Functional Outcome and Patient Satisfaction After Displaced Intra-Articular Calcaneal Fractures: A Comparison Among Open, Percutaneous, and Nonoperative Treatment

A. Siebe De Boer[1], Esther M.M. Van Lieshout, MSc, PhD[1], Dennis Den Hartog, MD, PhD[1], Bas Weerts, MD[2], Michael H.J. Verhofstad, MD, PhD[1], Tim Schepers, MD, PhD[1,3]

[1] Trauma Research Unit, Department of Surgery, Erasmus MC, University Medical Center Rotterdam, Rotterdam, The Netherlands

[2] Department of Orthopedic Surgery, Erasmus MC, University Medical Center Rotterdam, Rotterdam, The Netherlands

[3] Trauma Unit, Department of Surgery, Academic Medical Center, Amsterdam, The Netherlands

Level of Clinical Evidence: 3

Keywords: calcaneus, complication, conservative treatment, joint depression, open reduction internal fixation, trauma

ABSTRACT

The aim of the present study was to compare the outcomes of patients with a displaced calcaneal fracture treated by open reduction and internal fixation (ORIF), percutaneous treatment, or nonoperative methods. A retrospective cohort study was conducted at a level I trauma center of patients with a displaced intra-articular calcaneal fracture treated from January 1, 2002 to December 31, 2011. The patient-reported outcome measures included the Foot Function Index, American Orthopaedic Foot and Ankle Society hindfoot scale, Short Form-36, the EQ-5D from the EuroQol Group, and a 10-point visual analog scale. Clinical data were collected from 169 patients, and questionnaires were obtained from 78 patients (18 nonoperatively, 27 ORIF, and 33 percutaneously). The late intervention rate was significantly greater in the percutaneous group (N=18; 30%) than in the ORIF group (N=6; 12%) or the nonoperative group (N=8; 13%; *p*=.030). Significantly more disability was reported in the nonoperative group (median Foot Function Index score, 40 points) than in the ORIF group (median, 16 points; *p*=.010) or in the percutaneous group (median, 21 points; *p*=.034). In conclusion, the operatively treated patients (ORIF and percutaneous treatment) reported better functional outcome scores (Foot Function Index and American Orthopaedic Foot and Ankle Society hindfoot scale) than did the nonoperatively treated patients.

INTRODUCTION

Displaced intra-articular calcaneal fractures will occur mainly (60%) in patients who are still in their wage-earning period (i.e., 30 to 50 years old). The interval to work resumption has often been 5 to 10 months (1). A considerable number of patients will not be able to resume work within 1 year (2,3). These fractures can remain symptomatic for 1 to 2 years and can lead to the need for secondary arthrodesis in up to 16% of the nonoperatively treated patients (1,4).

In the Netherlands, the most frequently applied treatment modalities have been open reduction and internal fixation (ORIF; 46%), nonoperative treatment (39%), and percutaneous treatment (10%) (5).

Six meta-analyses of 4 randomized controlled trials, 1 prospective cohort study, and 3 retrospective studies have indicated a trend toward an overall improved outcome (e.g., work resumption, prevalence of complications, functional outcome, and shoe adjustments) in patients treated with ORIF (6–11). However, because most studies were powered for specific outcomes and used different outcome scores, no definitive answer to the best treatment can be given. To minimize surgical complications such as infection or nerve damage after calcaneal fracture repair, different minimally invasive, percutaneous techniques have been introduced (12,13). The percutaneous techniques have not been investigated as extensively as ORIF.

The primary aim of the present study was to examine the effect of ORIF, percutaneous, and nonoperative treatment using the Foot Function Index in adult patients who had sustained a displaced intra-articular calcaneal fracture. In addition, the effect of treatment on health-related quality of life, overall patient satisfaction, interval to work resumption, and the prevalence of complications and late interventions was examined.

PATIENTS AND METHODS

All consecutive patients with a displaced intra-articular calcaneal fracture ("International Classification of Diseases, 10th revision" code S92.06) (14) treated at a level I trauma center from January 1, 2002 to December 31, 2011 were considered eligible for the present retrospective case series. The patients were identified from patient registries using the Diagnosis Related Group for both diagnosis (code 236; calcaneal fracture) and surgery (code 339732; operative treatment calcaneal fracture). Fracture management consisted of ORIF, percutaneous treatment, or nonoperative treatment.

The patients were treated by a general orthopedic surgeon (Monday and Thursday) or an orthopedic trauma surgeon (the rest of the week). Both had different local preferences. Because of the retrospective nature of our study, the treatment choice could not be determined on a case basis. A general orthopedic surgeon (B.W.) primarily conducted the nonoperative management (19 of 24 patients, 79%), and the orthopedic trauma surgeons (D.D.H., T.S.) preferred operative management (105 of 145 patients, 72%). Until June 1, 2005, the primary operative management in this group was percutaneous treatment (33 of 33 patients, 100%). After June 1, 2005, the policy was changed to ORIF (48 of 72 patients, 67%), based on the available evidence. Surgeon experience with a certain technique and preference was the decisive factor between the choice of ORIF and percutaneous treatment. The other reasons for surgery included open or fracture dislocation.

The inclusion criteria for patient selection were an intra-articular calcaneal fracture with more than 2 mm of displacement (i.e., Sanders type II to IV) and age 16 to 70 years. The exclusion criteria were primary arthrodesis or amputation, a Gustilo grade III open fracture, known alcohol or drug abuse, and wheelchair-bound patients with a neurologic disability before, or caused by, the injury. Secondary arthrodesis was considered a

complication of primary treatment and was included in the analysis. Functional outcome was determined after the patients had provided written informed consent. Patients with American Society of Anesthesiologists class IV, those who had died, those with an unknown address or who had moved abroad, patients without trauma radiographs, and patients with an ongoing psychiatric illness or insufficient comprehension of the Dutch or English language to understand the study documents were also excluded. The local medical research ethics committee approved the study.

