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ORIGINAL ARTICLE

Long-term Clinical and Radiographic Outcomes Following Surgical Treatment for Ankle Fracture-Dislocations: Do poor radiographic outcomes always matter?

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Long-term Clinical and Radiographic Outcomes Following Surgical Treatment for Ankle Fracture-Dislocations:

Do poor radiographic outcomes always matter?

ABSTRACT

Background

Ankle fractures constitute 10% of all traumatic fractures in clinical practice. Concurrent tibiotalar dislocations form 21-36% of all ankle fractures. Although mechanism of injury is similar to non-dislocated ankle fractures, fracture-dislocations cause more extensive bone and soft tissue damage. Treatment is a challenge for orthopedic surgeons due to concomitant pathologies. It is associated with malreduction, chronic pain and most importantly, posttraumatic osteoarthritis. We aimed to investigate the relationship between ankle osteoarthritis radiographic stage and clinical outcomes.

Methods

27 patients (17 female, 10 male) were included in the study. Records and data were retrospectively analyzed. Clinical status at the final follow-up was evaluated by a single orthopedic surgeon. Range of motion (ROM), American Orthopedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score, visual analogue scale (VAS) were the clinical parameters that were assessed. Radiological assessment was made by standard anteroposterior [AP], lateral, and mortise views. Pre-operative osseo-ligamentous injury pattern, presence of posterior

malleolar fracture, syndesmosis injury and post-operative ankle osteoarthritis were investigated.

Results

For 27 patients that were evaluated, at the final follow-up, mean AOFAS was 85 ± 8.12, and mean VAS during daily activities was 1.52 ± 0.70. Mean ankle dorsiflexion and plantar flexion were significantly lower on the affected sides (14.07 ± 7.97° and 36.30 ± 6.59°) than on the unaffected sides (28.15 ± 2.82° and 46.30 ± 2.97°), respectively ($p < 0.001$). No significant difference for inversion and eversion was observed. Twenty-four patients demonstrated radiographic signs of ankle osteoarthritis, and three remained without evidence of osteoarthritis. No significant difference was found among Takakura's stages in any of the variables.

Conclusion

The results illustrated that although post-traumatic osteoarthritis rate was high for ankle fracture-dislocation patients, surgical treatment achieved excellent functional results. Even if advanced stages of ankle arthritis according to Takakura's classification developed, patients had satisfactory clinical and functional results.

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INTRODUCTION

Ankle fractures are among the most common orthopedic injuries, constituting 10% of all traumatic fractures in clinical practice (1, 2). Concurrent tibiotalar dislocations have been reported to emerge in as many as 21% to 36% of all ankle fractures (3, 4). Ankle fracture-dislocations typically result from similar injury mechanisms as nondislocated ankle fractures, although the progression or extent of the deforming forces is adequate to disturb any remaining bony and soft-tissue stability of the ankle mortise (3).

Dislocated ankle fractures present a considerable challenge to the treating orthopedic surgeon because of higher rates of concomitant pathologies, including open fractures, surrounding soft tissue damage, osteochondral lesions, and intraarticular loose bodies (5). The standard treatment for such fractures is open reduction and internal fixation (ORIF) to restore native ankle anatomy. Treatment of ankle fracture-dislocations has been traditionally associated with a greater risk of complications, such as articular malreduction, chronic pain, posttraumatic osteoarthritis, and worse clinical outcomes (4 – 7). Despite their clinical importance, there are relatively few studies addressing the long-term results of operative treatment for ankle fracture-dislocations (4, 6 – 8).

This study reports long-term clinical and radiographic outcomes of patients with ankle fracture-dislocations treated by ORIF at a minimum of 5-year follow-up. Furthermore, according to our senior author's experience, radiographic evidence of end-stage osteoarthritis may not

always be correlated with poor clinical outcomes in dislocated ankle fractures. Thus, the present study more specifically aims to address the question of whether final radiographic outcomes are associated with ultimate clinical and functional results in patients with ankle fracture-dislocations at long-term follow-up. We hypothesized that clinical outcome measures would worsen with increasing ankle osteoarthritis radiographic stage.

