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RESULTS OF FIXATION IN THE TREATMENT OF CALCANEUS FRACTURE: A CROSS-SECTIONAL STUDY

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ABSTRACT

The calcaneus bone is the largest ankle bone and calcaneal fractures are the most common fracture of the tarsal bones and represent 1% to 2% of all fractures. Roughly 75% of these fractures are intra-articular, which despite the therapeutic interventions is still known as a fracture with poor therapeutic outcomes. This study investigated the results of fixation in the treatment of calcaneus fracture among patients referred to Shahid Sadoughi and Shahid Rahmonun hospitals in Yazd during 2017-2018. This is a cross-sectional study and the data obtained from the patients with intra-articular calcaneus fracture -diagnosed by simple x-ray and CT scan- was analyzed using SPSS and statistical tests. The fractures involving the subtalar joint were included in the study. Demographic information, postoperative complications, infection, and duration of treatment and recovery were also investigated.Thirty two patients were included in the study; 28 of them (87.5%) were males

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and 4 patients (12.5%) were females. 93.8% of the participants suffered from postoperative chronic pain, which was the most common complication in this study. 7 patients (21.9%) had an infection, 2 of them (6.3%) had sudeck's atrophy, 2 patients (6.3%) had peroneal tendon pain, and one of them (3.1%) had calcaneocuboid. For 19 patients, the average pre and postoperative Bahler angle was 28.96±9.60 and 20.84±11.22, respectively (p-value=0.016, r=0.544), the average pre and postoperative Gissane was 136.15±10.54 and 142.93±16.60, respectively (p-value<0.001), the average pre and postoperative calcaneal pitch angle was 24.44±6.02 and 23.36±5.11, respectively (p-value=0.023), the average pre and postoperative talocalcaneal angle was 43.20 ± 6.80 and 42.25 ± 6.19, respectively (p-value < 0.001), the average pre and postoperative tibiotalar angle was 26.30±4.56 and 24.87±5.35, respectively (p-value=0.69), and the average pre and postoperative posterior surface slope was 28.96±9.60 and 20.84±11.22, respectively (p-value=0.016). The results showed that chronic pain is the most important postoperative complication in patients with calcaneus fractures, and surgery is somewhat effective in patients with calcaneus fractures.

KEYWORDS: calcaneal fracture; fixation treatment; Bahler angle; tibiotalar angle; Gissane angle; talocalcaneal angle; Calcaneal pitch angle; posterior surface slope.

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RESULTADOS DE LA FIJACIÓN EN EL TRATAMIENTO DE LA FRACTURA DEL CALCÁNEO: ESTUDIO TRANSVERSAL

RESUMEN

El calcáneo es el hueso más grande del tobillo, y las fracturas de calcáneo son las más frecuentes de los huesos del tarso y representan entre el 1% y el 2% de todas las fracturas. Aproximadamente el 75% de estas fracturas son intraarticulares, lo que, a pesar de las intervenciones terapéuticas, sigue siendo una fractura con malos resultados terapéuticos. Este estudio investigó los resultados de la fijación del calcáneo en pacientes remitidos a los hospitales *Shahid Sadoughi* y *Shahid Rahmonun* de Yazd durante 2017-2018. Se trata de un estudio transversal y los datos obtenidos de los pacientes con fractura intraarticular del calcáneo -diagnosticada mediante radiografía simple y tomografía computarizada- se analizaron mediante el uso de rayos X y tomografía computarizada- se analizaron mediante SPSS y pruebas estadísticas. Las fracturas de la articulación subastragalina. La información demográfica, las complicaciones postoperatorias, infección, duración del tratamiento y recuperación. Treinta y dos pacientes fueron incluidos en el estudio; 28 de ellos (87,5%) eran varones y 4 (12,5%) mujeres. El 93,8% de los participantes sufría dolor crónico postoperatorio, que era la complicación más frecuente en este estudio dolor crónico, que fue la complicación más frecuente en este estudio. 7 pacientes (21,9%) infección, 2 de ellos (6,3%) tenían atrofia de Sudeck, 2 pacientes (6,3%) tenían dolor en el tendón peroneo y uno de ellos tenía dolor en el tendón peroneo, y uno de ellos (3,1%) tenía calcaneocuboide. En

