

Clinical and radiographic analysis of calcaneal fracture surgically treated

Análises clínicas e radiológicas das fraturas de calcâneo tratadas cirurgicamente

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ABSTRACT

Objective: This study assessed clinically and radiographically patients who underwent surgery for articular calcaneal fractures. **Methods:** We evaluated 10 patients who underwent surgery at a type I trauma center between January, 2014 and July, 2015. All surgical procedures were performed by lateral accesses, 6 procedures used a L-shaped extended lateral incision and 4 modified Palmer access. Fractures were classified using the Sanders computed-tomography classification. All patients were clinically examined based on the AOFAS score for ankle and hindfoot and radiographically evaluated by comparison of Bohler and Gissane angles before and after surgery. **Results:** All patients were men aged between 24-52 years old. The time between surgery and application of questionnaires ranged between 4 and 19 months. Based on Sanders' classification, 7 fractures were type III, 2 were type II and 1 was type IV. We excluded open fractures, joint fractures type I and extra articular fractures. Patients with less than 4 months postoperatively were excluded. In addition, we did not consider early complications of surgical treatment. Parameters of AOFAS scale for foot and ankle were 26 ± 11.7 for pain, 29.6 ± 11.7 for function and 8.6 ± 1.0 for alignment, total mean score obtained in this study was 64.2 ± 21.8 points. Mean preoperative Gissane angles was $123.3^\circ \pm 24.8^\circ$ and Böhrler angle was $12.6^\circ \pm 13.3^\circ$. After surgery the mean Gissane angle was $113.1^\circ \pm 5.7^\circ$ and Böhrler angles was $\pm 24.0^\circ \pm 7.6^\circ$. **Conclusion:** The surgical treatment of calcaneal fractures can restore Böhrler and Gissane angles and provide adequate joint congruency of the posterior facet.

Keywords:

Calcaneus/injuries; Calcaneus/radiography; Calcaneus/surgery; Treatment outcome

RESUMO

Objetivo: Avaliar clínica e radiograficamente os pacientes submetidos ao tratamento cirúrgico de fraturas articulares de calcâneo. **Métodos:** Foram avaliados dez pacientes operados em centro de trauma tipo 1 entre janeiro de 2014 e julho de 2015. Todos os procedimentos cirúrgicos foram realizados por acessos laterais, sendo seis com incisão lateral em "L" estendida e quatro com acesso de Palmer modificado. As fraturas foram classificadas pela classificação tomográfica de Sanders. Todos os pacientes foram analisados clinicamente com base em pontuação da *American Orthopaedic Foot and Ankle Society (AOFAS)* para tornozelo e retropé, e avaliados radiograficamente por meio da comparação dos ângulos de Böhrler e Gissane pré e pós-operatórios. **Resultados:** Todos os pacientes eram do sexo masculino e tinham entre 24 a 52 anos. O tempo decorrido entre a cirurgia e a aplicação dos questionários variou entre 4 e 19 meses. Com base na classificação de Sanders, sete fraturas eram do tipo III, duas tipo II e uma tipo IV. Foram excluídas as fraturas expostas, as articulares tipo I e as extra-articulares. Foram excluídos pacientes com menos de 4 meses de pós-operatório. Não foram consideradas as complicações precoces do tratamento cirúrgico. Os parâmetros da escala AOFAS para pé e tornozelo foram $26 \pm 11,7$ pontos para dor, $29,6 \pm 11,7$ pontos para função e $8,6 \pm 1,0$ pontos para alinhamento. A média da pontuação total obtida neste estudo foi de $64,2 \pm 21,8$ pontos. A média dos ângulos de Gissane pré-operatório foi de $123,3^\circ \pm 24,8^\circ$ e dos ângulos de Böhrler foi de $12,6^\circ \pm 13,3^\circ$. Após o tratamento cirúrgico, foi obtida média de valores do ângulo de Gissane de $113,1^\circ \pm 5,7^\circ$ e dos ângulos de Böhrler de $24,0^\circ \pm 7,6^\circ$. **Conclusão:** O tratamento cirúrgico das fraturas de calcâneo foi capaz restabelecer os ângulos de Böhrler e Gissane, e de obter congruência articular adequada da faceta posterior.

