneal fractures, Agren et al.[14] reported that there was no statistically significant difference in the one-year follow-up results of the patient groups.

In the current study, we attempted to facilitate the mobilization process and return to daily living activities by starting the exercise at an early stage. Previous studies have demonstrated that functional results are improved in patients who start early exercise after conservative treatment and, thus, priority should definitely be given to the exercise program at an early stage.[3,15,16]

Furthermore, it has been well documented that ankle joint movements are adversely affected following calcaneal fractures. In the present study, average dorsiflexion and plantarflexion degrees of the patients were lower than the healthy controls; however, it did not reach statistical significance. This finding suggests that, in patients who start early exercise, ankle joint ROM can be regained similarly to healthy individuals, and this can increase both the functionality and quality of life of the patients.

Pain is a crucial determinant affecting return to work and overall patient satisfaction. Persistent pain is thought to be related to soft tissue damage which occurs after trauma in patients with calcaneal fractures.[17] In our study, the mean VAS score value of the patients was 2.83±1.80 in the patient group and 1.87±1.45 in the control group, indicating a statistically significant difference. Despite this, we believe that the mean VAS is relatively low in the patient group (2.83±1.80 out of 10). We believe that the low pain scores are due to the effectiveness of the analgesic and anti-inflammatory treatments recommended after the fracture, subsiding inflammatory process in the broken area over time, and the patients reaching a more tolerable level thanks to the appropriate rehabilitation programs.

In the present study, the mean AOFAS score of the patients (80.23±13.51) was lower than healthy individuals; however, there was no statistically significant difference between the groups ($p=0.211$). Ibrahim et al.[18] also found that 11 patients treated conservatively after calcaneal fractures had an average AOFAS score of 78.5 after 15 years of follow-up. The lack of a significant difference between the groups in our study suggests that pain levels are not always directly related to functional capacity and that pain is a subjective experience and some patients can tolerate it without significantly affecting their functions. Furthermore, the SF-36 is one of the patient-reported outcome scales which evaluates the emotional state, functional capacity, quality of life and general health of the person in eight subdomains. Although the scores of the patients in all subscales were lower than the healthy controls in our study, we observed no statistically significant difference between the groups. However, in another study including 161 patients with intra-articular calcaneal fractures, the patients were matched and compared with the overall population in terms of age, sex, and social status.[19] In the patient group, lower scores were obtained in all subscales of the SF-36 scale compared to the overall population and were found to be statistically significant.[19]

Gait disorders are associated with many diseases. Disturbances in gait patterns can lead to falls, injuries, and significant decreases in quality of life. Quantitative gait analyses help us identify these pathologies that impair gait and evaluate the progression of the current condition or the effectiveness of treatments. These analyses can be performed in a laboratory environment with special equipment; however, thanks to advanced technology, they can be currently performed with simpler, more accessible, and portable devices. Although marker-based gait analysis systems are the gold standard and provide high accuracy, they are costly, time-consuming, require trained personnel, and are laboratory-dependent systems. Currently, with the developments in inert sensor technology, accelerometers have been placed in electronic devices such as smartphones/iPods. In recent years, the use of smartphones in the health field has become widespread, and a significant progress has been made in gait analysis performed with smartphones. Several studies also support the fact that smartphones can effectively measure human body movements.[20] In the present study, we used the Gait Analyzer application which measures the spatiotemporal parameters of gait in a simple way.[9] Of note, since the objective is to evaluate between-group differences rather than within-subject consistency or inter-rater reliability, ICC analysis would not be methodologically aligned with the study design, which is expected to be addressed in future studies. However, in terms of gait application, to the best of our knowledge, the gait analysis app has not yet been validated specifically in patients with conservatively treated calcaneal fractures. As such, no ICCs or validation metrics are currently available for this subgroup. We acknowledge this as a limitation and suggest that future studies evaluate the test–retest reliability and validity of the app in this population to ensure the robustness of the gait measurements. According to the gait analysis data, we observed a statistically significant difference between the patient and control groups in terms of gait velocity, step time, step length, cadence, step time symmetry, step length symmetry and vert-COM values. Most pathologies associated with gait disturbance manifest themselves with a decrease in gait velocity. Also, it has been reported that vert-COM displacement is associated with energy consumption.[21] Also, the step time symmetry and step length symmetry of the patients were significantly impaired compared to the healthy controls in our study. The impairment of symmetry indicates irregularities in gait pattern and balance problems. These impairments in gait pattern may lead to an increase in the mechanical load that occurs during walking, thereby resulting in adverse effects on the joints in the long term.[22] In addition, some studies have indicated that there is a positive correlation between asymmetry and the metabolic power expenditure during walking. In a study of Ellis et al.,[23] the relationship between the symmetry of the steps and the metabolic power expenditure during walking was analyzed. According to the results, the metabolic power cost of those with an asymmetrical gait was higher than normal. Also, the impairment of symmetry suggests that patients spend more energy to maintain balance, and this may increase the feeling of fatigue in the long term.

