The European Research Journal

http://www.eurj.org

Original Article

e-ISSN: 2149-3189

DOI: 10.18621/eurj. 2016.5000139764

The effect of treatment protocol on calcaneus bone mineral densitometry after intra-articular calcaneal fractures

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ABSTRACT

Objectives. To identify the effect of treatment protocol on calcaneus bone mineral density of calceneal fractures treated with different methods. ***Methods.*** Sixty-three patients with intra-articular calcaneal fractures were observed prospectively. Patients were classified according to their treatment protocols such as; conservative treatment with short leg plaster cast (Group C), closed reduction and fixation with cannulated screws (Group S) and open reduction internal fixation with plate and screws (Group P). All patients' bilateral radiographies, CT scans, the American Orthopaedic Foot and Ankle Society (AOFAS) scores and calcaneus bone mineral density measurements by G&E Archilles Quantitative Ultrasound method were obtained at 15th month of follow up period. ***Results.*** Fourteen (22%) patients were female and 49 (88%) were male. The mean age was 43.7±12.1 years. The mean follow-up was 33.7±14.7 months. Bone mineral density measurements were calculated as; t scores; -1.48±1.24 for group C, -1.48±1.31 for group S, -0.27±1.68 for group P and z scores; -0.18±1.41 for group C, -0.17±1.9 for group S, 0.96 ± 1.54 for group P. Group P had the higher t and z scores of injured sides than other groups (p=0.008 and p=0.026, respectively). Average AOFAS scores were 78.13±13.04 in group S, 82.58±10.81 in group P and 79.82±11.75 in group C. No significant differences were detected between groups regarding AOFAS scores. ***Conclusion.*** Measurement of calcaneus bone mineral density which we used in our study is a method for evaluation of calcaneal fracture treatments and higher density values were found in open reduction and internal fixation group. This may be owing to better control of defect with the allograft and early mobilization by the evident improvement in angular correction..

Eur Res J 2016;2(2):116-120

Keywords: Calcaneal fracture; quantitative ultrasound method; bone mineral density; plaster; American Orthopaedic Foot and Ankle Society (AOFAS) scores; treatment protocol

Introduction

Calcaneus fracture is the most common tarsal bone injury and 1-2% of all fractures in the human body [1]. The optimum treatment of patients with intra-articular calcaneal fractures is still controversial. As a consequence of computed tomography (CT)'s invention, improvement of operation techniques and

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Received: September 1, 2016; Accepted: December 23, 2016; Published Online: May 12, 2016

implant designs, more successful outcomes are achieved by surgical treatment [2]. Despite this, calcaneal fractures are related with many complications and reduce life quality regardless which treatment method is used. Goal of the treatment of intra-articular calcaneal fractures is to gain a functional and painless foot. Therefore early articular motion, exact angular correction and union of the bone must be achieved in the earliest time. Otherwise complex regional pain syndrome (CRPS), which may result with chronic pain and osteopenia, is encountered frequently.

One of the important problems concerning this calcaneal fractures is the loss in mineral density leading calcaneal osteopenia. Calcaneal osteopenia may increase morbidity, cause union problems and increase risk of re-fracture.

The primary purpose of this study was to determinate which treatment method had the significant effect on calcaneal bone mineral density and it's correlation with clinical outcomes.

Methods

A prospective study was conducted in patients with intra-articular calcaneal fractures, treated with different methods such as open reduction and internal fixation, closed reduction and fixation with cannulated screws described by Essex-Lopresti and conservative treatment between 2008 and 2015. Sixty-three patients who came up to postoperative controls regularly and who had consent to attend the study have been observed. This study was performed under approval and supervision of Diskapi Training and Research Hospital Local Ethical committee.

The patients were classified according to treatment protocols as; conservative treatment with short leg plaster cast (group C), closed fixation with cannulated correcting screws (group S), open reduction and fixation with a plate (group P). In group P, to achieve articular restoration and angular correction, allograft was used during the operation.

Sander's classification was made on coronal CT images, Bohler and Gissane angles were measured on the radiographies taken before and after treatment. Sanders type II, III and IV fractures were included in this study. Sanders type I fractures were excluded since this fracture is treated only conservatively. Patients with bilateral calcaneal fracture were excluded just to compare the injured feet with the healthy ones. Patients with operation site problems and infections were also excluded.

In group C, after 6 weeks of immobilization, range-of-motion exercises were instructed followed by partial weight bearing (PWB) at 3rd month and weight bearing as tolerated (WBAT) at 4th month. In group S, range-of-motion exercises were instructed after 3 weeks' immobilization with a short leg splint and PWB at 2nd month and WBAT at 3rd month. In group P, range-of-motion exercises were instructed immediately after operation, PWB allowed at 2nd month and WBAT at 3rd month.

