EVOLUTION OF CALCANEUS DEVIATED INTRA-JOINT FRACTURES SURGICALLY TREATED

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SUMMARY

Fractures of the calcaneus account for 2% of all human body fractures. They present a strong social importance and a great economical impact, because they affect economically active individuals. In order to recognize the evolution of calcaneus intra-joint fractures evolution, a retrospective study is presented here. The sample was constituted by 71 patients with deviated intra-joint fractures of the calcaneus, being 63 males (88.73%) and 8 females (11.27%). Ages ranged 14 to 74 years old. According to the ESSEX-LOPRESTI scale, 55 of them were joint-depression type (77.46%) and 16 of tongue-kind 22.54%). The most commonly used incision was the lateral L-shape kind (91.55%). Sixty one fractures were fixed with a "double H" plate (85.92%), 9 required only screws (12.68%) and one was fixed with Kirschner wire. Seven fractures required bone graft (9.86%). The average follow-up time was 11.59 ± 6.72 months. Early complications were present in 33.82% of the patients, the most common ones were infections and necrosis of the skin. Late complications were identified in 63.38% of the patients, the most common ones being residual edema and arthrosis. The incidence of late complications was not related to the type of fracture. Joint-depression type fractures contributed to a greater restraint of activities (p=0.0315). The Böhler angle, postoperatively measured, showed a direct relationship with the final outcome, and angles smaller than 20 degrees determine a greater incidence of poor results (p=0.0111). According to the AOFAS scale, 59.26% of all patients developed good and excellent results.

Keywords: Foot injuries; Fractures; Internal fixation of fractures; Calcaneus; Wound healing

INTRODUCTION

Calcaneus fractures account for about 2% of all fractures in human body, of tarsal bones, the most frequently fractured, with a prevalence of approximately 60% of the major tarsal injuries. From these, 75% are intra-joint fractures.

Many methods have been proposed during the past century for treating calcaneus fractures. Conservative therapy has been used since Hipocrates era. In 1850, Clark introduced the surgical treatment with pin fixation and, in 1882, Charles Bell described the open reduction. Frederick Cotton and Lewis Wilson, in 1908, described a treatment method that consisted of a closed reduction or with minimal opening and immobilization with cast[1]. The bloody reduction of calcaneus joint fractures has gained a strong impulse after the publication of studies by Palmer[2] performing a surgical approach through lateral port, fragments reduction, repair of the subtalar joint surface depression, bone gap filling with bone graft and immobilization with cast. Subsequently, Palmer's technique was modified employing fracture fixation with screws and double port, medial and lateral[3]. In the 1990 decade, authors started using the extensive lateral port[4,5] and the possibility to use the Y plate and 3.5mm AO (Arbeitsgemeinschaft für Osteosynthese) screws[6] was added. Other authors made different proposals such as the percutaneous fixation or minimally invasive[7]. Myerson and Manoli called the attention to a compartmental syndrome in calcaneus fractures, which should be treated with immediate fasciotomy[8]. With the introduction of tomography, those fractures could be further studied and understood, and treatment could be customized to each situation.

Calcaneus fractures present a strong social and economical importance, because they occur in economically active individuals, most of them handworkers, who might be dependent on social security for a long time.

The objective of this retrospective study was to analyze the factors involved in surgical treatment and clinical results of calcaneus deviated intra-joint fractures.

MATERIALS AND METHODS

This study's research project was examined and approved by the Committee of Ethics in Research with Human Beings of the Pontifícia Universidade Católica - Paraná.

We assessed the medical files of 71 patients with calcaneus deviated intra-joint fractures, receiving care at Hospital Universitário Cajuru-PUCPR, within the period comprehending January 2000 and December 2003, meeting inclusion criteria: file containing all relevant data, i.e., since admission in the Service until definitive hospital discharge; age: 12 years old or above, and; previously submitted to surgical treatment.

Gender, age, mechanism of trauma, the existence of associated injuries, if fracture was an open or closed type, and affected side were assessed.

