

ORIGINAL ARTICLE

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Radiological and functional comparison of conservative and percutaneous methods in calcaneus fractures with severe soft tissue injury and edema Ceyhun Caglar¹,  Fahri Emre²¹Department of Orthopedics and Traumatology, Ankara City Hospital, Ankara, Turkey²Department of Orthopedics and Traumatology, Gulhane Training and Research Hospital, Ankara, Turkey

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Abstract

There are different methods to treat calcaneus fractures. Since it is a weak area especially in terms of soft tissue coverage, an appropriate treatment method should be selected for the patient. Our goal in this study is to compare closed reduction-plastering (CRP) and closed reduction-percutaneous fixation (CRPF) techniques radiologically and functionally in patients unable to have open reduction-internal fixation due to severe soft tissue injury and edema. A total of 116 patients who underwent CRP (65 patients) and CRPF (51 patients) techniques between January 2015 and December 2018 at our clinic were included in the study. These two groups were divided into two subgroups according to the Sanders classification. Patients were evaluated according to follow-up time and fracture type. They were also evaluated radiographically based on fracture healing time and Böhler and Gissane angle measurements before and after treatment, and functionally using the AOFAS, MFS, and NPRS scales. Both groups had a mean follow-up of 3 years. In the CRPF group, the Böhler and Gissane angles were found to be restored better than in the CRP group, although this was not statistically significant ($p=0.421$, $p=0.554$, $p=0.751$, $p=0.698$). In functional evaluations with the AOFAS and MFS scales, better scores were calculated in the CRPF group and a statistically significant difference was found ($p=0.017$, $p=0.023$). Also, better outcomes were found for Sanders type 2 fractures than type 3 fractures. In patients with severe soft tissue injury and edema, a better reduction of functional outcomes can be achieved with the CRPF technique compared to CRP. This technique is convenient, reliable, and cost-effective. With this technique, more improvement can be achieved in radiological measurements. Finally, the Sanders classification has prognostic significance.

Keywords: Calcaneus, Böhler angle, Gissane angle, Sanders classification**Introduction**

Calcaneus fractures constitute 2% of all fractures and the most common fracture type among tarsal bone fractures [1,2]. Approximately 75% of all calcaneus fractures are intraarticular fractures because they are usually caused by axial loading forces, such as in falls from heights or traffic accidents [3]. Serious soft tissue injury and edema also occur around calcaneus fractures. It is a common injury among the actively working middle-aged male population [4,5]. Since about 20% of these patients can take up to 5 years to return to work, this causes socio-economic problems [6].

There are many different opinions in the literature regarding the treatment of calcaneus fractures and discussions about the treatment method to continue. The aim of the treatment of calcaneus fractures is the restoration of the impaired subtalar joint and elevation of

the collapsed posterior facet [7,8]. Treatment techniques include different methods such as closed reduction-plastering (CRP), closed reduction-percutaneous fixation (CRPF), open reduction internal fixation (ORIF), and primary subtalar arthrodesis. While some authors highlight surgical treatment, other authors advocate the effectiveness of conservative treatment [9-11].

The weakness of the soft tissue around the calcaneus and the fact that the calcaneus is a spongy bone is a challenge for orthopedic surgeons [12]. Severe edema or hemorrhagic bullae occurring after injury make these cases particularly risky, especially in terms of surgery. In some patients, ORIF cannot be applied due to concerns of postoperative wound problems, since edema does not decrease despite adequate elevation and cold application.

Our aim in this study is to compare the results of treatment performed with the CRP and CRPF techniques in patients who could not undergo ORIF due to severe soft-tissue edema and injury.

Materials and Methods

After the approval of the ethics committee of our institution (Number/date: E1-20-311/11.03.2020), 116 patients with calcaneus

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fractures (81 males, 35 females; mean age 38 years; range 18-72) treated at our clinic between January 2015 and December 2018 were examined retrospectively. Patients were evaluated in terms of age, gender, type of fracture, duration of follow-up, radiographic fracture healing time, radiographic angle improvements, and treatment outcomes.

Criteria for inclusion in the study were as follows: type 2 and 3 fractures according to the Sanders classification, more than 2 mm of subtalar joint displacement in the posterior facet, Böhler angle of $<20^\circ$, and Gissane angle above $>130^\circ$. Any additional fracture beside the calcaneus fracture in the same limb, open fractures, Sanders type 4 fractures, foot deformity, previous foot surgery, and inflammatory arthritis were the exclusion criteria.

