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ORIGINAL ARTICLE

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Pre-operative tomographic evaluation of calcaneum fractures in surgical planning

Avaliação tomográfica pré-operatória das fraturas de calcâneo no planejamento cirúrgico

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ABSTRACT

Objective: To perform the correlation between the preoperative tomographic evaluation of patients with calcaneal fracture diagnosis and the access routes of choice, as well as the synthesis materials used.

Methods: We reviewed 19 medical records of patients between 23 and 56 years old who underwent calcaneal fracture surgery from 01/01/2014 to 12/31/2015. We evaluated the mechanism of trauma, side, Essex-Lopresti classification, Böhler and Gissane angle in the pre- and postoperative period, Sanders tomographic classification and type of osteosynthesis performed. Angular measurements served as a reference for radiological analysis of the quality of the reduction.

Results: 90% of the cases were of joint depression, the other 10% considered extra-articular. The preoperative Böhler angle varied between 5 and 40°, and between 10 and 38° in the postoperative period, and 55% of the fractures had an angular reconstruction considered good (between 20° and 40°). Gissane's angle, on the other hand, varied between 110 and 170° in the preoperative period, and 102 and 132° in the postoperative period. In the tomographic analysis, Sanders IV classification was predominant (65%), followed by type IIIBC fractures (20%), and fractures type I, IIA and IIIAB (5% each). Osteosynthesis with plate and screw was the most used method (89.47%).

Conclusion: Correct use of existing diagnostic imaging resources through radiographic and tomographic results provides the possibility of better preoperative planning in the intra-articular fractures of the calcaneus. However, in this study, there was no difference in the access route and synthesis according to the tomographic classification.

Level of Evidence IV; Therapeutic Studies; Case Series.

Keywords: Fractures, Bone; Calcaneus; Tomography.

RESUMO

Objetivo: Realizar a correlação entre a avaliação tomográfica pré-operatória de pacientes com diagnóstico de fratura de calcâneo e as vias de acesso de escolha, assim como os materiais de síntese utilizados.

Métodos: Revisamos 19 prontuários de pacientes entre 23 e 56 anos submetidos a cirurgia por fratura de calcâneo no período de 01/01 2014 a 31/12/2015. Avaliamos o mecanismo do trauma, lado, classificação de Essex-Lopresti, ângulo de Böhler e de Gissane no pré e pós-operatório, classificação tomográfica de Sanders e tipo de osteossíntese realizada. As aferições angulares nos serviram de referência para análise radiológica da qualidade da redução.

Resultados: 90% dos casos foram de depressão articular, sendo os outros 10% considerados extra-articulares. O ângulo de Böhler no pré-operatório variou entre 5 e 40°, e entre 10 e 38° no pós-operatório, sendo que 55% das fraturas tiveram uma reconstrução angular considerada boa (entre 20° e 40°). O ângulo de Gissane, por sua vez, variou entre 110 e 170° no pré-operatório, e 102 e 132° no pós-operatório. Na análise tomográfica, houve predomínio da classificação IV de Sanders (65%), seguida das fraturas tipo IIIBC (20%), e fraturas tipo I, IIA e IIIAB (5% cada). Osteossíntese com placa e parafuso foi o método mais utilizado (89,47%).

Work performed at the Hospital Maternidade Marieta Konder Bornhaunsen, Universidade do Vale do Itajaí, Itajaí, SC, Brazil.

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Conclusão: A utilização correta dos recursos de diagnóstico por imagem existentes, através dos resultados radiográficos e tomográficos proporciona a possibilidade de melhor planejamento pré-operatório nas fraturas intra-articulares do calcâneo, porém, neste estudo não demonstrou diferença da via de acesso e material de síntese de acordo com a classificação tomográfica.
Nível de evidência IV; Estudos Terapêuticos; Série de Casos.

Descritores: Fraturas ósseas; Calcâneo; Tomografia.