Study conducted at Hospital Universitário Cajuru - PUCPR

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Received in: 06/08/05; approved in: 07/26/05

The X-ray study, for fracture analysis purposes, consisted of axial-plane calcaneus X-ray (Harris plane), lateral plane and Bròden's planes. Fracture was classified according to Essex-Lopresti, which is based on primary and secondary fracture lines, into joint depression and tongue kinds.

It was checked if patients had been immediately submitted to surgery and, if not, the time interval between admission and surgical treatment.

When describing the surgical procedure, we checked for the kind of incision used, the way in which skin flap separation was made, and how fractures were fixed (with "double H" plates in sizes varying according to the length of the calcaneus and fracture trace, as well as 3.5 spongy screws and eventually Kirschner's wires). We also checked for the use of bone graft and drainage with continuous aspiration, for 24 hours.

Compliance to Service's protocol was observed by placing a sural-pedal cast splint for a period of two weeks and prophylaxis with antibiotics with cefazolin 1 g at anesthetic induction and maintenance up to 24 hours. After split was removed, the patient was encouraged to move the ankle, initially in a passive manner. When union was verified by X-ray, load was started with the use of axillary crutches until full support on affected limb was allowed.

We checked for early complications such as: skin dehiscence with or without necrosis, infection, sural nerve injury and reduction loss. Among late complications, the following were probed: residual edema, fibular tendonitis, arthrosis, osteomyelitis with or without plate removal, osteodystrophy and vicious union.

X-ray result of surgical treatment was provided by the assessment of postoperative Böhler's angle, which provided data on changes of the posterior joint facet. It should present a range of 20 to 40 degrees for the result to be considered as good.

The results were clinically assessed by AOFAS scale for ankle and hindfoot (American Orthopaedic Foot and Ankle Society), which takes the following items into consideration: pain intensity; function (activities restraint and need of support with orthosis); maximum distance of gait measured by blocks; gait abnormality; saggital mobility (flexion + extension); hindfoot mobility (inversion + eversion); ankle and hindfoot stability (anteroposterior + varus-valgus) and foot and ankle alignment. Scores for each item were added, providing scores from 0 to 100. Results were considered as excellent when scores ranged from 90 to 100, good when between 80 and 89, fair when ranging from 70 to 79 and bad when scores were below 69 (Chart 1). The return to work (or not) was also considered.

For group comparison regarding quantitative variables, the Student's t-test was used for independent samples, taking into consideration the homogeneity of the variances or the non-parametric Mann-Whitney test, when appropriate. Normality condition was verified by the Shapiro-Wilks' test. For group comparisons concerning categorical variables, the Fisher's exact test was used. A p value of ≤ 0.05 was considered as statistically significant.

RESULTS

Among the 71 patients followed up, we could notice a prevalence of males. Those were 63 in number (88.73%) and 8 were women (11.27%). Ages ranged from 14 to 74 years old, with an average of 41.41 years old and standard deviation of 13.44. Forty four patients (62%) were employees of the building industry and 38% had other kinds of jobs.

Falls from different ground levels were the mechanism accounting for 70 fractures (98.59%). Only one fracture had as a cause agent the impact in a car accident.

Sixty-two patients (87.32%) presented with only calcaneus fractures. Nine (12.68%) had other injuries: cranial-encephalic trauma, femoral fracture, knee fracture, lumbar spine fracture, radius fracture, and elbow fracture. Bone exposure was present only in one case (1.41%).

A uniform distribution of fractures was verified, because 35 were located at the right calcaneus (43.66%) and 36 at the left calcaneus (45.07%).

X-ray study allowed for the classification of fractures, according to Essex-Lopresti scale (1952) and revealed that 55 of them were joint depression type (77.46%) and 16 were of tongue type.

From the 71 patients, 11 were immediately operated (15.49%) and 60 were submitted to surgery in a time interval ranging from 1 to 20 days, with an average of 3.85 ± 3.64 days.