The patients received 1 of 3 different treatment modalities. Nonoperative management consisted of early non-weightbearing movement exercises or a plaster-of-Paris cast. In this cohort, closed reduction by external compression (molding) was not performed.

The current reference standard for the treatment of displaced intra-articular calcaneal fractures is ORIF using an extended lateral approach. In most cases, a sharp 100° to 110° angled incision was used, with the vertical limb situated almost over the lateral edge of the Achilles tendon. The fracture was fixed using a titanium nonlocking calcaneal plate (Synthes Bettlach GmbH, Bettlach, Switzerland), using titanium 3.5-mm screws (15).

Percutaneous treatment, as described by Forgon and Zadravecz (16) and Zadravecz and Szekeres (17) was performed using three 3.0-mm Kirschner wires inserted through the tuberosity of the calcanei, talar neck, and cuboid. A distracting force was applied with an external fixator between the talus and calcaneus and between the talus and cuboid. Additional Kirschner wires were used as “joysticks” to reduce the posterior facet. Osteosynthesis was performed under fluoroscopic control with 6.5-mm cannulated Biomet (Biomet NL, Dordrecht, The Netherlands) or 7.3-mm Synthes (Synthes Bettlach GmbH) screws (18).

The patient characteristics (i.e., gender, age at trauma, and comorbidities), fracture characteristics (i.e., affected side, trauma mechanism, and injury classification), treatment characteristics (i.e., treatment type, open or closed approach, and duration of plaster immobilization and non-weightbearing), complications, and late interventions were obtained from the electronic patient files. Data were collected by 5 of us (A.S.D.B., B.W., D.D.H., E.M.M.V.L., and T.S.).

Infectious complications were divided into superficial (i.e., minor) and deep (i.e., major) using the criteria from the Centers for Disease Control and Prevention to define a surgical site infection (19). Superficial infections could be treated nonoperatively (e.g., using oral antibiotics). Infections that required surgical intervention, readmission, or intravenous antibiotics were classified as deep infections (15).

The fractures were classified according to Essex-Lopresti (20) and Sanders et al (21). Böhler's angle was measured from the trauma and follow-up radiographs. The patients were queried regarding their dominant side, smoking habits, and work and sports activities at the age of trauma and at follow-up. Furthermore, the cosmetic result observed by the patients and any shoe adjustments were queried.

Patient-reported functional outcome was measured using validated questionnaires, which were sent by mail in September 2012. The Foot Function Index (primary outcome measure) was developed to measure the effect of the foot pathologic features on function in terms of pain, disability, and activity restriction (22). Twenty-three questions were scored from 1 (no pain, no difficulty, none of the time) to 10 (worst pain imaginable, so difficult or unable, all the time). The final maximum score could reach 100 points, with a higher score indicating more disability.

The American Orthopaedic Foot and Ankle Society hindfoot scale includes 9 questions related to the subdomains of pain (1 question; 40 points), function (7 questions; 50 points), and alignment (1 question; 10 points) (23,24). The maximum score is 100.

The Short Form-36 (SF-36) questionnaire is a validated multipurpose health survey with 36 questions, representing 8 health domains that are combined into physical (PCS) and mental component summaries (25,26). Scores from 0 to 100 points are derived for each domain, with lower scores indicating poorer function. The 1998 U.S. population was used as the reference because weighing factors for the PCS and mental component summary for the Dutch population are not available.

The EQ-5D is a validated questionnaire for health-related quality of life (27,28). The EQ-VAS is a standard vertical 20-cm visual analog scale for recording an individual's rating of their current health-related quality of life.

A 10-point visual analog scale, with 0 implying maximum dissatisfaction and 10, full satisfaction, was used to measure patient satisfaction with the overall outcome (18). The assessors of outcome (A.S.D.B., E.M.M.V.L.) were not involved in patient treatment.

The data were analyzed by 2 of us (E.M.M.V.L. and T.S.) using the Statistical Package for the Social Sciences, version 20 (SPSS, Chicago, IL). Continuous data were found to deviate from a standard normal distribution (determined by inspecting frequency histograms and Q–Q plots) and are expressed as the median and first to third quartile (P_{25}-P_{75}). Kruskal-Wallis analysis of variance with post hoc pairwise comparison using a Mann-Whitney U test was performed to assess the statistical significance of the continuous data among the treatment groups. Categorical data are presented as numbers and percentages and were analyzed using chi-square tests. A p value of $< .05$ was taken as the threshold of statistical significance.

RESULTS

Demographic data

During the 10-year study period, 178 patients were treated for a displaced intra-articular calcaneal fracture. Nine patients were excluded from the present study because the Sanders classification could not be determined owing to missing radiologic images or insufficient image quality. Clinical data were collected for the remaining 169 patients. Of the 169 patients, 59 had been treated nonoperatively, 49 with ORIF, and 61 percutaneously (Table 1). The median age at trauma was 41 years (P_{25}-P_{75} 33 to 50), and 130 patients (77%) were male. The right calcaneus was fractured in 77 patients (46%), and 23 patients (14%) had a bilateral calcaneal fracture. The fractures had mainly resulted from a fall from a height (n = 104; 62%) or low energy trauma (n = 38; 22%). Of the 169 patients, 45 (27%) had additional injuries. These baseline characteristics were not significantly different statistically among the 3 treatment groups.