Descritores:

Calcâneo/lesões, Calcâneo/radiografia; Calcâneo/cirurgia; Resultado do tratamento

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INTRODUCTION

Calcaneal fractures are the most common of tarsal bone fracture. Characteristics such as not particularly dense trabecular structure, thin cortices, and vulnerable position in the hindfoot make this bone susceptible to fractures.⁽¹⁾

Although they account for 60% of all tarsal fractures, the management of intra-articular calcaneal fractures still represents a challenge for the orthopedic surgeon, even with advances in imaging diagnosis and the progress of implants for internal fixation.^(2,3) The difficulty is largely due to the complex anatomy associated with its spongy bone quality, with scant soft tissue coverage, and the association with high-energy trauma.⁽¹⁾

The three-dimensional visualization of fracture components and their relationship to the midfoot and hindfoot joints are essential to understand and plan appropriate treatment. It is also important to consider that the calcaneus is a supporting bone, with a vulnerable soft tissue cover,⁽⁴⁾ and that the surgeon must decide on the most suitable time for the surgical approach in order to restore the joint surface, causing minimal damage to soft tissue.

Surgical treatment first emerged as a successful option following the publication of studies by Palmer, in 1948. The results were good in 50 to 80% of the cases.^(5,6) The current literature shows a large number of authors assessing the results of surgical treatment,⁽⁷⁻¹¹⁾ while conservative treatment is reserved exclusively, in most cases, for fractures without deviation and for patients with clinical comorbidities that contraindicate the surgical procedure.

Patients with calcaneal fractures are mostly male adults of an economically productive age, who will be obliged to go on medical leave for a minimum period of 3 months, which may represent a significant socioeconomic loss. Therefore, calcaneal fractures are of marked social and economic importance, as they occur in economically active individuals who may have to depend on the public welfare system for some time.^(11,12)

The aim of this study was to perform a clinical and radiographic evaluation of patients undergoing surgical treatment of articular calcaneal fractures.

METHODS

Ten patients operated at a type I public I trauma center in Salvador (state of Bahia) were analyzed. All patients were operated on by the same surgeon, a foot and ankle specialist, between January 2014 and July 2015.

The ten surgical procedures were performed by lateral approach; 6 procedures were performed via an extended

“L”-shaped lateral incision^(7,10) and the other 4 were performed by modified Palmer approach.^(2,13) The choice of approach depended of the time elapsed between the injury and the surgical procedure. No surgical procedure was performed by modified Palmer approach, and treatment occurred 15 days after the fracture. All the fractures were fixed with a steel calcaneal plate and 3.5mm screws.

The fractures were classified using the Sanders CT classification.^(12,14) Posterior articular facet fracture without deviation, regardless of the number of fragments, is classified as type I and fracture with severe comminution and joint fragmentation is classified as type IV. In type II, the joint is fractured in two fragments and subclassified into A, B or C, depending on the position of the main fracture line. In type 3, there is a three-part fracture, subdivided into AB, BC or AC, depending on the location of the two fracture lines.

Patients were clinically analyzed based on the American Orthopaedic Foot and Ankle Society (AOFAS) scores for ankle and hindfoot, which takes into account three parameters: pain intensity, function and alignment.⁽¹⁵⁾ The results were considered excellent when the score oscillated between 90 and 100; good when between 80 and 89; fair when between 70 and 79; and poor when below 69.

In addition to the clinical evaluation, the patients were also assessed radiographically by comparing the pre and postoperative Böhler and Gissane angles obtained from lateral radiographs of the calcaneus.

For the descriptive analysis of the results obtained, the quantitative variables were represented by their means and standard deviations, when their distributions were normal, and by medians and interquartile ranges, when not normal. The definition of normality was made by graphical analysis and Shapiro-Wilk test. The variables were represented by means of frequencies and percentages. Since the sample evaluated had a small number of patients, the graphical representation of the operative impact on the Böhler angle was performed by parametric estimate of the 95% confidence interval (95% CI). The analyses were conducted with the IBM Statistical Package for the Social Sciences (SPSS, Chicago, IL, USA), version 20.0 software.