Incisions used were: the lateral L-shape kind, in 65 patients (91.55%); a combination of the lateral L shape and medial incision in 1 fracture (1.41%) and the percutaneous port in 5 (7.04%).

Sixty-one fractures were fixed with the "double H" plate (85.92%), 9 required only screws (12.67%), one fracture was fixed with Kirschner's wires (1.41%), and 7 required bone graft (9.86%).

Parameter		Scores
1.Pain (score: 40)		
	None	40
	Mild, occasional	30
	Moderate, daily	20
	Strong, almost always present	0
2. Function (score: 50)		
2.1 Activities restraint and need of support		
	No restraints or supports	10
	No daily activities restraint, recreational restraint, no supports	7
	Daily and recreational activities restraint, cane	4
	Major daily activities restraint, crutches, walker, wheelchair	0
2.2 Maximum gait distance (blocks)		
	More than 6	5
	From 4 to 6	4
	From 1 to 3	2
	Less than 1	0
2.3 Gait surface		
	Easy in any surface	5
	Some difficult in irregular grounds, stairs or slopes	3
	Strong difficult in irregular grounds, stairs or slopes	0
2.4 Gait abnormality		
	None or mild	8
	Evident	4
	Marked	0
2.5 Saggital mobility (flexion + extension)		
	Normal or minimal restraint (30º or more)	8
	Moderate restraint (15º to 29º)	4
	Strong restraint (less than 15º)	0
2.6 Hindfoot mobility(inversion and eversion)		
	Normal or minimal restraint (75 to 100%)	6
	Moderate restraint (25 to 74%)	3
	Strong restraint (less than 25%)	0
2.7 Ankle and hindfoot stability (anteroposterior + varus-valgus)		
	Stable	8
	Unstable	0
3. Alignment (score:10)		
	Good – plantigrade foot, with aligned ankle and hindfoot	10
	Fair - plantigrade foot, some degree of non-alignment, no pain	5
	Bad – non-plantigrade foot, major and symptomatic non-alignment	0

***Chart 1** - AOFAS (American Orthopaedic Foot and Ankle Society) scale for clinical evaluation of the ankle and hindfoot*

Mean follow-up time was 11.59 ± 6.72 months (4 - 47 months). Among the patients submitted to surgery, 24 (33.80%) early complications were verified (Table 1). Among those, the most common one was the infection, which accounted for 10 cases (14.08%), 5 times isolated (7.04%) and three times combined with skin necrosis (4.23%) and two times associated to skin dehiscence (2.82%). Forty-five fractures evolved with late complications (63.38%) (Table 2). Residual edema accounted for 25 cases (35.21%), either isolated or combined with other sequels. Arthrosis existed in 18 calcaneus (25.35%). Other sequels were reported as: fibular tendonitis, exosthosis, osteomyelitis, and vicious union. Those complications were not related to the kind of fracture (Table 3) and although arthrosis may have contributed to late complications, its incidence was not related to the kind of fracture (p=0,3266).

The Böhler's angle, which indicates changes on posterior joint facet and is used to qualify fracture resolution, showed variations ranging from 0 to 40, with an average of 22.08 ± 8.95, without a significant difference regarding the kinds of fractures. This angle determines fracture resolution qualification and has been below 20º 24 times, translating bad outcomes, and 47 above 20º, translating good outcomes. This situation was similar in both kinds of fractures (p=1,0000).

The classification of outcomes according to AOFAS scale allowed for the recognition of 42 fractures (59.15%) evolving with good or excellent outcomes and 29 (40.85%) with outcomes considered as fair and bad (Table 4).

A relationship was found between Böhler's angle value and the scores of AOFAS table (Table 5).

The AOFAS scale assess data on pain, activities restraint and need of support, gait distance, gait abnormalities, saggital mobility (foot flexion and extension), hindfoot mobility (inversion and eversion), ankle and hindfoot stability, and ankle and hindfoot alignment. The analysis of such data has shown a difference in terms of activities restraint regarding the kind of fracture (Table 6).