When classified according to Essex-Lopresti (20), most of the fractures were of a joint depression type (n = 97; 57%) or a tongue type (n = 58; 34%). Comminuted fractures (not classifiable as joint depression or tongue type) were found in only 8 patients, 7 of which were treated with ORIF (p = .007). In each of the 3 groups, approximately 80% of fractures were Sanders type II.

Of the 169 patients, 108 were invited to complete the questionnaires because 61 had met an exclusion criterion (Fig. 1). Of the 108 patients, 78 returned the questionnaire (response rate 72%). Of the 78 respondents, 18 (23.1%) had been treated nonoperatively, 27 (34.6%) with ORIF, and 33 (42.3%) percutaneously (Table 2). The respondents had patient and fracture characteristics similar to those for the total study population of 169 patients. The median body mass index was 25 kg/m2, 10 patients reported cardiovascular disease or diabetes, and 42% smoked at the time they had sustained the trauma. The

patients' preferred (dominant) side was affected in 60% of the patients (Table 2). These characteristics were not significantly related to the treatment received. The same was true for the duration of plaster immobilization and non-weightbearing (Table 2).

Table 1: Characteristics and outcome for entire study population (N=169)

	Overall (N=169)	Non-operative (N=59)	ORIF (N=49)	Percutaneous (N=61)	P-value*
Age at trauma† (years)	41 (33-50)	40 (32-50)	41 (33-50)	44 (34-51)	.573 / .542
Male gender‡	130 (77%)	46 (78%)	38 (78%)	46 (75%)	.939 / .825
Affected side‡					
Right side	77 (46%)	27 (46%)	24 (49%)	26 (43%)	.551 / .649
Left side	69 (41%)	21 (36%)	21 (43%)	27 (44%)	
Bilateral	23 (14%)	11 (19%)	4 (8%)	8 (13%)	
Trauma mechanism‡					
LET	38 (22%)	13 (22%)	13 (27%)	12 (20%)	.130 / .453
HET fall from height	104 (62%)	32 (54%)	32 (65%)	40 (66%)	
HET other	5 (3%)	1 (2%)	1 (2%)	3 (5%)	
Other	1 (1%)	0 (0%)	1 (2%)	0 (0%)	
Unknown	21 (12%)	13 (22%)	2 (4%)	6 (10%)	
Concomitant injuries‡	45 (27%)	17 (29%)	12 (24%)	16 (26%)	.238 / .528
Essex-Lopresti classification‡					
Tongue Type	58 (34%)	18 (31%)	17 (35%)	23 (38%)	.007§/ .011§
Joint depression	97 (57%)	36 (61%)	25 (51%)	36 (59%)	
Comminuted	8 (5%)	1 (2%)	7 (14%)	0 (0%)	
Sanders classification‡					
Sanders II	132 (78%)	48 (81%)	38 (78%)	46 (75%)	.291 / .919
Sanders III	27 (16%)	5 (8%)	10 (20%)	12 (20%)	
Sanders IV	7 (4%)	4 (7%)	1 (2%)	2 (3%)	
Surgical delay† (days)	5 (2-7)	N.A.	6 (3-11)	2 (1-6)	N.A. /<.001§
Clinical follow-up† (months)	12 (5-19)	9 (1-16)	13 (9-19)	13 (6-25)	.001§‖ / .907
Follow-up > 30 d‡	149 (88%)	44 (75%)	47 (96%)	58 (95%)	<.001§ /1.000
Adverse event (incl. infection) ‡	56 (33%)	14 (24%)	14 (29%)	28 (46%)	.026§ / .077
Infection[2]	16 (9%)	N.A.	8 (16%)	8 (13%)	N.A. / .787
Surgical site infection	7 (44%)	N.A.	5 (63%)	2 (25%)	N.A. / .315
Deep infection	9 (56%)	N.A.	3 (38%)	6 (75%)	
Late intervention (excl. implant removal) ‡	32 (19%)	8 (14%)	6 (12%)	18 (30%)	.030§ / .037§
Subtalar arthrodesis	19 (59%)	7 (88%)	0 (0%)	12 (67%)	.002§ / .004§
Exostosis resection	5 (16%)	1 (13%)	1 (17%)	3 (17%)	
Wound debridement	5 (16%)	0 (0%)	2 (33.3)	3 (17%)	
Revision surgery	3 (9%)	0 (0%)	3 (50.0)	0 (0%)	
Implant removal‡	59 (35%)	N.A.	19 (39%)	40 (66%)	N.A. / .007§
Time until implant removal† (weeks)[1]	28 (17-52)	N.A.	55 (36-69)	22 (16-30)	N.A. / <.001§

Abbreviations: HET, high energy trauma; LET, low energy trauma; NA, not applicable; ORIF, open reduction and internal fixation.

Data presented as median (25th percentile to 75th percentile) or n (%).

* First *p* value from comparison of the 3 treatment groups; second *p* value for comparison of 2 surgical groups.

† Kruskal-Wallis analysis of variance.

‡ Chi-square analysis.

§ Difference found between nonoperative group and ORIF and percutaneous groups (both p = .001).

‖ Statistically significant.