MATERIAL AND METHODS

After approval of the institutional review board was obtained, the medical records of 30 patients diagnosed with acute unilateral ankle fracture-dislocations and treated by ORIF between 2001 and 2012 were retrospectively reviewed. The inclusion criteria for the study were: (I) a diagnosis of ankle fracture-dislocations with a complete loss of tibiotalar articular congruency in radiographs (Figure 1), (II) undergoing ORIF surgery, (III) a minimum follow-up of 5 years, (IV) complete medical records and radiographic images; and (V) being willing to participate in the study. Exclusion criteria included: (I) concomitant tibial pilon fractures, (II) chronic dislocated ankle fractures, (III) concomitant fractures of the ipsilateral lower extremity, (IV) a history of previous surgical treatment of the affected lower extremity, (V) lost to follow-up, and (VI) being unwilling to participate in the study.

After three patients were excluded (one was lost to follow-up, one was a chronic case of fracture dislocation, and one had inadequate medical records), the remaining 27 patients (17 females, 10 males) were included in the study and invited to a final follow-up appointment.

Medical records and radiographic data were retrospectively analyzed. The institutional review board approved this study before data collection, and all participants gave informed consent. The study was performed in two phases: (1) to analyze the clinical and radiographic outcomes of patients with ankle fracture-dislocations in the overall study population; (2) to investigate the correlation between ultimate clinical results and stages of ankle arthritis by comparing all the variables among Takakura's stages.

Clinical outcome measures

Demographic and clinical data were obtained from the hospital's electronic database and the patient medical records, including age at the time of surgery, gender, follow-up duration, and concomitant vascular or neural injuries. The open ankle fractures were classified based on the system developed by Gustilo and Anderson (9).

Clinical status at the final follow-up was evaluated based on the following variables by a single orthopedic surgeon blinded concerning the treatment regimen of each patient: range of motion (ROM) (angle of dorsiflexion, plantar flexion, inversion, and eversion) of the affected and unaffected ankle joints, the American Orthopedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score (excellent, ≥90; good, 75–89; acceptable, 50–74; poor, <50) (10), and visual analog scale (VAS) during daily activities. In addition, the 36-Item Short Form Survey (SF-36) (9) was also used to assess health-related functions and quality of life. ROM was measured using a universal standard goniometer with the patient in the supine position. VAS used in the current

study is a modified and simplified measure wherein pain intensity during daily activity is rated from 0–10, where 0 indicates no pain and 10 indicates the worst pain.

Radiographic outcome measures

A single orthopedic surgeon with a particular interest in foot and ankle surgery performed all radiographic evaluations. In pre-operative standard ankle x-ray series (anteroposterior [AP], lateral, and mortise views), the osseo-ligamentous injury pattern was determined, comprising bimalleolar fracture (posteroinferior tibiofibular ligament rupture with medial and lateral malleolar fracture), trimalleolar fracture (lateral, medial, and posterior malleolar fracture), and posterior malleolar fracture (deltoid ligament rupture with posterior and lateral malleolar fracture).

Lateral malleolus fractures were classified based on the Denis-Weber classification (10). The fragment size of the posterior malleolus fracture was calculated as the percentage of the involved distal tibial articular surface. The proportion of the articular surface of the fragment to the entire articular surface of the distal tibial end was measured on the lateral ankle radiographs. Direction of tibiotalar dislocation was defined as the direction of talus displacement with respect to the distal tibia (Figure 1).

Posttraumatic ankle osteoarthritis was examined and staged on the weight-bearing anteroposterior (AP) and lateral radiographs of the ankle based on the Takakura Staging System (Table 1) (11, 12) at the final follow-up appointment.

Surgical Management

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Closed reduction and temporary cast immobilization were applied to all cases in the emergency room until the definitive surgery. In four patients, unstable fracture-dislocations were fixed immediately by external fixators in the operating room. Surgical stabilization was obtained by ORIF of the medial malleolus and fibula (if fractured). The fibula fractures were stabilized by an anatomic distal fibular locking plate (3.5 mm screws for proximal holes and 2.8 mm screws for distal holes) , and the medial malleolus was fixed by 4 mm cannulated screws or tension band wiring technique. Fixation of the posterior malleolus was achieved directly or indirectly using 4 mm cannulated screws if the fragment involved 20% of the articular surface on the lateral ankle x-ray (Figure 2).

Additionally, the stability of the syndesmosis was intra-operatively evaluated by the Cotton test using a hook or an external rotation test after malleolar stabilization. In cases of evident widening of the syndesmosis following the stress test, syndesmotic fixation was performed with one or two tricortical 3.5 screws. The deltoid ligament's open repair was executed in four cases wherein the medial clear space remained widened after malleolar fixation.