Of the 71 patients, 14 (19.72%) did not return to work, and the kind of fracture was not shown to have any influence (p=0,1664).

DISCUSSION

Calcaneus joint fractures are severe injuries and frequently cause permanent and impairing sequels. They usually affect young male individuals, within an age group that is economically active, which can impose a great social-economical loss. In this sample, we report 88.73% of male patients, who were, in average, 41.41 ± 13.44 years old. By observing the stratified distribution of the patients, it was shown that 85.92% were within 20 to 60 years old, and only 7 were retired, corroborating the statement that this condition affects individuals who are at full social capacities.

The most common cause agent of calcaneus intra-joint fractures, as reported by literature, is the fall from different ground levels[1,9,10] , which was confirmed by this study, where this kind of fall accounted for 98.59% of the fractures.

Due to the axial mechanism of trauma, a possibility exists of associated injuries. Authors report this fact occurring in percentages ranging 8.5 to 46% of patients[9-13]. In this study, other injuries were found in 12.68% of the patients, such as: cranial-encephalic trauma, femoral fracture, knee fracture, lumbar spine fracture, radius fracture, elbow fracture, and an open fracture.

X-ray classification by Essex-Lopresti (1952) is classical. It determines fracture line, enabling treatment planning. Tomographic classification helps on the evaluation of severity and injury prognosis, being the most used classification that by Sanders e Gregory [14]. However, tomographic classifications are not uniform, and each group tries to find its own classification, which makes outcomes comparisons difficult, as well as recognizing the kind of injury they describe. It is recognized that tomography is an excellent test to identify fragments details and joint compromise, but this test is not always available in every service. This limitation justifies the use of X-ray classification.

According to Essex-Lopresti's classification, intra-joint fractures may be tongue-type or joint depression-type. In most of the case series, joint depression-type fractures are the most prevalent, accounting for 43 – 61% of intra-joint fractures [11,15,16]. In this study, we found 77.46% of joint depression-type fractures and 22.54% tongue-type fractures. It is interesting to match the kind of fracture to general activities restraint after union, because joint depression-type fractures were found to cause a higher incidence of restraints (p=0,0315).

For the open surgical treatment, there is a consensus of waiting some time between trauma and surgery, ranging from 7 to 14 days so that edema could be reduced and for preventing phlyctens to be formed, except in open fractures, which should receive immediate surgical care[13,14,17] or when percutaneous fixation is indicated[7]. In this study, the time interval between trauma and surgery for the 71 fractures was, in average, 3.85 ± 3.64 days, with 11 being immediately operated (15.49%).

The lateral access port in an "extended L shape" has been largely employed, because it allows a better visibility of the fracture, fragments reduction and internal fixation[9-12,14,18-20]. In this study, the lateral port in "extended L" was shown to be efficient in 91.55% of the cases.

Kind	Frequency	Percentage
Skin necrosis	7	9.86
Sural nerve injury	1	1.41
Skin dehiscence	5	7.04
Reduction loss	1	1.41
Infection	5	7.04
Infection + skin dehiscence	2	2.82
Infection + skin necrosis	3	4.23

Table 1 – *Early complications*

Kind	Frequency	Percentage
Edema	18	25.35
Edema + tendonitis	4	5.63
Edema + exosthosis	1	1.41
Edema +sural nerve compression	1	1.41
Edema + osteodystrophy	1	1.41
Arthrosis	18	25.35
Arthrosis + osteomyelitis	1	1.41
Osteomyelitis	3	4.22
Fibular tendonitis	2	2.82
Plate removal	1	1.41
Vicious union	1	1.41

Table 2 – *Late complications*

The use of bone graft is controversial. Some people consider it as osteoinductor and other people consider it as osteoconductive[15,17]. There are also those people considering it as unnecessary[21]. But we should remember that the use of bone graft increases the incidence of morbidity, because an additional incision is required for graft removal. In this study, bone graft removed from the iliac bone was applied in 7 of the 74 fractures assessed, a very small number to enable a conclusion about its use. The use of multiple osteosynthesis materials varied according to the size of fragments; big fragments were fixed with screws; fractures with more comminution were fixed with plate and one open fracture was fixed with Kirschner's wires.