The period of clinical follow-up differed significantly among the 3 treatment groups for the overall population of 169 patients (Kruskal-Wallis p = .001; Table 1). The median clinical follow-up at the outpatient department was shorter in the nonoperative group (median 9 months, P_{25}-P_{75} 1 to 16) than in the ORIF group (median 13 months, P_{25}-P_{75} 10 to 19; *p* = .001) or the percutaneous group (13 months, P_{25}-P_{75} 6 to 25; p = .001). In the nonoperative group, 75% of the patients were seen at regular intervals extending to 30 days. In the ORIF and percutaneous groups, 96% and 95% of patients were seen at the outpatient department for longer than 30 days. Transfer to a hospital abroad and refusal were the main reasons for not returning to the outpatient department. Only the patients who had attended the outpatient department for their entire clinical follow-up period were invited for the present study to report on their long-term functional outcome (Table 3). This resulted in monitoring for longer than 30 days in 99% of the responders, with a median follow-up period of 14 months. A total of 108 patients were sent the questionnaires, of whom 78 responded (72% response rate).

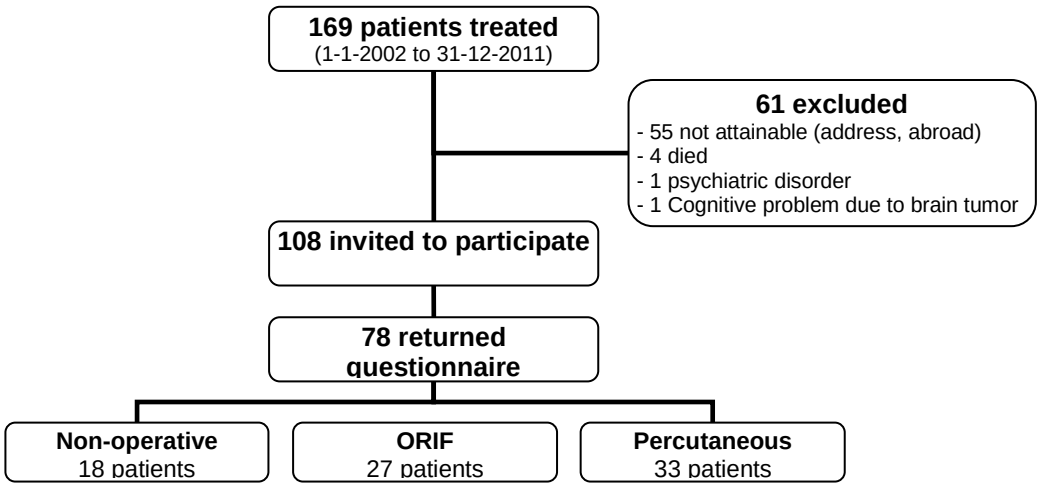

Fig. 1 Study flowchart. ORIF, open reduction and internal fixation.

Table 2: Characteristics of patients who returned the questionnaire (N=78)

	Overall (N=78)	Non-operative (N=18)	ORIF (N=27)	Percutaneous (N=33)	P-value*
Age at trauma (years) †	46 (36-55)	44 (34-59)	45 (34-56)	47 (40-54)	.697 / .435
Male gender‡	59 (76%)	14 (78%)	20 (74%)	25 (76%)	.960 / 1.000
BMI (kg/m^2) †	25 (22-27)	24 (22-27)	23 (22-27)	26 (23-28)	.174 / .070
Affected side[2]:					
Right side	33 (42%)	6 (33%)	15 (52%)	13 (39%)	.511 / .292
Left side	36 (46%)	9 (50%)	12 (44%)	15 (45%)	
Bilateral	9 (12%)	3 (17%)	1 (4%)	5 (15%)	
Dominant side affected‡	47 (60%)	13 (72%)	15 (56%)	19 (58%)	.491 / 1.000
Trauma mechanism‡					
LET	20 (26%)	3 (17%)	10 (37%)	7 (21%)	.479 / .311
HET fall from height	47 (60%)	11 (61%)	15 (56%)	21 (64%)	
HET other	2 (3%)	1 (6%)	0 (0%)	1 (3%)	
Other	1 (1%)	0 (0%)	1 (4%)	0 (0%)	
Unknown	8 (10%)	3 (17%)	1 (4%)	4 (12%)	
Concomitant injury‡	18 (23%)	7 (39%)	4 (15%)	7 (21%)	.253 / .457
Co-morbidity‡	10 (13%)	4 (22%)	0 (0%)	6 (18%)	.044§ / .028§
Cardiovascular disease	6 (8%)	3 (17%)	0 (0%)	3 (9%)	.112 / .245
Diabetes mellitus	4 (5%)	1 (6%)	0 (0%)	3 (9%)	.282 / .245
Smoking at age of trauma‡	33 (42%)	9 (50%)	9 (33%)	15 (45%)	.482 / .430
Essex-lopresti classification‡					
Tongue Type	35 (45%)	8 (44%)	13 (48%)	14 (42%)	.060 / .053
Joint depression	39 (50%)	10 (56%)	10 (37%)	19 (58%)	
Comminuted	4 (5%)	0 (0%)	4 (15%)	0 (0%)	
Sanders classification‡					
Sanders II	63 (81%)	16 (89%)	21 (78%)	26 (79%)	.236 / 1.000
Sanders III	14 (18%)	1 (6%)	6 (22%)	7 (21%)	
Sanders IV	1 (1%)	1 (6%)	0 (0%)	0 (0%)	
Surgical delay (days) †	5 (2-7)	N.A.	6 (3-8)	3 (1-7)	N.A. / .011§
Clinical follow-up (months) †	14 (9-24)	13 (6-24)	16 (12-21)	14 (8-30)	.406 / .899
Follow-up >30 days‡	77 (99%)	17 (94%)	27 (100%)	33 (100%)	.185/ 1.000
Plaster immobilization‡	33 (42%)	10 (56%)	10 (37%)	13 (39%)	.230 / 1.000
Plaster immobilization (weeks) ‡	6 (3-10)	9 (4-13)	4 (1-8)	6 (6-9)	.184 / .117
Non-weight bearing (weeks) †	12 (8-13)	12 (8-14)	12 (12-13)	12 (7-13)	.534 / .278

Abbreviations: HET, high energy trauma; LET, low energy trauma; NA, not applicable; ORIF, open reduction and internal fixation.