Bilateral antero-posterior and lateral radiographies of feet, the American Orthopaedic Foot and Ankle Society (AOFAS) scores and bilateral calcaneal mineral density measurements were taken on the 15th month of treatment. All implants were removed in group S and P on the 12th month of the treatment for proper measurement of bone mineral density. GE Achilles Bone Ultrasonometers® (General Electric Company) device was used for bone mineral density measurements. T and Z scores were assessed for each patient injured and non-injured calcaneal bones. Scorings, angle and density measurements were performed by the same physician.

Statistical Analyses

Significance of difference between groups was analyzed by student's t test when two groups existed and One way variance analyze (one way ANOVA) when more than two groups existed. Group's pre-operative vs. postoperative values and injured vs. none injured side measurement averages were analyzed by dependent t test to reveal any statistically significant difference. Whether there is a significant relationship between continuous or non-continuous variables was examined using Spearman's correlation test. For $p<0.05$ the results were accepted to be significant but in all probable multiple comparisons Bonferroni correction was carried out to control type 1 bias.

Results

Fourteen (22%) of 63 patients included in the study were female while 49 (88%) were males. Mean age was 43.75±12.1 years. Mean follow-up period was 33.68±14.67 months. Thirty-four (53.9%) of patients were injured from right foot while 29 (46.1%) of them

Table 1. Demographics and lesion localization of the groups

Variables	Group S (n=15)	Group P (n=26)	Group C (n=22)	*p*
Age	39.8±14.2	46.1±11.2	43.5±11.5	0.276
Sex				
Male	10 (66.7)	22 (84.6)	17 (77.3)	0.419
Female	5 (33.3)	4 (15.4)	5 (22.7)	
Side				
Right	8 (53.3)	13 (50.0)	13 (59.1)	0.171
Left	7 (46.7)	13 (50.0)	9 (40.9)	

Data are given as mean±SD or n (%), n=number of the patients

were injured from left. No gender and age differences were existent between three groups (Table 1).

Twenty-two of the patients (group C) were treated conservatively, 15 of them were treated closed reduction and fixation with cannulated screws (group S) and 26 of them were treated by open reduction and internal fixation (group P).

Distribution of fracture type according to Sanders classification between treatment groups were summarized in table 2.

Mean Bohlers' angle at admission were 20.9±12.3 in group C, 10.4±13.5 in group S and 12.2±11.4 in group P. Mean Bohlers' angles at first follow-up were 16.6±15.7 in group C, 21.7±6.3 in group S and 30.6±3.1 in group P. For group C and S, no difference was observed between mean angle values (p=0.019 and p=0.397, respectively), nevertheless group P follow-up mean Bohlers angle values were higher than the admission measurements (p<0.001). Mean postoperative angle differences were 4.3±18.9 for group S, -4.3±8.0 for group C and 8.9±10.8 for group P. Group P had the highest increase with regard to Bohler angles (p=0.002) (Table 3).

Mean preoperative Gissane angles were 111.9±9.4 in group C, 119.1±12.0 in group S and 118.7±14.4 in group P. Mean postoperative angles were 112.7±12.8

Table 2. Distribution of Sander's type between treatment groups

Sanders Type	Group C n (%)	Group S n (%)	Group P n (%)	*p**
II	**15 (68.2)**	**2 (13.3)**	5 (19.3)	***<0.001***
III	**7 (31.8)**	**12 (80.0)**	20 (76.9)	***<0.001***
IV		1 (6.7)	1 (3.8)	

*Sander's IV values were neglected while chi-square test was performed. Intergroup differences are marked boldly.

Table 3. Pre- and postoperative Bohler/Gissane angle measurements of groups

	Preoperative	Postoperative	*p*[a]	Difference
Bohler				
Group S	11.3±14.1	15.6±13.3	0.397	4.3±18.9
Group P	12.2±11.4	21.1±11.5	<0.001	8.9±10.8[c]
Group C	20.9±12.3	16.6±15.7	0.019	-4.3±8.0[c]
p				**0.002**[b]
Gissane				
Group S	119.1±12.0	114.0±7.6	0.162	-5.1±13.3
Group P	118.7±14.4	114.2±11.3	0.089	-4.5±13.0
Group C	111.9±9.4	112.7±12.8	0.774	0.8±13.2
p				0.287[b]

Data are given as mean±SD. [a] p<0.0083 values were approved as significant for in-group pre- and postoperative angle comparisons according to Bonferroni Correction, [b] p<0.025 values were approved as significant for inter-group mean angle difference comparisons according to Bonferroni Correction, [c] Differences between Grup P and Grup C were statistically meaningful (p=0.002)

Table 4. t and z scores of injured and noninjured extremities

Variables	Injured extremity	Uninjured extremity	p^a
T Score			
Group C	-1.48±1.24	-1.10±1.07	0.273
Group S	-1.48±1.31	-1.13±0.94	0.191
Group P	-0.27±1.68	-1.25±1.33	**0.004**
p	**0.008**	0.897	
Z Score			
Group C	-0.18±1.41	0.18±1.19	0.304
Group S	-0.17±1.9	0.79±1.32	0.020
Group P	0.96±1.54	0.3±1.34	**0.017**
p	0.026	0.348	

Data are given as mean±SD. [a]In each group comparisons of injured and noninjured side, results were accepted statistically significant for $p<0.017$ according to Bonferroni correction

in group C, 114.7±7.6 in group S and 114.1±10.8 in group P. No difference was observed between preoperative and postoperative mean angle values for any group. Mean postoperative angel differences were 0.8±13.2 for group C, -5.1±13.3 for group S and -4.5±13.0 for group P (p= 0.287).