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19 pacientes, el ángulo de Bahler pre y postoperatorio fue de 28,96±9,60 y 20,84±11,22, respectivamente (valor p-valor=0,016, r=0,544), la media pre y postoperatoria del ángulo de Gissane fue de 136,15±10,54 y 142,93±16,60, respectivamente (p-valor<0,001), el ángulo de inclinación del calcáneo pre y postoperatorio medio fue de 24,44±6,5, (p-valor=0,016, r=0,544), calcáneo pre y postoperatorio fue de 24,44±6,02 y 23,36±5,11, respectivamente (p-valor=0,023), el ángulo medio pre y postoperatorio talón calcáneo fue de 43,20 ± 6,80 y 42,25 ± 6,19, respectivamente (p-valor < 0,001), 0,001), el ángulo tibiotalar medio pre y postoperatorio fue de 26,30 ± 4,56 y 24,87 ± 5,35, respectivamente. 24,87±5,35, (p-valor=0,69), y la pendiente media de la superficie posterior pre y postoperatoria fue de 28,96±5,35, respectivamente (p-valor < 0,001), posterior pre y postoperatoria fue de 28,96±9,60 y 20,84±11,22, respectivamente (valor de p = 0,016). Los resultados mostraron que el dolor crónico es la complicación postoperatoria más importante en pacientes con fracturas de calcáneo, y la cirugía es algo eficaz en pacientes con fracturas de calcáneo.

PALABRAS CLAVE: fractura de calcáneo; tratamiento de fijación; ángulo de Bahler; ángulo tibiotalar; ángulo de Gissane; ángulo talón calcáneo; ángulo de cabeceo del calcáneo; pendiente de la superficie posterior.

INTRODUCTION

Calcaneal fractures are the most common fracture of the tarsal bones and represent

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1% to 2% of all fractures. Roughly 75% of these fractures are intra-articular and in the posterior calcaneus facet (1). The injuries to the lower extremity usually occur as a result of high-energy trauma due to falls or motor vehicle accidents that cause stress on the body's axis. These fractures often change life and the patient experiences a status like those affected by myocardial infarction and chronic kidney disease (2). The most common symptom includes pain in the calcaneus area, which usually occurs after falling from a height. Other symptoms include the inability to bear weight on the affected leg and restricted motion of the ankle and leg. During the examination, the attending physician may notice swelling, redness, and hematoma. The early and late complications associated with calcaneus intra-articular fractures lead to many challenges for surgeons and a wide discussion of the fractures' optimal management (1-5). ORIF (Open Reduction Internal Fixation) with a lateral approach is known as the standard treatment for intra-articular fractures (6). The non-surgical treatment is suitable for extra-articular fractures and Saunders type 1 intra-articular fractures, provided that the joint surface remains intact. Depending on the patient, the doctor may decide to use reduction with or without fixation or fixation alone. Intra-articular fractures with displacement require surgery before the bone hardens (up to 3 weeks after the fracture). Conservative surgery includes closed reduction and percutaneous fixation. This method causes fewer wound complications, better healing of soft tissue, and reduced operative time. However, it is associated with less adequate fixation compared to open reduction (7). Many calcaneus fractures are associated with severe soft tissue injuries, resulting in an increased risk of skin necrosis and infection, especially in diabetics and smokers (8,9). Improper management of calcaneus bone fractures has adverse consequences and unexpected complications. As the management of calcaneus bone fractures may cause unexpected complications, there is a need to investigate the

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postoperative results among the patients. Therefore, the present study aimed at examining the results of calcaneus fracture fixation treatment.

MATERIALS AND METHODS

This is a cross-sectional study to investigate the results of calcaneus fracture fixation treatment. The samples were selected using the total and available sampling method out of the patients with calcaneus fractures. Fractures involving the subtalar joint were included in the study. Tuberosity fractures, Achilles tendon involvement, and cases without subtalar involvement were excluded. Patients' demographic information, postoperative complications, infection, duration of treatment, and recovery were also studied. Infection complications include malunion, Sudeck's atrophy, chronic pain, subtalar arthrosis, calcaneocuboid, peroneal tendon pain, and plaque protrusion. The data was analyzed using SPSS and statistical tests to check the significance of the variables. Mean and standard deviation was used to describe quantitative variables, and frequency and relative frequency were used to describe qualitative variables. The chi-square test was used to check the relationship between the rank and nominal variables. Independent t-test or ANOVA was used to investigate the relationship between quantitative and nominal variables. The equivalent non-parametric test was also used if the conditions of parametric tests were not established.