Data presented as median (25th percentile to 75th percentile) or n (%).

* First *p* value from comparison of the 3 treatment groups; second *p* value for comparison of 2 surgical groups.

† Kruskal-Wallis analysis of variance.

‡ Chi-square analysis.

§ Statistically significant.

Adverse Events, Late Interventions, and Implant Removal

Of all 169 patients, 56 (33%) experienced an adverse event, including 16 patients who developed an infection. The prevalence of adverse events was lowest in the nonoperative group (n = 14; 24%) and greatest in the percutaneous group (n = 28; 46%; p =.026; Table 1).

The difference in the prevalence of infections between the 2 operative methods was not significant 16% (5 superficial and 3 deep) in the ORIF group and 13% (2 superficial and 6 deep) in the percutaneous group (p = .315 comparing superficial and deep infection in the operative groups; Table 1).

Late intervention (excluding implant removal) was performed in 32 patients (19%). This percentage was significantly greater in the percutaneous group (n = 18; 30%) than in the ORIF group (n = 6; 12%) or nonoperative group (n = 8; 14%; p = .030; Table 1).

The main late intervention (excluding implant removal) was subtalar arthrodesis in 19 patients, followed by exostosis resection in 5, wound debridement in 5, and revision of the osteosynthesis surgery in 3. Secondary arthrodesis was performed most frequently in the nonoperative group (7 of 8 patients undergoing late intervention; 88%; p = .002), followed by the percutaneous group (12 of 18, 67%; p = .004), and was not needed in the ORIF group.

Overall, arthrodesis was performed in 12% of patients in the nonoperative group and 20% of patients in the percutaneous group.

Implants were removed more frequently in the percutaneous group (n = 40; 66%) than in the ORIF group (n = 19; 39%; p = .007; Table 1). In addition to the lower prevalence of removal, the implants remained in situ for a significantly longer period in the ORIF group (median 55 weeks, P_{25}-P_{75} 36 to 69) than in the percutaneous group (median 22 weeks, P_{25}-P_{75} 16 to 30; p < .001; Table 1).

Patient-reported Outcome Measures

Questionnaires were completed by 78 patients (18 treated nonoperatively, 27 with ORIF, and 33 percutaneously). The Functional Foot Index score differed significantly among the treatment groups, with the greatest disability reported by the nonoperative group (median overall score 40 points; Table 4 and Fig. 2A). This was significantly greater than in the ORIF group (16 points; $p = .010$) or the percutaneous group (21 points; $p = .034$). This was mainly attributable to differences in the subdomain activity limitation. The median American Orthopaedic Foot and Ankle Society hindfoot score ranged from 61 points in the nonoperative group to 81 in the percutaneous group. No statistically significant relation with treatment was found, neither in the overall score nor in the individual subdomains. However, the data suggested a trend in favor of operative treatment.

The median visual analog scale score for patient satisfaction ranged from 6.3 in the nonoperative group to 8.5 in the percutaneous group ($p > .05$).

The SF-36 mental component summary score was similar in all treatment groups, with all median values within the normal range of 50 ± 10 points (Table 4 and Fig. 3B). However, the median PCS score was below the normality boundaries in the nonoperative group (38 points). The median PCS score was 50 in the percutaneous group and 52 in the ORIF group. The difference between the operative and nonoperative groups did not reach statistical significance ($p = .050$; Table 4 and Fig. 3A).

The EQ-5D utility score (median 0.78, P_{25}-P_{75} 0.77 to 0.93) and EQ-visual analog scale score (median 80, P_{25}-P_{75} 70 to 89) were unrelated to the treatment used.

Table 3: Clinical and cosmetic outcome in patients who returned the questionnaire (N=78)