Group C t scores were -1.48±1.24 for injured side, -1.10±1.07 for non-injured side and z scores were -0.18±1.41 for injured side, 0.18±1.19 for non-injured side. Group S t scores were -1.48±1.31 for injured side, -1.13±0.94 for non-injured side and z scores were-0.17±1.9 for injured side, 0.79±1.32 or non-injured side. Group P t scores were -0.27±1.68 for injured side and -1.25±1.33 for non-injured side and z scores were 0.96±1.54 for injured side, 0.3±1.34 for non-injured side (Table 4). For group P, injured extremities had higher t and z scores than non-injured sides (p=0.004 and p=0.017, respectively) and group P had higher injured extremity t scores compared with other groups (p= 0.008).

Mean AOFAS scores were 79.82±11.75 in group C, 78.13±13.04 in group S and 82.58±10.81 in group P (p=0.475).

Discussion

Quantitative Ultrasound Index (QUI), which we used in our study, is a method for evaluation of osteoporotic fracture risk in both genders. Since calcaneus is a superficial bone with thin soft tissue coverage, it is a good candidate for densitometric sonographic evaluation. Advantages of using ultrasound are its low cost, wide using area and having no radiation exposure. It is used mostly in calcaneus because of its similarity to vertebral bone. In a wide study on 14,824 patients it was reported that calcaneal QUS is a good method to evaluate the risk for hip fractures and in another study performed on 6,189 patients' calcaneal QUS was shown to be as hip and femur dual-energy X-ray absorptiometry (DEXA) measurements. Despite favorable results, QUS is not accepted as a standard diagnostic tool for determination of fracture risk worldwide. More improvements are necessary with further studies for its wide usage [5-8].

In literature, many studies are available regarding biomechanical and plantar pressure evaluation, clinical and radiographic outcome regarding calcaneal fracture treatment [2, 3, 9, 10]. However, calcaneal bone mineral densitometric status following calcaneal fractures was not investigated previously. Bone mineral density measurement is a method that gives physician an opinion about bone microstructure. Hence it would be useful to use QUS in future studies in order to make a comprehensive evaluation of the methods. In our study, calcaneal QUI measurement is performed after implant removal given the fact that implants could lead calculation mistakes due to its metal content. As a consequence, density measurement should be carried out on patients without implants.

Avoidance of weight bearing and possible complications may alter bone mineral density of calcaneus negatively. Most important finding of this study is that higher calcaneal densities can be achieved with open reduction and internal fixation after treatment of intra-articular calcaneal fractures. In our study, t and z scores of patients in group P were found to be higher than other groups. This situation may depend on the fact that better reduction is achieved in open surgical treatment and that the defect is

supported by the bone graft. In addition, open reduction and plate fixation enables early weight bearing and this may contribute the mineral density of calcaneus.

Better anguler correction and higher Bohlers measurements were achieved with open reduction in this study. Open reduction of the bone fragments and maintaining the position with plate, screws and bone graft provides better geometrical correction of calcaneus compared to conservative or closed surgical treatment. Similar results were reported before about Bohlers angle [16]. Although open reduction provides better anguler correction of Bohler angle, no difference was observed between groups about Gissane angles before and after treatment.

Another important problem about evaluating patients with calcaneus fracture is not having a score to determine the outcomes [11-14]. Contemporarily Maryland and AOFAS foot evaluating scales are applied usually [8]. Maryland foot scoring system deals with patients' pain, walking functions, cosmetic view and functional activities. As for AOFAS, it contains about pain, function and anatomic sequence. Although both scales comprise similar properties, there is still not a consensus on which scale yields more accurate results [14]. In our study, AOFAS foot evaluation score is preferred which is applied widely [9]. Contrary to findings of Griffin *et al.* [15] we observed that patients who treated with open reduction and plate fixation had slightly higher AOFAS scores compared to conservative treatment. Although this difference was not significant we believe that early functional recovery with open reduction and plate fixation may provide better functional scores.

Conclusions

We conclude that, significant angular reduction and higher bone mineral density can be achieved with open reduction and internal fixation for treatment of intraarticular calcaneal fractures.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

Financing

The authors disclosed that they did not receive any grant during conduction or writing of this study.

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