Early complications may accompany the evolution of calcaneus intra-joint fractures treatment. Among them, we can found the skin dehiscence (with or without necrosis), infection, sural nerve injury, reduction loss, and, also, the compartmental syndrome resulting from hematoma formation[8]. Although the incision in "extended L" is performed so as to separate, anteriorly, the sural nerve and the fibular artery, necrosis of the anterior portion of the flap are seen as result of either an inadvertent injury to the artery or its ramifications or an excessive flap traction leading to ischemia. In literature, the most common early complications were the skin necrosis, ranging from 11% to 40%, and infection, ranging from 3.3% to 22%[3,6,9,12,18,20,22]. In this study, we found 33.80% of early complications, being infection present in 14.08% of the cases, whether combined or not to skin dehiscence or necrosis and infection in 7.04%.

Late complications are important, since they may lead to work and general activities disability. some patients need special shoes due to the presence of deformities. Among late complications, we may find osteomyelitis – the most feared one – which may, in rare occasions, lead to amputation. Arthrosis may also been seen, which, leading to arthrodesis, is the most limiting complication. Other situations may occur, such as: edema, chronic pain, gait abnormalities, fibular tendonitis, mobility restraint, and lack of foot alignment [1,6,18,20]. Sanders[1] states that the anatomical reduction of the subtalar joint is required for achieving good and excellent outcomes, but this is nor warranted, probably due to cartilage injury resulting from trauma, not to mention that the higher the number of intra-joint fragments, the worse outcomes would be.

The Böhler's angle, considered as normal within measurements ranging from 20º to 40º, is used for indication changes on the posterior joint facet and for qualifying fracture resolution. Loucks and Buckley[19] performed a prospective and randomized study to evaluate the Böhler's angle and its correlation with fracture treatment outcomes. They observed that surgical treatment improved angle graduation as well as the functional status. The stated that fractures with a Böhler's angle markedly reduced at the immediate post-trauma period provided bad outcomes and they suggested that the high energy of trauma produces angle flattening, with a more extensive bone and soft parts injury. In this study, variations between 0º and 40º were found, with an average of 22.08º ± 8.95º, with no significant difference regarding the kinds of fracture. The value of this angle showed a correlation with the quality of outcome. So that 70.21% of the reductions with an angle above 20º presented good and excellent outcomes, while only 37.50% of the reductions below 20º showed a similar result (p=0,0111). Angle restoring is directly correlated to the quality of fragments reduction.

In the evaluation of the results by AOFAS scale, we found rates in literature ranging from 42.22% to 62% of excellent results [19,21,23]. In this study, outcomes were considered as good and excellent in 59.15%. One cannot say for sure that the kind of fracture may have influenced scores, because the tongue-type sample studied here is small, if compared to the joint depression-type. Scale was further divided into its items in order to provide a better assessment of the outcomes, being significant the activities restraint in joint depression-type fractures (p=0,0315).

O'Farrel et al[24] reported that 66.66% of the patients submitted to surgery returned to work, were able to walk more than 4 km without modifications on the size of shoes. Those authors compared their results achieved in patients submitted to surgery to those of the non-operated ones, and they noticed that among non-operated patients, 12% returned to work and 66.66% had to change their shoe sizes. Tennent et al[22] reported that 94% of their patients returned to work in an average time of 6 months, and Asik and Sem[12]

Complications	Fracture classification				Total	
	Joint Depression		Tongue			
	N	%	N	%	N	%
Absent	18	32.73	8	50.00	26	36.62
Present	37	67.27	8	50.00	45	63.38
Total	55	100.0	16	100.0	71	100.0