Post-operative follow-up protocol

The ankle was routinely immobilized in a below-knee plaster cast for one or two post-operative weeks until pain relief was achieved. The cast was then removed, and active range-of-motion exercises were started. Patients were kept non-weight bearing for a post-operative period of six weeks and then allowed to walk with toe-touch weight-bearing for an additional

six weeks. Radiographs were taken at the 12-week follow-up visit; if syndesmotic fixation was performed, the screw was routinely removed, and full-weight bearing was started (Figure 3).

Statistical analysis

All statistical analyses were performed using SPSS software (version 25, Armonk, NY: IBM Corp.). A p-value < .05 was regarded as significant. Normality tests were conducted using the Shapiro–Wilk test and histogram graphics. Data are presented as "arithmetic mean," "median," and "range" from "minimum" to "maximum." In addition, the correlation between the variables (ankle ROM, presence of posterior malleolus fracture, and AOFAS score, VAS, SF-36) and stage of ankle arthritis was evaluated by comparing the relevant variables among Takakura's ankle osteoarthritis groups using Fisher's Exact test for categorical data or Kruskal-Wallis test for continuous variables.

RESULTS

Baseline characteristics

Twenty-seven patients (13 males, 14 females) were analyzed in the study. The mean age at surgery was 42.8 (range = 24-88) years, and the mean follow-up was 112 (range = 48–176) months. The mechanism of injury was low-energy trauma in 17 patients and high-energy in ten patients. Four patients presented with open fractures (15%), one of which was grade I and the

remaining three were grade II according to Gustilo Anderson classification. There were no associated neurovascular injuries requiring intervention in any of the patients. Comorbidities were present in four patients (14.8%), including chronic hypertension in two (7.4%) and diabetes mellitus in one (3.7%). All comorbidities were in control at baseline (Table 2).

Clinical outcomes

No major intra- or post-operative complications were observed. However, two patients suffered from a superficial wound infection that was successfully treated by oral antibiotic therapy and local debridement. One patient was complicated by wound breakdown that was controlled by vacuum-assisted closure therapy followed by standard wound dressing. Two patients suffered from complex regional pain syndrome managed by medication, physical therapy, and rehabilitation programs.

At the final follow-up, the mean AOFAS was 85 ± 8.12, and the mean VAS during daily activities was 1.52 ± 0.70. The clinical status as per the AOFAS score was determined as excellent in ten patients (37%), good in 14 patients (51%), and acceptable in three (12%). The mean ankle dorsiflexion and plantar flexion were significantly lower on the affected sides (14.07 ± 7.97° and 36.30 ± 6.59°) than on the unaffected sides (28.15 ± 2.82° and 46.30 ± 2.97°), respectively ($p < 0.001$ for both variables). The mean inversion and eversion were 26.11 ± 4.87 ° and 20.74 ± 3.59° on the affected sides and 27.59 ± 3.76° and 21.67 ± 3.40° on the unaffected sides, respectively. No significant differences were found in both variables between the affected and unaffected sides ($p >0.16$, $p > 0.25$, respectively). The mean SF-36 mental and

physical component scores were 55.6 ± 1.17 and 56.2 ± 1.17, respectively, which were found above the mean scores of the population (Table 3).

Radiographic outcomes

Lateral malleolus fractures were present in all patients, medial malleolus fractures in 26 (96.30%), and posterior malleolus fractures in 11 (40.74%). Regarding osseo-ligamentous injury patterns, bimalleolar fractures were documented in 18 patients (66.70%) and trimalleolar fractures in five patients (18.51%). Syndesmotic instability was detected and fixated in ten patients (37.04%).

Based on the Denis-Weber classification, lateral malleolus fractures were classified as type A in one patient (3.7%), type B in 21 (77.78%), and type C in five (18.55%). The mean fragment size of the posterior malleolus fractures was 25.5 % (range, 10 – 50). The Direction of talus displacement was anterolateral in six patients (22.22%), posterolateral in 14 (51.85%), posteromedial in six (22.22%), and posterior in one (3.70%).

At the final follow-up, 24 patients demonstrated radiographic signs of ankle osteoarthritis, and three remained without evidence of osteoarthritis (11%). According to the Takakura system, osteoarthritis was defined as stage I in six patients (22%), stage II in eleven patients (42%), stage III in four patients (14%), stage IV in three patients (12%). The incidence of posttraumatic osteoarthritis was 90%.

