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Original Article

Extensile approach versus minimally invasive technique in management of calcaneus fractures

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Abstract: Background: Calcaneus fracture is one of the important fractures in orthopedic surgery. Here we aimed to investigate and compare the extensile approach and minimally invasive technique in patients with calcaneus fractures. Methods: This is a randomized clinical trial that was performed in 2019 in Kashani and Alzahra hospitals in Isfahan, Iran. The study population consisted of 30 patients with intraarticular calcaneus fractures. Thirty patients were divided into two groups. In the first group, surgery was performed using the minimally invasive technique and in the second group, the extensile approach was performed. Patients were followed for 12 months. Data regarding the duration of surgery, Boehler and Gisan angles, quality of joint reduction, subtalar joint movement, the incidence of soft-tissue complications and pain of the patients were measured and compare between two groups. Results: A total number of 30 patients entered the study and were divided into two groups each containing 15 patients. The duration of operation in the extensile approach group was significantly higher than the minimally invasive group (P = 0.03). The severity of pain and mean Boehler angle were significantly higher in the minimally invasive group than in the extensile approach group (P = 0.001 and P = 0.002 respectively). The quality of reduction was also significantly better in the extensile approach group than minimally invasive (P = 0.01) but the extensile approach group had more soft tissue complications than the minimally invasive group (P = 0.006). Conclusion: Extensile approach was associated with lower pain, lower Boehler angle and better quality of reduction compared to minimally invasive technique but also higher operation duration and surgical site complications. We suggest that the extensile approach should be used in patients with calcaneus fractures with attention to possible complications.

Keywords: Calcaneus fracture, minimally invasive, extensile approach

Introduction

The calcaneus is the largest bone in the ankle and the most common tarsus bone in which fractures occur. Based on data, this fracture is responsible for 1 to 3% of total body fractures [1, 2]. 75% of these fractures are intra-articular [3]. The mechanism of calcaneus injury is mainly the pressure from the vertical axis to the calcaneus bone [4]. Usually, the population affected by this injury is men between 30-60 years. Because the calcaneus is generally made of spongy bone and has a very thin cortex, even mild compressive forces such as falling from a low height can cause an intra-articular fracture by inserting the talus into the calcaneus [5]. The main goals of treatment of this type of fracture are complete relief of back pain, ability to walk and the ability to wear ordinary shoes again [6]. In the last two decades, following the development of modern surgical techniques and imaging based on CT scan, the quality of bone replacement has increased and surgical treatments have become the main therapeutic option for this fracture [7, 8].

Most orthopedic surgeons usually prefer non-surgical treatments to treat calcaneus fractures because the results of the surgery have been unpredictable [9]. However, studies have shown that the rate of late complications and socioeconomic burden of the disease in the treatment of open reduction and fixation of displacement and intra-articular fractures of the calcaneus is lower than non-surgical treatments [2]. The extensile lateral surgical ap-

proach is currently widely used to treat intra-articular calcaneus fractures. However, this procedure is associated with the risk of adverse complications such as wound dehiscence or infection at the surgical site [10]. To deal with this complication, physicians use the alternative method of percutaneous reduction with the minimally invasive approach. It has been shown that in the minimally invasive method, proper fracture reduction is not achieved and due to the importance of anatomical reduction in future joint function, this challenge is very important [11]. Previous studies have discussed the advantages of both surgical methods. Comparison of Minimally invasive technique versus an extensile lateral approach for calcaneus fractures has shown the same clinical results in some studies but most of the former studies have focused on the differences between complications of these approaches [12, 13].

As mentioned above, surgical treatments of calcaneus fractures have high clinical importance and former studies could not clarify which approach is superior. Due to the importance of calcaneus fractures and their complications, determining the appropriate treatment approach is very important, so in this study, we will try to compare these two common treatments for the first time in Iran, in terms of effectiveness and different clinical parameters and also complications.

Methods and material

Study design

This is a randomized clinical trial that was performed in 2019 in Kashani and Alzahra hospitals in Isfahan. The study population consisted of 30 patients with intraarticular calcaneus fractures referring to Kashani and Alzahra hospitals in 2019. The current study was approved by the Research Committee of Isfahan University of Medical Sciences and the Ethics committee has confirmed it.

Inclusion and exclusion criteria

The inclusion criteria were: Patients aged 18 to 75 years, intra-articular fracture of the calcaneus with a displacement of more than 2 mm detected by coronal, sagittal and axial CT scans (except for open fractures and Sanders Type 4 fractures), no previous history of surgery, fractures, osteoarthritis and inflammatory arthritis in the foot and ipsilateral ankle, absence of major comorbidities (uncontrolled hypertension, previous history of MI, cancer, history of stroke or TIA, obstructive pulmonary disease, cardiac arrhythmia, peripheral vascular disease, diabetes, peripheral neuropathy, and severe obesity), no smoking and the minimum follow-up of 12 months. The exclusion criteria were: Patients who have fractures due to secondary causes at the operation site, such as re-trauma, patients who did not follow the scheduled follow-up for any reason and death for any reason.