	Overall (N=78)	Non-operative (N=18)	ORIF (N=27)	Percutaneous (N=33)	P-value*
Follow-up (months) †	76 (54-88)	78 (51-88)	56 (28-76)	88 (68-107)	<.001‡/<.001‡
Working pre-fracture‡	78 (100%)	18 (100%)	27 (100%)	33 (100%)	1.000 / 1.000
Heaviness of work‡					
Heavy	19 (24%)	6 (33%)	7 (26%)	6 (18%)	.515 / .777
Mild	33 (42%)	9 (50%)	10 (37%)	14 (42%)	
Light	25 (32%)	3 (17%)	10 (37%)	12 (36%)	
Work resumption at FU‡	63 (81%)	13 (72%)	26 (96%)	24 (73%)	.052 / .031‡
Returned to same position	44 (56%)	7 (39%)	21 (78%)	16 (48%)	.016‡ / .043‡
Returned to changed position	19 (24%)	7 (39%)	5 (19%)	7 (21%)	
Unable to work due to complaints	10 (13%)	4 (22%)	1 (4%)	5 (15%)	
Pension or unknown	5 (6%)	0 (0%)	0 (0.0)	5 (15%)	
Sports activities pre-fracture‡	37 (47%)	9 (50%)	14 (52%)	14 (42%)	.744 / .604
Sports activities resumed at FU‡	28 (36%)	5 (28%)	10 (37%)	13 (39%)	.702 / 1.000
Walking barefoot‡					
No problems	46 (59%)	8 (44%)	19 (70%)	19 (57%)	.360 / .545
With problems	30 (38%)	10 (56%)	7 (26%)	13 (39%)	
Unable to do	2 (3%)	0 (0%)	1 (4%)	1 (3%)	
Able to run‡	43 (55%)	9 (50%)	17 (63%)	17 (52%)	.596 / .438
Stiffness‡	61 (78%)	18 (100%)	23 (85%)	20 (61%)	.003‡ / .046‡
Continuous	31 (51%)	10 (56%)	12 (52%)	9 (45%)	.799 / .763
Only in the morning	30 (49%)	8 (44%)	11 (48%)	11 (55%)	
Change in shoe size‡	22 (28%)	5 (28%)	8 (30%)	9 (27%)	.979 / 1.000
Size change †	1.0 (1.0-1.0)	1.0 (-0.1-1.0)	1.0 (0.6-1.0)	1.0 (1.0-2.0)	.184 / .131
Changes in type of shoe‡					
Unchanged / mild concession	53 (68%)	8 (44%)	21 (78%)	24 (73%)	.186 / .885
Slight orthopedic changes (insoles)	12 (15%)	5 (28%)	3 (11%)	4 (12%)	
Orthopedic shoes / shoes impossible	13 (17%)	5 (28%)	3 (11%)	5 (15%)	
Change in foot shape‡					
Unchanged	19 (24%)	3 (17%)	6 (22%)	10 (30%)	.440 / .295
Mild changes	42 (54%)	9 (50%)	18 (67%)	15 (45%)	
Moderate changes	13 (17%)	4 (22%)	3 (11%)	6 (18%)	
Major changes	4 (5%)	2 (11%)	0 (0%)	2 (6%)	
Adverse event (incl. infection) ‡	27 (5%)	4 (22%)	9 (33%)	14 (42%)	.345 / .595
Infection‡	11 (14%)	N.A.	5 (19%)	6 (18%)	N.A. / 1.000
Surgical site infection	6 (55%)	N.A.	4 (80%)	2 (33%)	N.A. / .242
Deep infection	5 (45%)	N.A.	1 (20%)	4 (67%)	
Late intervention (excl. implant removal) ‡	14 (18%)	1 (6%)	4 (15%)	9 (27%)	.135 / .348
Subtalar arthrodesis	7 (50%)	1 (100%)	0 (0%)	12 (67%)	.187 / .057
Exostosis resection	2 (14%)	0 (0%)	1 (25%)	1 (11%)	
Wound debridement	3 (21%)	0 (0%)	1 (25%)	2 (22%)	
Revision surgery	2 (14%)	0 (0%)	2 (50%)	0 (0%)	
Implant removal‡	36 (46%)	N.A.	10 (37.0)	26 (78.8)	N.A. / .001‡
Time until implant removal† (weeks)	25 (14-42)	N.A.	55 (30-71)	23 (12-32)	N.A. / .014‡

Abbreviations: FU, follow-up; NA, not applicable; ORIF, open reduction and internal fixation.
Data presented as median (25th percentile to 75th percentile) or n (%).
* First *p* value from comparison of the 3 treatment groups; second *p* value for comparison of 2 surgical groups.
† Kruskal-Wallis analysis of variance.

‡ Chi-square analysis.
§ Statistically significant.

Work Resumption, Sports Resumption, and Cosmesis

All 78 patients had worked before their trauma, with no significant difference in the number of patients performing heavy labor among the treatment groups (Table 3). Patients in the ORIF group had resumed work in 96% of cases, significantly more than that in the percutaneous group (75%; $p = .045$). In the nonoperative group, 72% had returned to work at the time of completing the questionnaires. Because of the lower number of patients in the nonoperative group, this was not significantly different statistically from the rate in the operative groups. In addition to resuming work more often, a significantly greater proportion of the ORIF group had returned to the same position as before their injury.

Of the 78 patients, 37 (47%) had participated in sports activities before their injury. At the last follow-up point, 28 (76%) had resumed their sports activities, irrespective of the treatment type.

Also, 46 patients (59%) were able to walk barefoot without problems, and 43 were able to run. Again, no relation with treatment was found. All patients in the nonoperative group reported stiffness of the ankle compared with 85% in the ORIF group and 61% in the percutaneous group ($p = .003$; Table 3). A total of 22 patients reported changes in shoe size, 59 reported a change in foot shape, and 25 reported the use of adjusted shoes at follow-up compared with before fracture. These findings were not associated with the treatment modality (Table 3).

DISCUSSION

In the present retrospective study, patients with a displaced intra-articular calcaneal fracture generally showed better functional outcomes after operative treatment (i.e., ORIF

and percutaneous treatment) than after nonoperative treatment. Although a greater percentage of patients in the operative treatment groups had adverse events (including infections) and late interventions, the patient-reported outcome scores were better in the operative groups.