Correlation between clinical outcomes and radiographic stage of ankle osteoarthritis

Table 4 illustrates the clinical outcomes of each Takakura stage. No significant difference was found among Takakura's stages in any of the variables.

DISCUSSION

Ankle fracture-dislocations may pose significant challenges to orthopedic surgeons because of the concomitant soft tissue and osteochondral pathologies. ORIF is the standard surgical treatment for dislocated ankle fractures, and the main treatment goal is to restore the anatomic congruency of the ankle to correct the abnormal loadings on the articular cartilage and prevent the development of posttraumatic arthritis (13 – 15). Nevertheless, complications such as articular malreduction, chronic pain, or posttraumatic arthritis may occur even after radiologically successful surgical treatment. Despite their clinical significance, relatively few studies have examined the long-term outcomes of surgical treatment for ankle fracture dislocations (4, 6 – 8). We conducted a long-term retrospective study on a consecutive case series to determine the natural course of the dislocated ankle fractures following surgical treatment with ORIF.

In one of the few studies available (4, 6 – 8), Warner et al. investigated the effect of dislocation on functional outcomes of pronation external rotation ankle fractures (7). The authors concluded that dislocated ankle fractures were associated with a higher incidence of articular malreduction and poorer functional outcomes compared to those without dislocation at a mean follow-up of 31 months. In other study by Regan et al. which set out to evaluate the long-term clinical and radiographic outcomes following surgical fixation of unstable ankle

fractures, data from 141 patients demonstrated that most of the patients were in good health in spite of the presence of radiographic arthritis in 63% of patients at a mean of 11.6 years after surgery (4). In a recent study, Fonkoue et al. reported a posttraumatic arthritis rate of 43% in 44 patients with ankle fracture-dislocations surgically treated after a mean follow-up period of 27.2 (16). Compared to the previous literature on the topic, our cohort showed a higher rate of posttraumatic osteoarthritis (90%) among patients with dislocated ankle fractures at a mean of 14.6 years. The difference in rates may be due to diagnostic criteria for osteoarthritis, size of the sample, age of patients, and follow-up period. We believe the fundamental cause was the adoption of the Takakura classification to identify posttraumatic osteoarthritis as the present study is the first to use such a specific staging system in patients with ankle fracture dislocations.

Although ankle fracture-dislocations are associated with a high incidence of posttraumatic ankle osteoarthritis, the effect of posttraumatic osteoarthritis on patients' functionality remains controversial, with a limited number of studies addressing this issue. In a comparative study, Sculco et al. discovered that concurrent dislocation at the time of ankle fracture was associated with poorer radiographic and functional outcomes (17). In contrast, Fonkoue et al. found no significant difference in the functional outcome and satisfaction between patients with and without ankle osteoarthritis (16). Differently from the previous literature, the present study more specifically investigated the possible relationship between clinical and radiographic outcomes in this specific group of patients based on the author's

clinical experience. Our findings refute the hypothesis that clinical outcome measures would worsen with increasing ankle osteoarthritis radiographic stage as no significant differences were observed in any of the clinical and functional variables (ankle ROM, AOFAS score, VAS, and SF-36) among the Takakura stages of the ankle osteoarthritis.

It also should be mentioned that ankle plantar flexion and dorsiflexion ROM were significantly impaired compared to those on the unaffected sides of our patient cohorts. However, our findings revealed that despite the inability to achieve a comparable ankle ROM to the unaffected side, surgical treatment with ORIF could provide good to excellent functional status (as per the AOFAS) with higher quality of life for patients with ankle fracture-dislocations at a long-term follow-up.

The presence of posterior malleolus fracture, especially if the fragment is >25%, and concomitant syndesmotic injury have been traditionally associated with the development of posttraumatic osteoarthritis in ankle fractures (18). Unlike the previous studies, the present study investigated the relationship between these two radiographic variables and ankle osteoarthritic radiographic stages. No significant effect of concomitant syndesmotic injury and posterior malleolus fracture on the long-term radiographic outcomes were observed.

When interpreting the findings of this study, some limitations and strengths should be considered. The major limitations of the study were its retrospective nature and limited sample size. A prospective controlled study with the population of non-dislocated ankle fractures would be ideal, but would be difficult to conduct due to the relatively rarity of the condition.