All the patients were male. Ages ranged from 24 to 52 years, with an average of 38.7 years. The time elapsed between surgery and the application of the questionnaires ranged from 4 to 19 months, with an average of 6.9 months. Seven of the ten fractures evaluated were classified as Sanders type III; two were classified as type II and one as type IV (Table 1). The surgical approaches were the classic open technique, with extended “L”-shaped lateral approach, for fractures operated on more than 15 days following injury, and minimally invasive approach, modified

Table 1 | Characteristics of the sample

Characteristic	General (n=10)
Age	38.7±9.4
Sanders Classification, n (%)	
IIA	1 (10.0)
IIB	1 (10.0)
IIIAB	6 (60.0)
IIIAC	1 (10.0)
IV	1 (10.0)
Gissane Angle	
Preoperative	123.3°±24.8°
Postoperative	113.1°±5.7°
Böhler Angle	
Preoperative	12.6°±13.3°
Postoperative	24.0°±7.6°
AOFAS Score (zero to 100 points)	
Pain	26.0±11.7
Functional	29.6±11.7
Alignment	8.6±1.0
Total score	64.2±21.8

All the data are presented as mean±standard deviation, unless otherwise specified.
AOFAS: American Orthopaedic Foot and Ankle Society.

Palmer subfibular, for fractures operated on less than 15 days following injury.

Open fractures, articular fractures classified as Sanders I, and extra-articular fractures were excluded. Patients operated on less than 4 months previously were excluded, as they were not bearing full weight on the operated limb.

The early complications of surgical treatment of calcaneal fractures, such as necrosis or skin dehiscence, were not considered as the clinical evaluation for this study occurred after a minimum of 4 months following surgery. In the sample evaluated, none of the patients presented with impaired wound healing or osteomyelitis.

RESULTS

The parameters of the AOFAS scale for foot and ankle were 26±11.7 points for pain, 29.6±11.7 points for function, and 8.6±1.0 points for alignment. The mean of the total score obtained in this study was 64.2±21.8 points (Table 1). When evaluated separately, one patient achieved an excellent result, two achieved good results and one achieved a fair result.

The mean of the measurements of the preoperative crucial angles of Gissane was 123.3±24.8° while that of the Böhler angles was 12.6±13.3°. After surgical treatment, with open reduction and internal fixation of fractures, the mean of the Gissane angle and Böhler angle values was,

respectively, 113.1±5.7° and 24.0±7.6° (Table 2). Of the calcanei evaluated, 70% achieved a postoperative Böhler angle within the range of 20° to 40°, while the other values were 13°, 14° and 17° (Figure 1).

The total score obtained on the AOFAS scale did not show a statistically significant relationship with the complexity of the initial pattern of the injury, using the Sanders classification as a parameter of severity (Figure 2).

Table 2 | Characteristics of the pre- and postoperative anatomical angles

Característica	Preoperative	Postoperative
Böhler Angle	12.6±13.3	24.0±7.6
Gissane Angle	123.3±24.8	113.1±5.7

All the data are presented as mean±standard deviation.

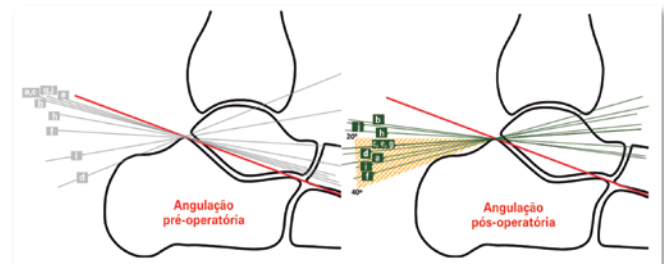


Figure 1 | Diagrammatic representation of the surgical impact on the Böhler angle; pre- and postoperative values for each patient with cross-hatched area, indicating a normal range for a healthy population.