In our study, we also evaluated the possible correlation between the VAS scores and gait analysis. Decreased gait velocity and cadence, increased step time, and impaired step time symmetry and step length symmetry along with increased VAS scores suggest the adverse effects of pain on gait. We observed a positive correlation between VAS scores and step time symmetry and step length symmetry, indicating that gait symmetry deteriorates with the increase in scores. The patients exhibited a more balanced gait, as the VAS scores decreased, which was associated with gait efficiency. These results indicate the effects of the patients' subjective pain perception on gait patterns.

One of the main factors that may have influenced gait outcomes in our study is the type of fractures. It is well known that displaced intra-articular fractures are associated with subtalar joint incongruity and stiffness, which can lead to long-term alterations in gait mechanics.[5] In contrast, extra-articular or minimally displaced intra-articular fractures (e.g., Sanders type 1) usually preserve joint congruence, allowing for more favorable biomechanical outcomes during walking. Although our study group included a heterogenous population with various fracture patterns, the majority consisted of patients with extra-articular or minimally displaced intra-articular fractures. This may explain the absence of significant differences in some functional scores and the relatively mild gait deviations observed.

Another important consideration is the potential for selection bias. Since our study included only patients who completed follow-up and were able to undergo gait analysis, it is possible that individuals with poorer outcomes or persistent functional limitations may have been unintentionally excluded. However, we sought to minimize this risk by including all eligible patients with confirmed fracture union and the ability to bear full weight, regardless of their functional scores. Importantly, no patients were excluded based on pain severity or gait quality at the time of evaluation, which we believe enhances the representativeness and generalizability of our findings.

The results of this study have important implications for the clinical management of calcaneal fractures. In our cohort, patients treated conservatively, particularly those with extra-articular or minimally displaced intra-articular fractures (e.g., Sanders type 1), demonstrated satisfactory functional recovery and relatively minor gait deviations compared to healthy controls. These findings suggest that patients with preserved joint congruence and minimal displacement are likely to benefit most from conservative treatment. In addition, younger individuals with good baseline mobility and no significant comorbidities also showed favorable outcomes. The comparable functional scores and mild gait deviations observed in these patients indicate that non-operative management can lead to satisfactory results, while avoiding complications associated with surgical intervention, such as wound healing problems, infection, or hardware-related issues. These results support a more selective and confident use of conservative approaches in clinical practice, potentially reducing patient morbidity and health care burden. Furthermore, the integration of smartphone-based gait analysis in this study highlights the growing potential of accessible, objective tools for functional monitoring in outpatient settings. However, it is essential to acknowledge the heterogeneity of fracture types in our study and the relatively short follow-up period. Therefore, future large-scale, prospective studies with longer follow-up are needed to validate these preliminary findings and to refine treatment guidelines and to better delineate the long-term functional outcomes of conservative management in calcaneal fractures.

Nonetheless, there are some limitations to be acknowledged. First, it has a single-center, retrospective design. Second, fractures were not classified as extra-articular and intra-articular fractures; instead, they were considered a single group. Having a heterogeneous group in terms of fracture morphology may not clearly reflect the effect of conservative treatment on functionality, quality of life and gait pattern of the patients. Third, during the gait analysis, the patients were asked to walk at a self-selected walking speed. Studies have indicated that particularly the parameters related to symmetry are evaluated more accurately during fast walking and gait analysis should be repeated at several different walking speeds to obtain more accurate results.[24,25] Fourth, the relatively small sample size may have affected the accuracy of our results. Fifth, we acknowledge that the absence of a second observer may represent a potential limitation. However, given the standardized placement procedure and repeated practice prior to data collection, we believe that this source of bias was effectively minimized. Finally, although all patients included in our study completed the 18-month follow-up period, differences were observed during the total follow-up periods which may have also affected our results.

On the other hand, the main strength of this study is that, to the best of our knowledge, there is no study in the literature examining the effect of calcaneal fracture on human gait using smartphone-based gait analysis and comparing the results with healthy individuals. Our study is the first to compare the functional scores and gait analysis data of patients undergoing conservative treatment after calcaneal fractures with healthy individuals. We believe that this study would provide additional contribution to the body of knowledge in the literature on this subject.

In conclusion, although the functionality and gait patterns of the patients may be affected after conservative treatment of calcaneal fractures, the lack of a significant difference between the patient and control groups indicates that this treatment method can be preferred in this group of patients, particularly in extra-articular and Sanders type 1 intra-articular fractures, combined with appropriate rehabilitation. The findings emphasize the importance of short-term immobilization and appropriate rehabilitation program to manage pain, maintain gait symmetry, and improve overall quality of life. Of note, future large-scale and long-term follow-up studies may contribute to the development of more targeted strategies to better understand the effects of conservative treatment and improve patient outcomes.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Conceptualization, methodology, data collection, data interpretation, writing the article, review & editing: E.Y., M.A.; Supervision: M.A. All authors read and approved the final manuscript.

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