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INTRODUCTION

Calcaneal fractures account for approximately 2% of all fractures of the human body, and the calcaneus is the most frequently fractured bone of the tarsus, representing 60% of all major lesions[1]. Falls from high places and automobile accidents are the main causes of such fractures. Calcaneal fractures occur more frequently in adults and young adults and are of great social and economic importance because these fractures are highly disabling, require prolonged time away from work for treatment and are associated with adverse posttreatment results such as residual pain and limited subtalar mobility[2].

Calcaneal fractures are diagnosed using imaging tests (radiography or computed tomography). Radiologically, the fracture can be classified as intra- or extra-articular, which indicates whether the subtalar joint is involved[3]. Because intra-articular fractures (equivalent to 70% of all calcaneal fractures) have a higher risk of degenerative sequelae leading to pain and restricted joint mobility, they require a more thorough evaluation. In these cases, computed tomography is very useful, allowing better visualization of fracture fragments and intra-articular displacements.

The treatment for calcaneal fractures is mostly surgical; however, no consensus has been reached regarding the best surgical technique for correction of such a lesion according to its classification[4].

By analyzing medical records, this study aimed to evaluate preoperative computed tomography images of calcaneal fractures that occurred between January 2014 and December 2015 among patients who were hospitalized in the orthopedic department to identify a relationship between tomography classifications and the surgical techniques used for correction of the fractures. The objective of this work is to demonstrate the importance of using computed tomography to determine the best access route and synthesis material according to the tomography classification.

METHODS

This study was approved by the Research Ethics Committee with registration in the Brazil Platform under CAAE number: 51141815.6.0000.0120.

This is a documentary, retrospective and descriptive study.

Participants

The inclusion criteria for this study were patients of both sexes aged 15 years or older who underwent osteosynthesis of a calcaneal fracture between January 1, 2014 and December 31, 2015. Patients who did not have preoperative computed tomography images in the service system or with insufficient data in their records were excluded from the study.

The included records were assessed using two worksheets, including one with a list of the patients who underwent calcaneal fracture osteosynthesis, and another with a list of the patients who underwent calcaneal tomography at the orthopedic department. The spreadsheets were organized by year and included each patient's name, medical record number and the affected side in the case of CT scans. The orthopedic department provided computers and physical space for the spreadsheet analysis. Medical records from patients diagnosed with calcaneal fractures confirmed by tomography examination performed at the orthopedic department who underwent surgical treatment were selected.

The search for pertinent records was initiated by identifying patients who underwent calcaneal fracture surgery in the orthopedic department from January 2014 to December 2015, which yielded 53 patients. Of these patients, only those who underwent computed tomography of the calcaneus in the orthopedic department during the same period were included in the study, resulting in a total of 20 patients. During data collection, one medical record was not found, and only 19 patients were ultimately included in the analysis (Table 1).

Table 1. Characteristics of the sample

Name Initials	Age	Sex	Mechanism	From	Side	Associated fracture
A.A.B.	41	M	Fall from height	Itajaí	L	N
E.X.O.	42	M	Automobile accident	Itajaí	L	N
J.C.R.	56	M	Fall from height	Itajaí	L	N
L.M.Q.	23	F	Automobile accident	Itajaí	L	R Radius
M.S.	39	M	Fall from height	Navegantes	R	Talus
O.C.	53	M	Fall from height	Itajaí	R	N
R.S.	42	M	Fall from height	Navegantes	L	N
D.L.	31	M	Fall from height	Itajaí	R	Polytrauma
E.L.C.	42	M	Automobile accident	Itajaí	L	N
I.S.G.	40	M	Fall from height	Camboriú	R/L	N
J.C.S.	57	M	Fall from height	Itajaí	L	N
M.A.J.	42	F	Fall from height	Navegantes	R	N
R.U.C.	26	M	Fall from height	Itajaí	R/L	N
R.R.D.	29	M	Fall from height	Cianorte	L	N
S.L.S.	67	M	Fall from height	Itajaí	L	N
E.R.M.	46	M	Fall from height	Piçarras	L	N
L.W.	56	M	Fall from height	Itajaí	L	N
O.C.	37	M	Fall from height	Itajaí	R	R Navicular
S.P.	40	M	Automobile accident	Itajaí	R	R Navicular

M= Male; F= Female; L= Left side; R= right side.
Source: Prepared by the author based on the results of the research.