Fischer´s exact test p = 0,2457

Table 3 - *Incidence of late complications related to kind of fracture*

Outcome/Scores	Fracture classification				Total	
	Joint Depression		Tongue			
	N	%	N	%	N	%
1 - Bad (< 69)	17	30.91	2	12.50	19	26.76
2 - Fair (70 a 79	8	14.55	2	12.50	10	14.08
1 + 2	**25**	**45.46**	**4**	**25.00**	**29**	**40.84**
3 - Good (80 a 89)	22	40.00	7	43.75	29	40.84
4 - Excellent (> 90)	8	14.54	5	31.25	13	18.32
3 + 4	**30**	**55.54**	**12**	**75.00**	**42**	**59.26**
TOTAL	55	100.0	16	100,0	71	100.0

Fisher's exact test
Combining bad + fair x good + excellent classifications p=0.1629
Combining fair + good + excellent x bad outcomes p=0.2045

Table 4 - *Classification of outcomes according to AOFAS scale*

	BÖHLER'S ANGLE					
	< 20o		> 20o		TOTAL	
OUTCOMES	N	%	N	%	N	%
Excellent + Good	9	37.50	33	70.21	42	59.26
Fair + Bad	15	63.50	14	29.79	29	40.84
TOTAL	24	100.0	47	100.0	71	100.0

Fisher exact test p=0.0111

Table 5 - *Böhler's angle values correlation with AOFAS scale*

Activities restraint	Kind of Fracture				TOTAL	
	Joint Depression		Tongue			
	N	%	N	%	N	%
1-No restraint	8	14.54	5	31.25	13	18.31
2- Recreational restraint	34	61.62	11	68.75	45	63.38
1+2	**42**	**76.36**	**16**	**100.0**	**58**	**81.69**
3- Activ. Restraint + cane	12	21.85	0	0	12	16.9
4- Major restraint	1	1.82	0	0	1	1.41
3+4	**13**	**23.67**	**0**	**0**	**13**	**18.31**
TOTAL	**55**	**100.0**	**16**	**100.0**	**71**	**100.0**

Fisher's exact test
Combining 1+2 x 3+4 classifications p=0.0315

Table 6 - *Incidence of activities restraint*

reported 68,42% of patients returning to work with full capacity within 2 years. Buckley et al[18] conducted a prospective, randomized and multicenter study comparing surgical and conservative treatments for deviated calcaneus intra-joint fractures. They reported no difference in quality between both treatments, especially in non-stratified groups; however, after removing the information that some patients received payment for job withdrawal, the results were significantly better in the group of operated patients. We could not evaluate this datum in our study, but it seems that patients having any kind of payment for job withdrawal present worse outcomes. It's difficult to avoid this masked result, since this is an informative datum about the patient. Despite of that, 80.28% of the patients in our series returned to work.

Concerning outcomes and sequels, it is possible that a longer follow-up period may provide further information, because, as mentioned before, the mean follow-up time in this study was approximately one year (11.59 $\pm$ 6.72 months).

Although this study was retrospectively designed, it served as to recognize the evolution of patients treated at Hospital Universitário Cajuru-PUCPR. We can see that the outcomes were much similar to those reported in literature. It also served as to create the awareness that the development of treatment protocols enabling prospective studies would be better for providing more reliable information both on fractures preoperative period and on their evolution.

CONCLUSIONS

This retrospective analysis of calcaneus intra-joint fractures allowed the observation of the following: the most frequent kind of fracture, according to the Essex-Lopresti classification is the joint-depression one; early complications were present in 33.82% of the patients and the most common ones were infection(14.08%) and skin necrosis (9.86%); late complications were identified in 63.38% of the patients, and the most common ones were residual edema (25.35%) and arthrosis (25.35%); the incidence of late complications was not related to the kind of fracture; joint depression-type fractures accounted for an increased activities restraint ($p=0,0315$); the Böhler's angle, as measured postoperatively, presented a direct correlation with end results and angles smaller than 20 degrees determined a higher incidence of bad outcomes ($p=0,0111$); and, by observing the AOFAS scale, 59.26% of all patients evolved with good and excellent outcomes.

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