Table 4: Functional outcome and quality of life in patients who returned the questionnaire (N=78)

	Overall (N=78)	Non-operative (N=18)	ORIF (N=27)	Percutaneous (N=33)	P-value
FFI:					
Overall score	22 (7-37)	40 (10-69)	16 (7-29)	21 (4-37)	.031*
Pain	26 (9-48)	47 (11-68)	20 (9-41)	21 (2-45)	.063
Disability	19 (8-50)	52 (11-70)	16 (1-34)	17 (2-47)	.077
Activity limitation	5 (0-17)	16 (5-51)	4 (0-6)	2 (0-21)	.017†
AOFAS:					
Overall score	77 (59-89)	61 (43-78)	76 (64-85)	81 (66-95)	.060
Pain	30 (20-30)	20 (20-30)	30 (20-30)	30-(20-40)	.132
Function	40 (32-47)	31 (20-41)	41 (34-47)	42 (34-48)	.069
Alignment	10 (5-10)	10 (4-10)	10 (5-10)	10 (8-10)	.208
SF-36:					
PCS	48 (36-54)	38 (27-53)	52 (42-57)	50 (38-54)	.050
MCS	57 (47-61)	54 (45-60)	58 (56-61)	57 (45-62)	.490
EQ-5D:					
EQUS	0.78 (0.77-0.93)	0.78 (0.52-0.81)	0.81 (0.78-0.93)	0.78 (0.78-0.93)	.095
EQVAS	80 (70-89)	75 (63-83)	80 (75-90)	80 (70-90)	.102
Patient satisfaction (VAS)	8.0 (6.0-9.5)	6.3 (3.8-9.5)	8.0 (6.0-9.5)	8.5 (7.0-10.0)	.081

Abbreviations: AOFAS, American Orthopaedic Foot and Ankle Society hindfoot score; CI, confidence interval; EQ-5D, EuroQol-5D; EQUS, EuroQol utility score; EQVAS, EuroQoL visual analog scale; FFI, Foot Function Index; MCS, mental component summary; PCS, physical component summary; SF-36, Short Form-36; VAS, visual analog scale.
Data presented as median (25th to 75th percentile).
Kruskal-Wallis analysis of variance used to assess statistical significance between the treatment groups, followed by post hoc pairwise comparisons using the Mann-Whitney U test if significantly different.
* Statistically significant difference found between nonoperative and ORIF groups (p = .010) and nonoperative and percutaneous groups (p = .034).
† Statistically significant difference found between nonoperative and ORIF groups (p = .004) and nonoperative and percutaneous groups (p = .025).

The nonoperatively treated patients reported more difficulties, such as shoe adjustments and hindfoot stiffness, and returned to work later. Of the 2 surgical procedures, the results were in favor of the ORIF treatment strategy. In the percutaneous group, more complications were seen, implants had to be removed more often, and patients required late intervention more frequently.

The published data have indicated that less invasive procedures might allow accelerated weightbearing, less joint stiffness, and greater patient' satisfaction compared with ORIF (29,30). However, in the present study, ORIF provided better results. Almost one fifth of the percutaneously treated patients required secondary arthrodesis compared with none in the ORIF group. The 20% secondary arthrodesis rate after percutaneous treatment found in the present study was comparable to the previously reported 15% (18).

ORIF treatment has been known for infectious complications (1). In our study, 16% of patients in the ORIF group (8 of 49) experienced an infectious complication, which was not much different from the 13% in the percutaneous group. This infection rate of 13% was comparable to that in previous reports (31). Thus, the functional results in our study were not negatively affected by a learning curve of the surgeons in our medical center or a high infection rate. Although the implant removal rate of 39% for ORIF was comparable to that of other reports (39% to 49%) (32,33), the 57% rate in the percutaneous group was much greater than the 12% reported previously (34). Considering the complaints of the patients in our study, it is plausible that the large screw head of the implants used for the percutaneous treatment was the cause of the high rate of implant removal (18,31). Especially for percutaneous treatment, less prominent implants (i.e., headless screws) should be considered (35,36).

The response percentage for the different treatments groups was 31% (18 of 59 patients) in the nonoperative group, 55% (27 of 49 patients) in the ORIF group, and 54%

(33 of 61 patients) in the percutaneous group, indicating that fewer conservatively treated patients completed the questionnaires. The response percentage of both operative treatment groups was nearly identical.

Although nonoperative treatment of calcaneal fractures did not lead to the best results, it could still be a viable treatment modality given the noncompliance of some patients concerning mobilization advice during follow-up. Early studies (37,38) showed that early exercise will be the best nonoperative modality. The nonoperatively treated patients reported inferior functional outcomes and more disability in the questionnaires than did the operatively treated patients. This might explain why the vast majority of late interventions in the nonoperative group were secondary arthrodesis.

Several comparative studies have described the results of ORIF and nonoperative management but did not use a standardized functional outcome scoring system (39–42). Studies comparing ORIF and nonoperative management that did use a disease-specific outcome score have shown conflicting results. Three studies reported a significantly greater outcome for operatively treated fractures (43–46). In another study, only a trend toward a better outcome in the operative group was seen (47). Two studies failed to find a significant difference (48,49).

Just as with any retrospective study, we acknowledge the presence of limitations. The follow-up duration was different among the treatment groups because of a changes in the local protocol during the study period. The preferred surgical treatment changed from percutaneous to ORIF from 2005 onward. To some extent, the difference in functional outcome scores could have resulted from the differences in the interval between the trauma and questionnaire completion. With a median follow-up of 56 and 88 months, the ORIF and percutaneous groups had, overall, significantly better outcomes than did the nonoperatively treated patients, who had completed the questionnaires after 78 months.

Clinical data could be retrieved for 9 months in the nonoperative group compared with 13 months in both operative groups. A shorter clinical follow-up period for the conservative group might have resulted in an underestimation of the true rate of complications and late interventions. This underestimation for the infectious complication rate in the present study was probably minimal, because more than 95% of the patients in the operative groups were followed up for at least 30 days, which we believed would be a relevant period for the identification of delayed or problematic wound healing.