RESULTS

In this study, 32 patients with intra-articular calcaneus fractures were examined. The demographic information of the patients is summarized in Table 1.

Table1. Patient's demographic information

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Variable		Mean± standard deviation	Number (%)
Age		40.5 ± 16.63	-
Gender	Male	-	4(12.5)
	Female	-	28 (87.5)

The patients' average age was about 40 years; the youngest patient was 11 years old and the oldest one was 70 years old. According to the table, among the 32 patients, 28 of them (87.5%) were males and 4 patients (12.5%) were females.

Table 2 presents the pre and postoperative average Bahler, Gissane, calcaneal, talocal, and talar angles as well as the posterior surface slope of the subjects.

Table2. The pre and postoperative average Bahler, Gissane, calcaneal, talocal, talar angles, and the posterior surface slope

Variable	Mean ±standard	P value

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		deviation	
Bahler angle	Preoperation	20.84 ± 11.22	0.005
	Postoperation	27.33 ± 10.08	
gissane	Preoperation	142.93 ± 16.6	0.014
	Postoperation	138.2 ± 13.96	
calcaneal	Preoperation	23.36 ± 5.11	0.492
	Postoperation	23.13 ± 6.8	
talocal	Preoperation	42.25 ± 6.91	0.337
	Postoperation	42.16 ± 6.99	
talar	Preoperation	24.87 ± 5.35	0.295
	Postoperation	26.61 ± 4.66	
posterior surface slope	Preoperation	20.84 ± 11.22	0.005
	Postoperation	27.33 ± 10.08	

According to the table and the Wilcoxon test, there is a significant difference in the average Bahler and Gissane angle and the average posterior surface slope before and after the operation. However, there is no significant difference in the mean calcaneal, talocal, and talar angles before and after surgery.

DISCUSSION

The calcaneus bone is the largest ankle bone and calcaneal fractures are the most common fracture of the tarsal bones and represent 1% to 2% of all fractures. Roughly 75% of these fractures are intra-articular, (10), which are still known as fractures with

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poor therapeutic results and consequences despite the therapeutic interventions (11). The treatment of this type of fracture has ever been controversial and has drawn the attention of many articles (12-15). The injury mechanism includes the pressure from the vertical axis to the calcaneus bone (16,17), and the vast majority of the injuries occur after falling from a height and driving accidents with high energy (18).

The population affected by such an injury is mostly men in their thirties and sixties decade of their life (18). The main goal of treatment pertains to complete pain relief, the return of walking ability, and the ability to wear normal shoes again. In the past, conservative and non-surgical techniques were the main treatment of intra-articular calcaneus fractures because surgical treatments, in addition to causing various complications, didn't help achieve the goals mentioned (19-23). However, during the last two decades, surgical approaches have been the main treatment for this fracture following the advances in surgical techniques and modern imaging based on CT scans, which shows the quality of reduction better (24).

As mentioned, calcaneus fracture treatment is very controversial (25). Some studies have shown the superiority of surgical treatment, especially concerning early return to work and a lower likelihood of developing talocalcaneal arthritis whereas the worst results of this treatment pertain to the complications such as infected wounds (26-31).

Studies comparing the results of conservative and surgical treatment, including some meta-analyses, show that surgery is not the most appropriate treatment for patients with comorbidities such as diabetes or peripheral vascular disease, smokers,

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and patients who are not likely to follow medical recommendations during the postoperative period (32-35).

Radiological data on calcaneus fractures are limited. In a study, results of ankle and foot fractures showed a functional outcome of 48% good to excellent and 52% moderately poor. Similar results have been reported and the high rate of poor results is mainly attributed to the severity of the fracture, which makes restoration of normal anatomy difficult (36).