The patients were divided into 2 groups as CRP (65 patients, Group 1) and CRPF (51 patients, Group 2). The patients in both groups were again divided into two groups as a result of the Sanders classification, which was made according to the coronal sections of computerized tomography (CT) images taken preoperatively (Group 1: 36 patients Sanders type 2, 29 patients Sanders type 3; Group 2: 24 patients Sanders type 2, 27 patients Sanders type 3) (Figure 1).

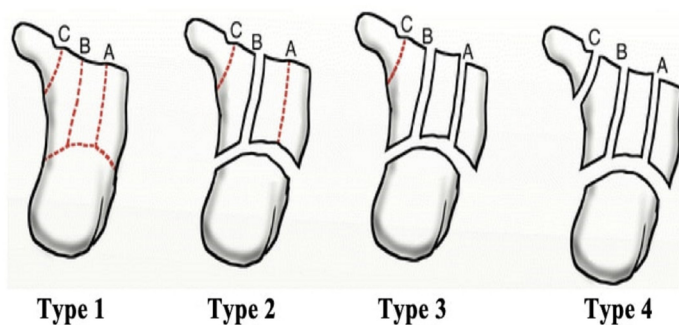


Figure 1. Sanders classification used in calcaneus fractures

Standard anteroposterior (AP) and lateral radiographs were taken before and after treatment for all patients. Böhler and Gissane angle measurements were done from lateral radiographs before and after treatment (Figures 2a,b). Functional scores of the patients were evaluated according to the American Orthopedic Foot and Ankle Score (AOFAS), the Maryland Foot Score (MFS), and a numerical pain rating scale (NPRS).



Figure 2a. Measurement of Böhler angle in a patient with a calcaneus fracture



Figure 2b. Measurement of Gissane angle in a patient with a calcaneus fracture

Treatment procedure

First of all, since all patients had severe soft-tissue edema, all patients underwent resting, elevation, and cold application (Figure 3). Patients whose edema had decreased in follow-up and whose wrinkle test became positive were treated an average of 7.3 (range 3-14) days later. Subsequently, all patients were offered surgical treatment. CRP treatment was performed to patients who did not accept surgery, and CRPF treatment was applied to other patients.



Figure 3. A calcaneal fracture patient with severe soft tissue injury and edema

After the fracture patterns were evaluated, manual reduction with the Omoto method, and a short leg cast were applied for patients who underwent the CRP technique [13]. All patients were discharged on the same day after reduction was confirmed on the radiographs.

For patients undergoing the CRPF protocol, the first two Schanz screws were placed in the tuber calcanei and posterior facet under anesthesia. After the tuber calcanei and the posterior facet were seen to be reduced under fluoroscopy and the joint surface was restored, percutaneous fixation was performed with 2 or 3 cannulated screws of 6.5 mm from the posterior to the anterior (Figure 4). Afterward, all of the patients who underwent short leg splinting were discharged after being followed for 1 day in the hospital.

Rehabilitation

The casts of patients in the first group were removed in approximately the 8th week of their follow-up. Passive and active range of motion (ROM) exercises were performed between 8 and 12 weeks, respectively. After the 12th week, patients started

weight-bearing as much as they could tolerate.

As fixation was applied for the patients in the second group, their splints were removed in the 4th to 6th weeks of follow-up. Passive and active ROM exercises were performed between 6 and 12 weeks, respectively. After the 12th week, patients started weight-bearing as much as they could tolerate, as in the first group.



Figure 4. Postoperative lateral radiography of the patient undergoing CRPF method

Statistical analysis

All statistical analyses were performed using SPSS 15.0 (SPSS Inc., Chicago, IL, USA). The independent group t-test was used for the evaluation of parametric measurements and the Mann-Whitney U test was used for the evaluation of non-parametric measurements.

Results

The demographic characteristics, follow-up times, fracture healing times, and current pain scores of the patients are presented in Table 1. When evaluated in terms of age, the means of the two groups were close to each other. Both groups had mean follow-up times of at least 3 years. Although the radiographic fracture healing time was shorter and the mean NPRS score was slightly lower in the CRPF group, there were no statistically significant differences between the two groups ($p=0.117$, $p=0.345$).