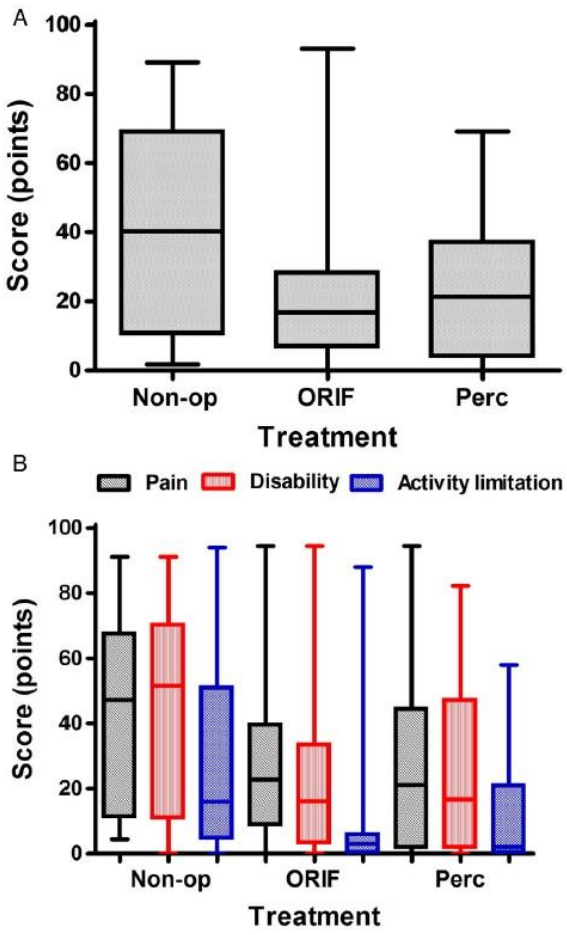

Fig. 2. (A) Foot Function Index total score. (B) Foot Function Index subdomain scores. Nonop, nonoperative; ORIF, open reduction and internal fixation; Perc, percutaneous.

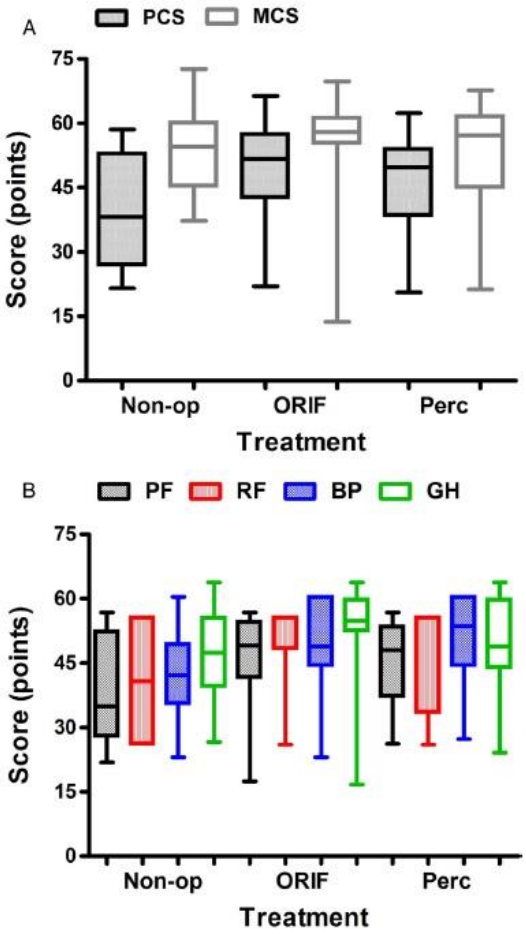

Fig. 3. (A) Short Form-36 (SF-36) and physical component summary (PCS) scores. (B) SF-36 physical component summary score for the subdomains. BP, bodily pain; GH, general health; PF, physical functioning; RF, role physical.

Another limitation was that of the 169 patients, only 108 (64%) met the eligibility criteria for an invitation to complete the questionnaires. The clinical data from the sample of 108

patients were similar to the data from the total population of 169 patients, supporting the idea that the invitees were representative of the total population. The response rate for the questionnaires was 72%, consistent with that previously reported (50). This could have introduced some selection bias. Because the response percentage was comparable in each treatment group, the bias could not explain the differences found.

Minimally invasive, percutaneous treatment has often been chosen in patients with comorbidities, which might explain the complications in the percutaneous group. The differences in the complication rates between the percutaneous and ORIF groups should thus be interpreted with care. No difference in any of the observed patient characteristics (i.e., gender, age at trauma, smoking, diabetes mellitus and other comorbidities) or injury characteristics (i.e., affected side, trauma mechanism, injury classification, and concomitant injuries) among the treatment groups was noted in our study. Therefore, any consequent bias can be assumed to be, at most, marginal.

Concomitant injuries are not rare with calcaneal fractures. In the published data, there are indications that polytrauma patients with calcaneal fractures have had a worse clinical outcome than patients with isolated calcaneal fractures. The present study lacked statistical power to evaluate the relationship between polytrauma and functional outcome stratified by treatment modality.

In conclusion, our results have indicated that operatively treated patients report improved outcomes and better Foot Function Index and American Orthopaedic Foot and Ankle Society hindfoot scale score compared with the nonoperatively treated patients. These results support previous data (51–53). Patients treated with ORIF had the best outcome measures. In the present study, both functional and patient-related outcomes from the 3 different treatment strategies for displaced intra-articular calcaneal fractures were

investigated. Overall, ORIF resulted in superior functional outcomes and greater patient satisfaction, with an acceptable complication rate and no secondary arthrodesis required.

Financial Disclosure: None reported.

Conflict of Interest: None reported.

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