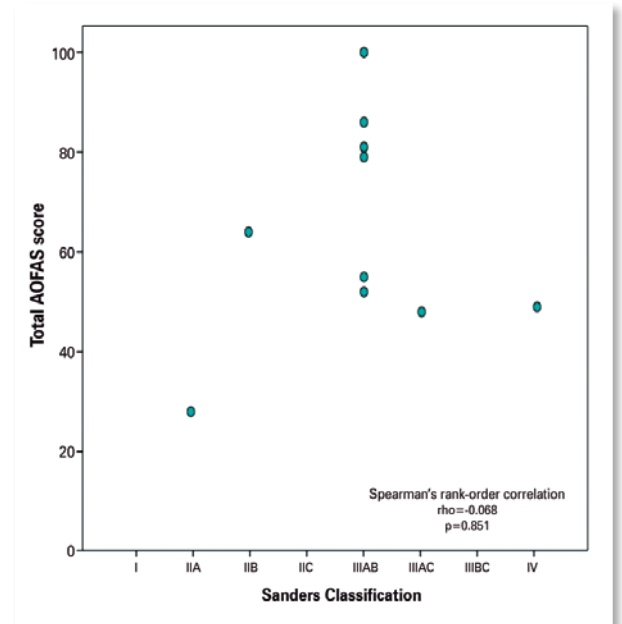


Figure 2 | Box plot and total correlation of the American Orthopaedic Foot and Ankle Society (AOFAS), according to Sanders classification.

DISCUSSION

Calcaneal fractures are serious injuries, with a high potential to produce complications and varying degrees of disability in adults in an economically active age group. Regardless of the surgical technique, rigid internal fixation has been the treatment of choice for deviated articular fractures, provided that an anatomical reduction of the joint surface is achieved.

Males predominated in this study, which is consistent with the epidemiology presented by the international literature, with 100% of the participants evaluated by this study being men. The average age of the patients evaluated was 38.7 years, corresponding to an age group of economically active adult patients.

The Böhler angle, considered normal with measures ranging from 20° to 40°, is used to indicate abnormalities of the posterior articular facet and to qualify the fracture reduction radiographically.

In our series, most of the fractures were severe, with only one case being classified by computer tomography as Sanders II and all the others as III and IV. Regardless of fracture severity, the surgical treatment was able to radiographically improve the Böhler and Gissane angles, with 70% of the calcanei achieving a postoperative Böhler angle within the range considered normal.

Grala et al. reported the follow-up of 23 surgically treated fractures and also used the Böhler angle as a means of assessing the posterior articular facet. They concluded that treatment depends on adequate preoperative planning, and that a good or excellent reduction protects patients from problems throughout functional follow-up.⁽¹⁶⁾ Loucks and Buckley,⁽¹⁷⁾ in a prospective, randomized study, evaluated the Böhler angle and its correlation with calcaneal fracture treatment outcomes and concluded that surgical reduction improves the angle values and the patients' function.

From a clinical and functional point of view, the main complaint of patients was related to pain and to limitation of activities of daily living, even with good results for hindfoot alignment, showing the considerable potential for complications of this type of fracture. These data are consistent with the literature, which shows a high rate of residual pain in the sinus tarsi after calcaneal fractures.⁽¹⁸⁻²⁰⁾ The mean of the total score obtained in this study was 64.2±21.8 points, with 40% of patients having excellent to fair results. In the literature, it is possible to find a great variation of results considered excellent in the evaluation by the AOFAS scale, with rates of 42-62%.^(17,21,22)

Despite the small sample size, this study serves the purpose of emphasizing that surgical treatment is a suitable option for reestablishing the anatomical reduction of fractures, according to the radiographic pattern of the Böhler and Gissane angles. The unsatisfactory results of the functional assessment can be attributed to the short follow-up period associated with damage not assessed in this study, such as articular cartilage injury.

CONCLUSION

The initial severity of the fracture was found to be unrelated to the postoperative American Orthopaedic Foot and Ankle Society score. This fact leads us to believe that the importance of initial fracture deviation is no greater than that of attempting the anatomical reestablishment of the joint surface to minimize the risks of complications.

Other factors, besides anatomical reduction, appear to interfere with the satisfactory functional result. These include soft tissue and articular cartilage injury at the time of trauma. Both injuries can have a negative impact on progress, with late onset complications, and have poor functional results in patients.^(10,21-23)

With the surgical treatment of calcaneal fractures, it is possible to restore the Böhler and Gissane angles and achieve adequate articular congruence of the posterior facet. Reconstruction of the anatomy represents an important factor for minimizing complications caused by post-traumatic degeneration of the affected joints.