Table 1. Evaluation of patients in terms of age, follow-up time, radiographic fracture healing time and pain scores by groups

	CRP	CRPF	p Value
Age (Year) ($\pm$SD)	41.4 $\pm$ 23.8	34.5 $\pm$ 21.7	0.912
Follow-up time (Month) ($\pm$SD)	38.3 $\pm$ 5.4	39.7 $\pm$ 6.1	0.754
Radiographic fracture healing time (Month) ($\pm$SD)	2.43 $\pm$ 0.91	2.26 $\pm$ 0.88	0.117
NPRS ($\pm$SD)	3.24 $\pm$ 1.82	2.98 $\pm$ 1.53	0.345

CRP, Closed reduction-plastering; CRPF, Closed reduction-percutaneous fixation; SD, Standard deviation; NPRS, Numeric pain rating scale

The Böhler and Gissane angles were measured on the lateral radiographs taken before and after the treatment of the patients and their averages are shown in Table 2. Although the results of both treatment techniques were radiographically obtained to be better than before, there was no statistically significant difference between these angle changes ($p=0.421$, $p=0.554$, $p=0.751$, $p=0.698$). However, in the CRPF group, more restoration was detected radiographically compared to the CRP group.

Table 2. Comparison of Böhler and Gissane angles before and after both treatment techniques

	Before Treatment	After Treatment	p Value
Böhler Angle (Degree) ($\pm$SD)			
CRP	5.7 $\pm$ 3.1	10.4 $\pm$ 5.8	0.421
CRPF	4.3 $\pm$ 2.6	26.9 $\pm$ 6.3	0.554
Gissane Angle (Degree) ($\pm$SD)			
CRP	154.2 $\pm$ 11.4	143.8 $\pm$ 10.1	0.751
CRPF	155.7 $\pm$ 13.5	121.1 $\pm$ 12.2	0.698

CRP, Closed reduction-plastering; CRPF, Closed reduction-percutaneous fixation; SD, Standard deviation

In Table 3, the patients are divided into two different subgroups as Sanders type 2 and type 3 within each of the two main groups and the functional results of these 4 different subgroups are evaluated with the AOFAS and MAS scales. While there were close results for the two treatment groups, better results were found for Sanders type 2 fractures than type 3 fractures. The values obtained with both the AOFAS ($p=0.017$) and MAS ($p=0.023$) scales were statistically significant.

Table 3. Functional results after treatment, relationships between treatment groups and Sanders classification

	CRP		CRPF		p Value
	Sanders Type 2	Sanders Type 3	Sanders Type 2	Sanders Type 3	
n	36	29	24	27	
AOFAS ($\pm$ SD)	82.52 $\pm$ 7.37	71.44 $\pm$ 6.24	94.75 $\pm$ 5.51	82.97 $\pm$ 6.77	0.017*
MFS ($\pm$ SD)	83.12 $\pm$ 8.33	73.63 $\pm$ 4.88	95.23 $\pm$ 5.26	85.65 $\pm$ 5.04	0.023*

CRP, Closed reduction-plastering; CRPF, Closed reduction-percutaneous fixation; SD, Standard deviation; AOFAS, American Orthopaedic Foot and Ankle Score; MFS, Maryland Foot Score; *, Statistically significant

No acute complications such as neurovascular injury, compartment syndrome and superficial or deep infection were observed in any patients. A total of 4 patients developed pressure sores due to their casts, which was noticed when the casts were removed, and these

wounds were treated with conservative methods. It was observed that stage one subtalar osteoarthritis developed in 3 patients in the CRP group in mean 12.7 months of their follow-up and 1 patient in the CRPF group in 15.6 months of his follow-up.

Discussion

Approximately 90% of calcaneus fractures occur in the actively working male population aged 21 to 45. These fractures cause serious harm to a country's economy in terms of both hospital costs and labor losses [14]. Therefore, it is important to apply optimal treatment suitable for the type and pattern of fracture.

Treatment options of intraarticular calcaneus fractures can be divided into 4 different methods [15]. These are CRP, CRPF, ORIF, and primary subtalar arthrodesis [16]. In our study, we compared the CRP and CRPF techniques. We did not apply ORIF or subtalar arthrodesis techniques in these patients because all of the patients we included in the study had severe soft tissue injury and edema.