Statistical analysis

The present study involved a quantitative approach. The variables analyzed from the data collected from the medical records and imaging examinations were the number of records, date of birth, sex, city of origin, trauma mechanism, fractured side, Essex-Lopresti classification based on preoperative radiographs, Böhler's and Gissane's angles in the pre- and postoperative periods, Sanders classification based on computed tomography and the type of osteosynthesis.

To ensure greater study credibility, the Essex-Lopresti[5] and Sanders classifications as well as Gissane's and Böhler's angles[6,7] were determined by physicians in the third year of the Orthopedics and Traumatology residency and members of the hospital orthopedics and traumatology team (4 general orthopedists and one foot and ankle specialist). A simple frequency distribution analysis was used to analyze the obtained data. For the statistical analysis of the data, graphics and percentage tables were generated and a descriptive analysis of the data was performed.

RESULTS

Among the 19 medical records, males were more prevalent, with 17 male patients (89.47%) and only 2 female patients (10.53%). The patients' ages ranged from 23 to 56 years, with a mean of 42.57 years and a standard deviation of 11.36 years. When comparing the age frequency by sex, the mean age among the males was found to be 43.76 years old, 25% of whom were between 26 and 37 years old, while 50% of these patients were between 37 and 51 years old and 25% were older than 57 years. The ages of the females ranged from 23 to 42 years, with a mean age of 32.5 years (Figure 1).

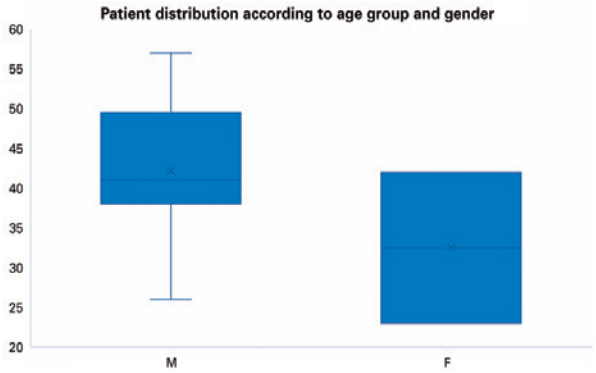

Figure 1. Distribution of patients by age group and gender according to medical records
Source: Prepared by the author based on the results of the research.

Most patients came from Itajaí (SC) (66.67%), which was expected because Itajaí is the largest and the most economically active city in the region. Its neighboring city, Navegantes (SC), ranked second with 16.67% of the trauma patients. Camboriú (SC), Piçarras (SC) and Cianorte (PR) had one patient each, accounting for 5.56% of the study patients.

Fall from a high place was the most prevalent trauma mechanism, which occurred in 15 cases (78.95% of the total sample) (Figure 2). Automobile accidents represented the other mechanism observed and accounted for 4 cases (21.05%). Regarding the fractured side, 57.89% of the patients were affected on the left side, and 31.57% of the patients were affected on the right side. The fracture was bilateral in 10.52% of the cases.

No patients had a large number of associated fractures, and 72.22% of the patients had only a calcaneal fracture. A total of 11.11% of the patients had a concomitant navicular fracture. Fractures of the talus and radius and polytrauma were identified in 5.56% of the cases.

Although the total number of patients was 19, the total number of fractures was 21 due to two cases of bilateral fractures (Table 2). The Essex-Lopresti classifications (1952)[5] based on lateral radiographs showed that 90% of the cases involved joint depression, and 10% of the cases were extra-articular fractures. Böhler's angle (1931)[6] varied between 5° and 40° preoperatively and between 10° and 38° postoperatively, and 55% of the fractures (11 of the total sample) exhibited good angle reconstruction (between 20° and 40°). Gissane's angle (1947)[7] ranged from 110° to 170° in the preoperative period and from 102° to 132° in the postoperative period, indicating adequate angular recovery (less than 130°) in 45% of the cases (9 fractures). In some cases, the angles could not be calculated due to poor positioning during radiography, thus precluding correct angle evaluation of displacements.