Our study focused on the surgical outcome in terms of improved radiological parameters that reflect anatomical repair. The results revealed the improvement of Bahler, Gissane, Calcaneal pitch, and talocalcaneal angles and a significant decrease in the posterior surface slope. Moreover, the improvement was maintained over time. However, the surgical approach has complications as well. The majority of the subjects in the present study had postoperative chronic pain as the most common complication. Infection, sudeck's atrophy, peroneal tendon pain, and other complications were also reported.

Since computed tomography (CT) (37) was not available to assess calcaneus bone shape for all analyzed cases, radiographic parameters were used in this study. The literature provides evidence for measurements of calcaneus bone anatomy such as Bahler angle, Gissane angle, posterior surface slope, tibiotalar angle, talocalcaneal angle, and Calcaneal pitch angle (38, 39).

Various radiographic parameters have been used to describe calcaneus bone fractures. Bahler's angle is an accepted method for quantifying fracture displacement and has prognostic value in predicting calcaneus fracture complications. Mitchell and colleagues observed a strong

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correlation between the Bahler angle and the Sanders classification based on an analysis of data obtained from 80 patients (40). In another study, analyses of the data obtained from 274 patients showed a weak correlation between the preoperative Bahler angle and the Sanders classification. Loucks and colleagues reported that a severe decrease in the Bahler angle of the affected legs indicates a poorer outcome at a two-year follow-up (41). Buckley and colleagues considered Bahler's angle as an alternative measure of the amount of energy absorbed by the foot (42). That is, the more energy absorbed by the calcaneus bone, the more severe the fractures. A sharp preoperative decrease in Bahler's angle indicates a more severe injury of calcaneus fractures (43).

In our study, the mean Bahler angle was significantly lower after the operation; the average postoperative range was about 20.84 ± 11.22.

Restoring the Bahler angle to the normal range of 25-40 degrees is one of the goals of surgery in clinical practice (113), which is an important factor in achieving satisfactory results (44, 45). However, their findings on the association of Bahler's angle restoration with the improved clinical outcome are different. Some authors think that surgical repair of Bahler's angle can improve the functional outcome of affected feet (46-50) and the Bahler angle has prognostic significance (51). Conversely, a poor performance outcome can be seen in patients without Bahler angle repair. Janzen and colleagues reported that the loss of Bahler angle at follow-up was weakly associated with clinical outcomes (52).

Gissane's angle is formed by two strong cortical struts that extend laterally, one along the lateral border

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of the posterior facet and the other in front of the calcaneus bone beak (53). Zhang and his colleagues showed that the average preoperative Gissane's angle changed from 93.58 degrees to postoperative 125.23 degrees. The increase in the angle's degree significantly affected the patient's recovery (54). Their results are consistent with the results obtained in the present study; i.e., the postoperative Gissane's angle is significantly bigger.

Our findings showed that the average pre and postoperative calcaneal pitch and talocalcaneal angle are significantly low.

Lee's results showed that there is a significant difference in the pre and postoperative average talocalcaneal, calcaneal pitch, and Bahler angles (55). These results are also in line with our study.

The main goal of calcaneus reconstruction was to improve the talocalcaneal relationship by restoring calcaneus height. Restoration of calcaneus height relieves anterior tibiotalar impingement as the talus changes from horizontal to vertical. But in our study, there is no significant difference in the angle before and after the operation. In this regard, the results of Savva and colleagues indicated that anterior tibiotalar impingement after subtalar fusion is not an important problem (56).

The study has several limitations. Although the sample size was obtained based on the total sampling method, the corona pandemic caused a high drop in the number of samples. In addition, the study lacked a control group. Applying the reconstruction technique, it may be interesting to compare the clinical and radiological changes to those observed after subtalar arthrodesis. Therefore, more prospective studies with long-term follow-ups are needed to evaluate the

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occurrence of subtalar arthritis in the future.

CONCLUSION

The results showed that chronic pain is the most important postoperative complication in patients with calcaneus fractures. Other complications include infection, sudeck's atrophy, peroneal tendon pain, and calcaneocuboid.

Surgery is somewhat effective on patients with calcaneus fractures because there is a significant difference in the angles measured and the posterior surface slope before and after the operation. Bahler, Calcaneal pitch and talocalcaneal angles and the average posterior surface slope were significantly lower before and after the operation, but the Gissane angle was significantly more after the operation.

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