When the literature is analyzed, there are many different opinions about the CRPF technique. Although Khurana et al. reported that they achieved poor clinical outcomes with this technique [17], Zeng et al. stated that they had good outcomes for Sanders type 2 and 3 calcaneus fractures with the CRPF technique, and especially Sanders type 2 fractures [18]. In our study, we obtained higher functional scores in the CRPF group than the CRP group after at least 3 years of follow-up.

Kitoaka et al. [11] performed gait analysis of 16 conservatively treated patients with displaced intraarticular fractures and found permanent functional disorders in some cases. In the study conducted by O'Farrell et al. [19], 12 patients were treated conservatively, and 12 patients were treated surgically, and better results were reported in the surgical group. In another study performed by Leung et al. [20], 44 patients who underwent surgery and 19 patients who were followed conservatively were compared in terms of pain, ROM, hind-foot swelling, and return to work after 3 years of follow-up and more satisfactory results were found in the surgical group. In our research, we had better outcomes in many respects in the group for which we performed the surgery. Also, due to the confidence in the fixation applied in the CRPF group, joint ROM exercises can be started earlier, which enables better functional results with this technique.

Medical drugs are tried to accelerate the healing of the fractures after the surgery. In a study, ibandronate, which is a bisphosphonate type, was used after surgery in the tibia fracture model in rats, but no positive contribution to fracture healing was shown [21]. We also think that immobilization of the fracture is much more effective than medical drugs in fracture healing.

Although there are many classification systems for calcaneus fractures, the Sanders classification, based on the widest point of the posterior facet, is routinely used in the clinic. According to Sanders et al. [22], the Sanders classification is an important criterion in determining prognosis, whereas according to some authors it has no prognostic value [23,24]. When the data that we obtained in our study were evaluated, we concluded that the Sanders classification was prognostic for calcaneus fractures. In both treatment groups, we found better clinical outcomes in cases of Sanders type 2 fractures than type 3 fractures, which is further evidence of the prognostic significance. In a study of Sanders type 4 fractures conducted by Jain et al. [25], which we did not include in our study, the results were poor despite the excellent reduction,

and it was stated that primary subtalar arthrodesis should be considered for these patients.

The Böhler angle indicates the collapse of the joint surface. This angle may decrease with both intraarticular and extraarticular fractures. The Böhler angle being below zero before treatment increases the probability of subtalar arthrodesis by approximately ten times [26]. Another variable is the Gissane angle, and its value increases in cases of calcaneus fractures. In our study, it was shown that the Böhler and Gissane angle reached the desired values after treatment in the CRPF group, but such good results were not achieved in the CRP group. The reason for this is that although the manual reduction was performed with the Omoto method in the CRP group, the better correction was provided in the CRPF group with the help of Schanz screws [13].

When the ORIF technique, which is applied with a lateral approach in the treatment of calcaneus fractures, is examined, complications such as skin necrosis and surgical site infection are present in approximately 25% of patients, especially in patients with severe soft tissue injury and edema [27]. In our study, although 116 patients were treated, we did not encounter any wound or infection problems.

Our study has some limitations. As it is a retrospective study, first of all, it may have some biases. Secondly, there is no correlation between the fracture pattern and the treatment technique selected. Thirdly, since the scales used in the evaluation are based on patients' statements, the objectivity of the data that we obtained may be questioned. Another point is that comorbid diseases that may affect the healing process of patients were not included in this study. Finally, although we have a mean follow-up time of over 3 years, we need longer follow-up times to better evaluate clinical outcomes.

Conclusion

The functional superiority of the CRPF technique compared to CRP was noticeable in this study among patients who could not undergo the ORIF technique due to severe soft tissue injury and edema. Both techniques are effective when the length of hospital stay and complication possibilities are evaluated. The Sanders classification has prognostic significance after treatment. The CRPF technique is more successful in restoring the Böhler and Gissane angles. In conclusion, the CRPF technique is a very suitable, reliable, economical, and satisfying treatment method for calcaneus fractures.

Conflict of interests

The authors declare that they have no conflict of interest.

Financial Disclosure

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Ethical approval

This study was approved by Ankara City Hospital Ethics Committee (Ethical permission no:EI-20-311/ 11.03.2020).

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