Study population

All patients signed the informed consent form at the beginning of the study and were excluded from the study whenever they decided to leave the study. The sampling method in this study was available or simple. The method of allocating patients to the two groups under study was completely random and using SPSS statistical software.

Patients were divided into two groups. The grouping was performed using random allocation software version 2.0. In the first group, surgery was performed using the minimally invasive technique and in the second group, the extensile approach was performed.

Surgical procedures

In the first group, the patient was placed in a lateral position. The tourniquet was closed above the ankle and left on for up to 2 hours. The incision was given from the site of the lateral malleolus to the base of the fourth metatarsus. With the help of this method, posterior facet and, if necessary, anterior and calcaneocuboid joint facets could be seen and reduced. In the second group, the extensile lateral approach was placed in the lateral position. The tourniquet was closed above the ankle and left on for up to 2 hours. The patient underwent surgery using a large L-shaped incision in the lateral ankle according to Benirshcke and Sangeorzan methods. All surgeries were performed by a single orthopedic surgeon and the same surgical team.

Measuring tools

Demographic information including age, sex, and type of trauma was collected. The dur-

Table 1. General information and clinic feature of patients

Variable		extensile approach (N = 15)	minimally invasive (N = 15)	*P*-value
Age (Mean ± SD) (years)		35.33 ± 11.69	41.61 ± 7.46	0.17
Gender (N (%))	Male	12 (80%)	11 (73.3)	0.75
	Female	3 (20%)	4 (26.7%)	
Pain intensity (Mean ± SD)		5.23 ± 1.12	5.14 ± 1.44	0.62
Boehler angle (degree)		18.24 ± 3.10	19.17 ± 2.18	0.77
Gisan angle (degree)		143.77 ± 3.25	142.32 ± 2.79	0.63

ation of surgery was recorded by the surgeon. Patients were continuously referred for follow-up and their information was collected for up to 12 months. The radiographs performed were lateral and Broden 30-degree X-rays taken before and after surgery, as well as 3, 6, and 12 months later, and the Boehler and Gisan angles were measured and recorded using a goniometer. CT scans were also performed before and after surgery and 12 months later to assess joint surface reduction.

The reduction was classified into three groups according to the criteria of Janzen and colleagues [14] based on the quality of reduction of posterior subtalar joint facet: 1-Anatomical reduction (step-off joint surface zero), 2-Close to anatomical (step-off < 2 mm joint surface), 3-Non-anatomical (step-off > 2 mm joint surface).

The hindfoot direction was classified into three groups: Varus, Valgus and Neutral by measuring the angle between the longitudinal axis of the calcaneus and the axis of the leg. Subtalar osteoarthritis in patients was classified into three groups: 1-Mild (reduced joint space), 2-Moderate (reduced joint space and subchondral sclerosis), 3-Severe (severely reduced joint space or lack of joint space).

The amount of subtalar joint movement was assessed using the method explained by Morrey and Wiedeman as follows: The patient was placed in the supine position. The ankle was kept in the neutral position and the inversion and eversion of the calcaneus were measured and compared with the healthy side. Ankle function using the American Orthopedic Foot and Ankle Society (AOFAS) questionnaires, which consisted of two subjective sections completed by the patient and an objective section completed by the physician. This questionnaire includes three parts of pain (40 points), function (50 points) and alignment (10 points) that the sum of patient scores is calculated from zero to one hundred.

Also, the severity of patients' pain during walking and activity was measured and recorded according to the visual analogue scale (VAS) based on the patient's own diagnosis [15] scoring their pain from 0 (least pain) to 10 (worst pain). The incidence of soft tissue complications such as surgical site infection, surgical wound dehiscence, bread union or delayed union, erythema or cellulitis were recorded by the orthopedic surgeon during 12 months of follow-up.

Statistical analysis

Finally, the data were analyzed in SPSS software (version 24, IBM Corporation, Armonk, NY). Qualitative variables were compared using X^2 and quantitative variables were compared using the Paired T-test. Quantitative variables had a normal distribution and a standard deviation was presented. Independent t-test and Chi-square tests were also used for data analysis. The statistical significance of this study was 95% confidence interval and *P*-value < 0.05 was considered as the significant threshold.