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The present study included no control group of patients with non-dislocated ankle fractures, as differently from the previous literature, we specifically explored the relationship between clinical and functional outcomes with radiographic osteoarthritic stages. Despite these limitations, the current study is one of the few studies to present the long-term outcomes of surgical treatment in the management of ankle fracture dislocations.

Conclusion

Evidence from the study has revealed that despite the higher rates of posttraumatic osteoarthritis, surgical treatment with ORIF could provided good to excellent functional status (as per the AOFAS) and high quality of life with less pain and impairment for patients with ankle fracture-dislocations at a long-term follow-up. Even if advanced stages of ankle arthritis according to Takakura's classification develop, satisfactory clinical and functional outcomes can be expected in this specific group of patients.

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Conflict of interest

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Figure 1: Postero-medial fracture-dislocation seen in AP and lateral X-rays

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Figure 2: Early post-operative x-ray of postero-medial fracture dislocation, lateral malleolus fracture is treated by ORİF with lateral malleolus anatomical plate. Medial malleolus is treated by tension band wiring technique.

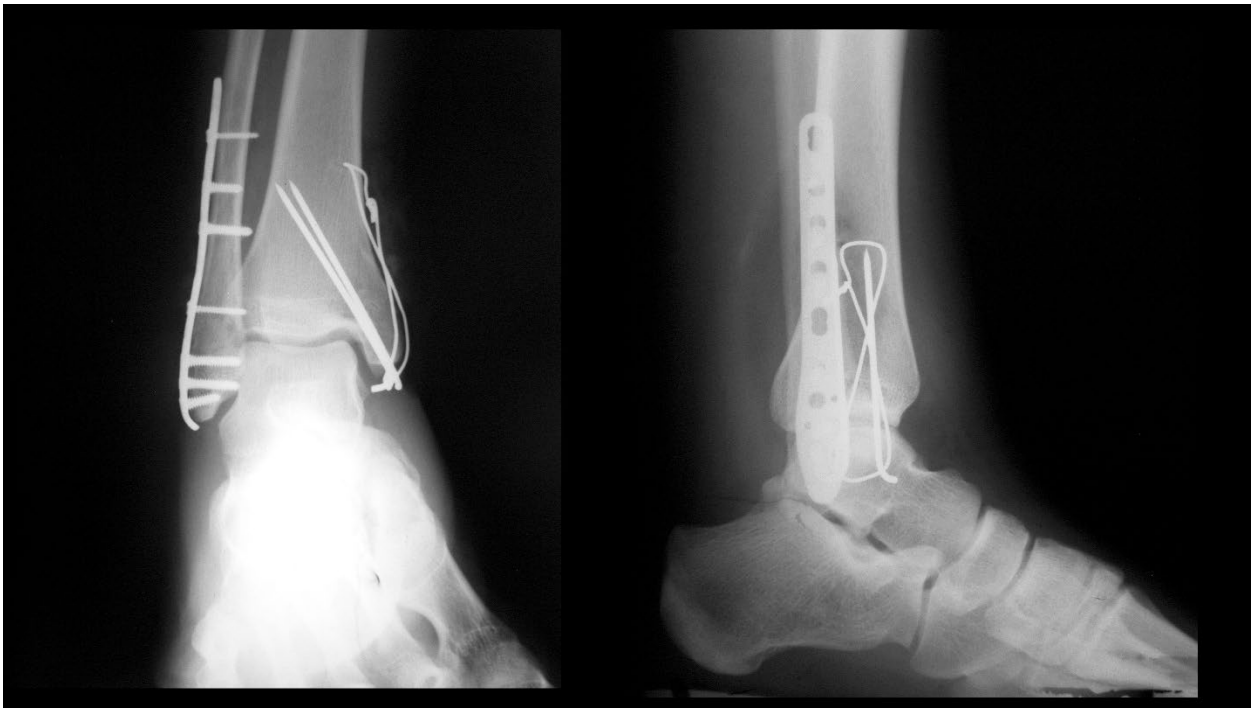

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Figure 3: X-rays of ankle at final follow-up

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Table 1: Takakura Staging System

Stages	**Radiographic Osteoarthritis Signs**
Stage 1	No joint narrowing, minimal sclerosis and osteophyte
Stage 2	Medial joint space narrowing
Stage 3	Obliteration of joint space, medial subchondral bone contact
Stage 4	Obliteration of the whole joint space, complete bone contact