The Sanders classifications based on tomography analysis showed a prevalence of comminuted fractures (classification IV), representing 65% (13 cases) of the fractures evaluated, followed by type IIIBC fractures, which accounted for 20% of the cases. Fracture types I, type IIA and type IIIAB were each observed in 5% of the sample (1 case each) (Figure 3). Although type I fractures do not require surgical treatment[8], one such fracture was present in the sample because one patient had a bilateral calcaneal fracture, and the other fracture was classified as type IIA according to the Sanders classification.

The mean time between the occurrence of the trauma and osteosynthesis surgery was 13 days, with a standard deviation of 8.92 days.

Regarding the surgical access routes used, three types of incisions were implemented: lateral, L-shaped lateral, and wide L-shaped lateral. The lateral approach was the most frequently used method and was cited in 45% of the surgeries. The wide L-shaped lateral incision was performed in 35% of the cases, and the L-shaped lateral incision was used in 15% of the cases. For one fracture (5%), conservative treatment was selected.

Of the total number of surgeries performed (19), osteosynthesis with a plate and screw was the most frequently used method, accounting for 89.47% of all surgeries. The use of a Kirschner wire in association with a plate and screw was described only once (5.26%). The use of Kirschner wire and a screw was also described only once. After surgery, the mean length of hospital stay was 1.31 days, with a standard deviation of 0.47 days.

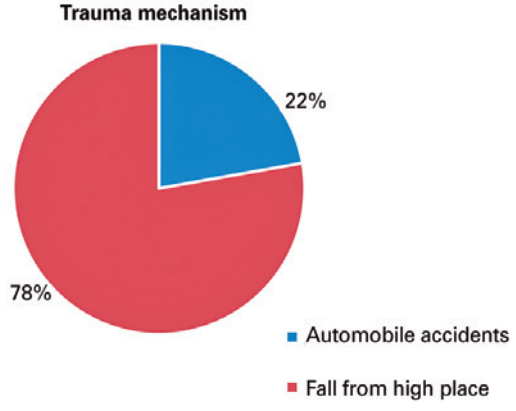

Figure 2. Trauma mechanism.
Source: Prepared by the author based on the results of the research.

DISCUSSION

The aim of the present study was to evaluate preoperative CT scans of calcaneal fractures to establish a relationship between fracture classification and the osteosynthesis method and access route used.

Calcaneal fractures usually occur in young males in an age group considered economically active, which can cause a substantial socioeconomic impact[1-4,9]. The present sample was compatible with the literature[1] since male patients predominated (88.89% of the total sample). Considering the age range of the sample (from 23 to 56 years, with a mean of 41.22±9.70 years), all patients were of an economically active age.

Table 2. Classification and osteosynthesis of the fractures of the sample

Name	Side	Essex-Lopresti	Böhler pre-	Böhler post-	Gissane pre-	Gissane post-	Sanders TC	Access	Osteosynthesis
A.A.B.	L	JD	14°	22°	140°	NC	IV	Lateral L-shaped	Plate + screw
E.X.O.	L	JD	30°	NC	170°	NC	IV	Lateral L-shaped	Plate + screw
J.C.R.	L	JD	12°	10°	122°	132°	IV	Lateral	Plate + screw
L.M.Q.	L	JD	22°	22°	110°	NC	IIIAB	Lateral	Plate + screw
M.S.	R	JD	35°	32°	110°	110°	IV	Wide L-shaped lateral	Plate + screw
O.C.	R	JD	5°	20°	122°	102°	IV	Lateral	Plate + screw
R.S.	L	JD	35°	21°	130°	119°	IV	Lateral L-shaped	Plate + screw
D.L.	R	JD	20°	22°	122°	132°	IV	Wide L-shaped lateral	Plate + screw
E.L.C.	L	JD	10°	25°	130°	118°	IV	Wide L-shaped lateral	Plate + screw
I.S.G.	R / L	JD/JD	5°/NC	NC/28°	142°/NC	NC/131°	IV/IV	Wide L-shaped lateral/ lateral	Plate + screw
J.C.S.	L	JD	NC	22°	NC	NC	IIIBC	Wide L-shaped lateral	Plate + screw
M.A.J.	R	JD	2°	10°	132°	130°	IV	Lateral	Plate + screw
R.U.C.	R / L	EA/EA	NC/DC	NC/8°	NC/NC	NC/118°	I/IIA	CT/lateral	CT/KW + Plate + screw
R.R.D.	L	JD	13°	38°	NC	128°	IIIBC	Wide L-shaped lateral	Plate + screw
E.R.M.	L	JD	20°	NC	115°	NC	IIIBC	Wide L-shaped lateral	Plate + screw
L.W.	L	JD	20°	18°	120°	118°	IV	Lateral	Screw + KW
O.C.	R	JD	13°	15°	142°	120°	IV	Lateral	Plate + screw
A.A.B.	L	JD	40°	30°	140°	118°	IIIBC	Lateral	Plate + screw