Results

Population

A total number of 30 patients entered the study and were divided into two groups each containing 15 patients. Analysis of demographic data showed that the mean age of the extensile approach group was 35.33 ± 11.69 years and the mean age of the minimally invasive group was 41.61 ± 7.46 years. Twelve patients (80%) in the extensile approach group were males and 11 patients (73.3%) in the minimally invasive group were male. General pre-operative clinical information of patients are summarized in **Table 1**. No significant differences were observed between the two groups regarding age (P = 0.17) and sex (P = 0.75). We also evaluated patient's pain, Gisan

Table 2. Evaluation and comparing the post-operative variables in the minimally invasive and extensile approach groups

	extensile approach (N = 15)	minimally invasive (N = 15)	*P*-value
Operation time (min.)*	68.66 ± 11.8	61.33 ± 3.5	0.03
Boehler angle (degree)*	40.45 ± 5.59	48.73 ± 7.9	0.002
Gisan angle (degree)*	130.26 ± 7.6	126.9 ± 11.3	0.35
Pain intensity*	2.46 ± 0.5	3.93 ± 1.2	0.001
Quality of reduction**			
Anatomical	9 (60%)	-	0.01
Close to anatomical	6 (40%)	8 (53.3%)	
Non-anatomical	-	7 (46.7%)	
Soft tissue complications**			0.006
Yes	10 (66.7%)	3 (20%)	
No	5 (33.3%)	12 (80%)	

*Results are reported based on Mean + SD. **Results were reported based on frequency and percentage.

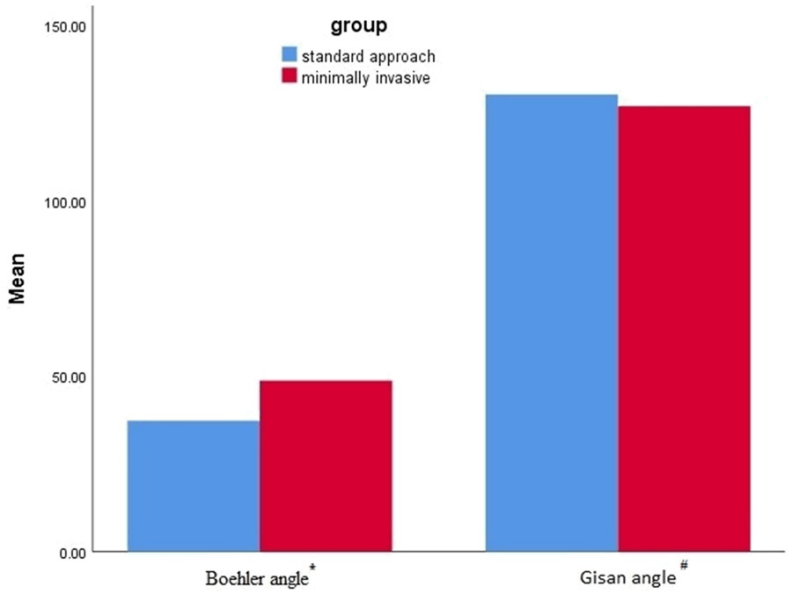

Figure 1. Differences in Post-operative angles in two groups. *Boehler angle was significantly lower in standard (extensile) approach group compared to minimally invasive (40.45 ± 5.59 vs. 48.73 ± 7.9, P = 0.002). #Gisan angle was not significantly different between two groups (130.26 ± 7.6 vs. 126.9 ± 11.3, P = 0.35).

and Boehler angles and showed no significant differences between two groups (P > 0.05).

Quantitative variables

Evaluation and comparing the distribution of the main variables of the study including (duration of operation, Boehler and Gisan angles, pain intensity, quality of reduction and soft tissue complications) in the minimally invasive and extensile approach groups are summarized in **Table 2**. These results showed that among the quantitative variables, the duration of operation in the extensile approach group was significantly higher than the minimally invasive group (P = 0.03). Furthermore, it was indicated that the severity of pain and mean Boehler angle were significantly higher in the minimally invasive group than in the extensile approach group (P = 0.001 for pain and P = 0.002 for the Boehler angle). However, no significant difference was observed between the study groups and the mean Gisan angle in the groups (P = 0.35). **Figure 1** demonstrates the differences in both angles between groups.

Qualitative variables

The results of the Chi-square test showed that there was a significant difference between the distribution of qualitative variables including quality of reduction and soft tissue complications in the minimally invasive extensile approach group, so that in the extensile approach group the quality of reduction was significantly better than minimally invasive (P = 0.01) and the extensile approach group had more soft tissue complications than the minimally invasive group (P = 0.006) (**Table 2**; **Figure 2**). We should note that 10 patients (66.7%) in the extensile approach group had soft tissue complications (6 wound dehiscence, 3 delayed unions, and 1 surgical site infection) while 3 patients (20%) in the minimally invasive group had these complications (2