Table 2. Baseline characteristics of all the study participants

Baseline characteristics	***Total N=27***
Age	***42.8 (24-88)***
Sex, female	***14 (51.85%)***
Follow-up duration (months)	***112 (48-176)***
Trauma type - High energy	***10 (37.03%)***
Trauma type - Low energy	***17 (62.69%)***
Open fractures	***4 (14.81%)***
Gustilo Anderson Type 1	***1 (3.70%)***
Gustilo Anderson Type 2	***3 (11.11%)***
Comorbidities	***4 (14.81%)***
Chronic Hypertension	***2 (7.4%)***
Coronary artery disease	***1 (3.7%)***
Hypothyroidism	***1 (3.7%)***
Diabetes Mellitus	***1 (3.7%)***

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Table 3: Functional scores and range of motion of study participants

Clinical outcome measures	***Mean*** *± SD*	***Range*** *(min-max)*
AOFAS	98.25 ± 1.06	96 - 100
VAS	1.52 ± 0.70	1 - 3
Ankle Dorsiflexion		
Affected side	14.07 ± 7.97°	0-45
Unaffected side	28.15 ± 2.82°	40-59
Ankle Plantarflexion		
Affected side	36.30 ± 6.59	25 - 50
Unaffected side	46.30 ± 2.97°	40 - 50
Ankle Inversion		
Affected side	26.11 ± 4.87 °	15 - 35
Unaffected side	27.59 ± 3.76°	20 - 35
Ankle Eversion		
Affected side	20.74 ± 3.59°	15 - 25
Unaffected side	21.67 ± 3.40°	15 - 25
SF-36 Mental	55.6 ± 1.17	55.3 - 56.4
SF-36 Physical	56.2 ± 1.17	54 - 57.4

AOFAS = American Orthopaedic Foot and Ankle Society; VAS = Visual Analogue Scale

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Table 4: Clinical outcomes of each Takakura's stage

	Stage 0 (n=3, 11%)	**Stage-I (n = 6, 23%)**	**Stage-II (n = 11, 40%)**	**Stage-III (n = 4, 15%)**	**Stage-IV (n = 3, 11%)**	**P-values**
Presence of posterior malleolus fragment *(n)*	2	4	2	2	1	0.285 [a]
Presence of syndesmosis injury *(n)*	2	3	3	1	2	0.659 [b]
Plantar flexion ROM of the affected side; mean (median), (min-max)	36.67 (35) (35-45)	37.50 (37.50) (25-50)	35.91 (35) (25-50)	38.75 (40) (35-40)	31.67 (35) (25-45)	0.567 [b]
Dorsiflexion ROM of the affected side; mean (median), (min-max)	13.33 (15) (10-15)	11.67 (12.50) (0-20)	15.91 (15) (4-45)	11.25 (12.50) (5-15)	16.67 (20) (10-20)	0.736 [b]
AOFAS score; mean (median), (min-max)	80 (84) (67-90)	92 (91) (84-99)	84 (84) (74-96)	86 (85.50) (73-98)	80 (81) (75-85)	0.716 [b]
Clinical status	Excellent: 1 Good: 1 Acceptable: 1	Excellent: 3 Good: 3 Acceptable: -	Excellent: 3 Good: 7 Acceptable: 1	Excellent: 2 Good: 1 Acceptable: 1	Excellent: 1 Good: 2 Acceptable: -	0.760 [a]
VAS; mean (median), (min-max)	1 (1) (0-1)	1.83 (1.5) (1-3)	1.45 (1) 1-3	1.5 (1.5) 1-2	1.67 (2) 1-2	0.548 [b]
SF-36 PCS; mean (median), (min-max)	56.40 (56.20) (55.6-57.4)	56.30 (56.60) (54-57.4)	56.23 (56.20 (54.4-57.4)	56.35 (56.20 (55.6-57.4)	57.27 (57.40) (57-57.4)	0.437 [b]
SF-36 MCS; mean (median), (min-max)	54.77 (56.10) (51.8-56.4)	55.76 (56.10) (53.9-56)	55.87 (56.10) (53.9-56.4)	55.25 (55.55) (53.5-56.8)	55.57 (56.40) (53.9-56.4)	0.818 [b]

[a] = **Fisher's exact test**

[b] = **Kruskal-Wallis H test**