REFERENCES

1. Atkins RM, Allen PE, Livingstone JA. Demographic features of intra-articular fractures of the calcaneum. *Foot Ankle Surg.* 2001;7(1):77-84.
2. Gupta A, Ghalambor N, Nihal A, Trepman E. The modified Palmer lateral approach for calcaneal fractures: wound healing and postoperative computed tomographic evaluation of fracture reduction. *Foot Ankle Int.* 2003;24(10):744-53.
3. Crosby LA, Fitzgibbons T. Computerized tomography scanning of acute intra-articular fractures of the calcaneus. A new classification system. *J Bone Joint Surg.* 1990;72(6):852-9.
4. Lopes FA, Zambelli R, Pinto A, Gonçalves EL, Melo GL, Tavares R, et al. Tratamento cirúrgico das fraturas articulares desviadas do calcâneo por abordagem minimamente invasiva. *Rev Bras Ortop.* 2008;43(10):426-32.
5. Palmer I. The mechanism and treatment of fractures of the calcaneus. *J Bone Joint Surg Am.* 1948;30A(1):2-8.
6. Demore AB, Kim A, Camargo LM. Acesso suprafibular para tratamento das fraturas cirúrgicas do calcâneo. *ABTPé.* 2013;7(1):16-24.
7. Benirschke, SK, Sangeorzan BJ. Extensive intra-articular fractures of the foot. Surgical management of calcaneal fractures. *Clin Orthop.* 1993;(292):128-34.
8. Letournel E. Open treatment of acute calcaneal fractures. *Clin Orthop.* 1993;(290):60-7.

9. McReynolds IS. The case for operative treatment of fractures of the calcaneus. In: Leach RE, Hoaglund FT, Riseborough EJ, editors. *Controversies in orthopaedic surgery*. Philadelphia: W.B. Saunders, 1982. p. 245.
10. Sanders R. Intra-articular fractures of the calcaneus: present state of the art. *J Orthop Trauma*. 1992;6(2):252-65.
11. De Paula SS, Biondo-Simões ML, Luzzi R. Evolução das fraturas intra-articulares desviadas do calcâneo com tratamento cirúrgico. *Acta Ortop Bras*. 2006;14(1):35-9.
12. Zwipp H, Tschern H, Thermann H, Weber T. Osteosynthesis of displaced intraarticular fractures of the calcaneus. *Clin Orthop*. 1993; (290):76-86.
13. Maxfield JE, McDermott FJ. Experiences with the Palmer open reduction of fractures of the calcaneus. *J Bone Joint Surg*. 1955;(37): 99-106.
14. Sanders R, Gregory P. Operative treatment of intra-articular fractures of the calcaneus. *Orthop Clin North Am*. 1995;26(2):203-14.
15. Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M. Clinical rating systems for the ankle, hindfoot, midfoot, hallux, and lesser toes. *Foot Ankle Int*. 1994;15(7):349-53.
16. Grala P, Machyńska-Bučko Z, Kierzyńska G. Surgical treatment of articular calcaneal fractures. *Ortop Traumatol Rehabil*. 2007;9(1):89-97.
17. Loucks C, Buckley R. Bohler's angle: correlation with outcome in displaced intraarticular calcaneal fractures. *J Orthop Trauma*. 1999; 13(8):554-8.
18. Myerson M, Quill GE. Late complications of fractures of the calcaneus. *J Bone Joint Surg Am*. 1993;75(3):331-41.
19. Parmar HV, Triffitt PD, Gregg PJ. Intra-articular fractures of the calcaneum treated operatively or conservatively. A prospective study. *J Bone Joint Surg Br*. 1993;75(6):932-7.
20. Paley D, Hall H. Intra-articular fractures of the calcaneus. A critical analysis of the results and prognostic factors. *J Bone Joint Surg Am*. 1993;75(3):342-54.
21. Longino D, Buckley RE. Bone graft in the operative treatment of displaced intraarticular calcaneal fractures: is it helpful? *J Orthop Trauma*. 2001;15(4):280-6.
22. Prado Jr. I, Rocha MA, Rezende RR. Tratamento cirúrgico das fraturas intra-articulares desviadas do calcâneo, através de osteossíntese interna, sem enxerto ósseo. *Rev Bras Ortop*. 1999;34(7):421-9.
23. Eastwood DM, Gregg PJ, Atkins RM. Intra-articular fractures of the calcaneum. Part II: Open reduction and internal fixation by extended lateral transcaneal approach. *J Bone Joint Surg Br*. 1993;75(2):189-95.