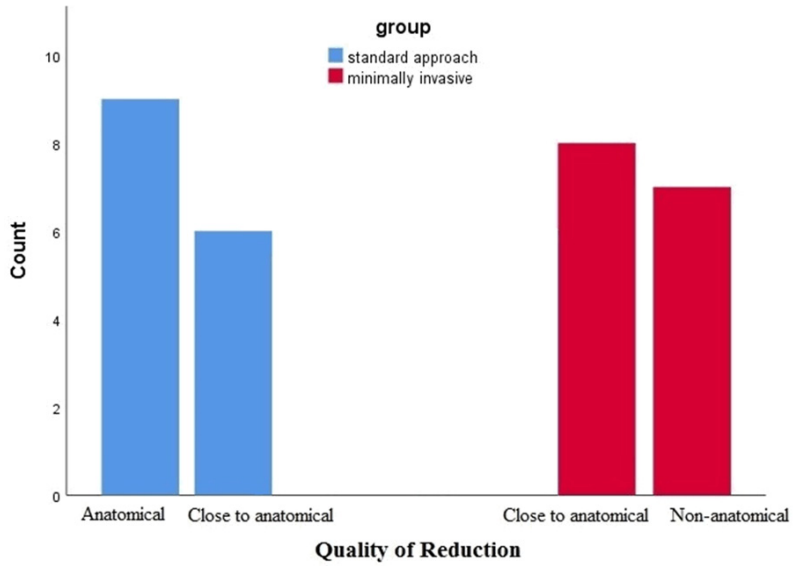

Figure 2. Clustered Bar Count of Quality of Reduction by Group.

wound dehiscence and 1 surgical site infection).

Discussion

In the present study, we indicated that the severity of pain and mean Boehler angle were significantly higher in the minimally invasive group than in the extensile approach group. On the other hand, we showed that the duration of operation in the extensile approach group was significantly higher than the minimally invasive group and patients in the extensile approach group had a significantly better quality of reduction. We also indicated that the extensile approach group had more soft tissue complications than the minimally invasive group. It should also be noted that in the extensile approach group, both Boehler and Gisan angles were in normal range due to the better quality of reduction in these patients. These results indicate better therapeutic results for extensile approach surgical technique.

Some previous studies have also evaluated these methods. Kline and others performed a study in 2013 on 112 cases with calcaneus fracture and compared the therapeutic results of the minimally invasive and extensile approach. They showed that pain and clinical data were similar between the two groups but the minimally invasive technique was associated with lower surgical site complications and had a lower incidence of secondary surgeries [12]. Another study was conducted in 2018 by Zeng and others on eight previous clinical trials containing 495 patients. They explained that both surgical techniques are effective and associated with satisfying clinical results but using the extensile approach could result in better results compared to minimally invasive. On the other hand, the duration of operation was lower in the minimally invasive techniques [16]. These results are in line with the findings of our study showing the importance and effectiveness of both surgeries. We also explained that the mean Boehler angle and pain severity were significantly higher in the minimally invasive technique meaning the better therapeutic results in the extensile approach.

Khurana and others also assessed 21 patients with closed Sanders type 2 and 3 calcaneus fractures and reported that although the soft tissue complications were lower in minimally invasive technique the clinical and radiological results were better in patients undergoing extensile approach [17]. These findings were also in line with our results emphasizing the effectiveness of the extensile approach in patients. Mehta and colleagues also had a survey on minimally invasive and extensile approaches and showed that minimally invasive technique for calcaneus fractures was associated with shorter operation duration and had a lower incidence of complications [18]. We also showed the same results but furthermore, we showed that the severity of pain and mean Boehler angle were significantly higher in the minimally invasive group than in the extensile approach group. The higher severity of pain and lower clinical results in the minimally invasive approach was mentioned in some other previous studies.

Most of the previous studies have assessed the minimally invasive surgical technique and reported shorter operation duration and lower

surgical site complications [19, 20] but the key point of our study was that we used Boehler angle and quality of reduction along with the severity of pain to compare these two methods. As Kiewiet and colleagues have mentioned, quality of reduction and radiological indexes like Boehler angle could play important roles in determining the beneficial techniques for calcaneus fractures [21]. The results of the current study were in line with most previous studies. We believe that by using the extensile approach, patients will have better clinical results and lower pain but surgeons should pay more attention to the incidence of surgical site complications and follow the proper strategies to minimize them. Based on these data and the results of our study, we suggest that the extensile approach should be used in younger, non-smoker patients with unilateral fracture and intact skin and on the other hand, the minimally invasive technique should be used for other cases.

The limitation of the current study was restricted study population and also lack of proper and organized follow up in patients. Some patients also resisted against control CT imaging that finally were convinced by the research team.

Conclusion

Here we showed that the extensile approach was associated with lower pain, lower Boehler angle and better quality of reduction compared to minimally invasive technique but also higher operation duration and surgical site complications. These findings were in line with most of the previous studies. We suggest that the extensile approach should be used in patients with calcaneus fractures with attention to possible complications.

Disclosure of conflict of interest

None.

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