R= right; L= left; JD= joint depression; EA= extra-articular; NC= not calculable; KW= Kirschner's wire; CT= conservative treatment.
Source: Prepared by the author based on the results of the research.

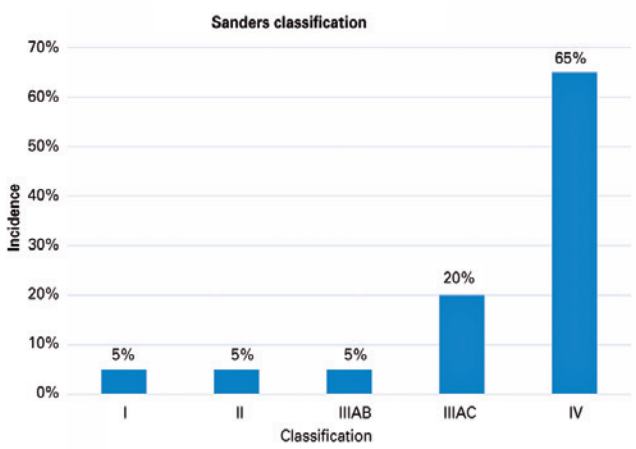

Figure 3. Sanders classification.
Source: Prepared by the author based on the results of the research.

Regarding the mechanism of trauma, fall from a high place was the main cause of trauma in the studies that addressed this variable[1,2], and the present study corroborated the reports in the literature.

Radiography should always be performed for initial assessment of calcaneal trauma. Regarding the lateral incidence, performing angle calculations facilitates selection of the best method of treatment. Böhler's angle is used to evaluate changes in the posterior facet and to qualify the resolution of the fracture, and variation from 20° to 40° is considered acceptable. Angles less than 20° correspond to a higher incidence of a poor outcome. Planning of the surgical intervention should include reconstruction of the postfracture angle since an improved classification is related to greater postoperative functional recovery[1]. Gissane's angle should also be measured to evaluate depression of the anterior facet, which is present when the angle is greater than 130°. In the present study, reestablishing Böhler's and Gissane's angles postoperatively was difficult in approximately half of the cases, which were the most serious cases identified by Sanders classification preoperatively.

Computed tomography should be performed when a radiograph indicates an intra-articular fracture. This method will allow correct evaluation of the number of fragments present and their displacements[3]. The Sanders classification is essential for therapeutic evaluation[7] since the fracture type indicates the need for either conservative or surgical treatment as well as the corresponding access route. As the patients in the sample were selected from a list of calcaneal surgeries during the study period, the large numbers of type III and IV fractures, classifications for which surgery is required, are understandable.

According to the manual of orthopedic trauma[3], calcaneal fractures are not considered an orthopedic emergency. Thus, patients should wait 7 to 14 days for surgery. The present study corroborates reports in the literature and indicated the need to postpone surgery for good soft tissue recovery.

The lateral access route has been used most frequently by the authors[2,10], although its modifications, such as L-shaped lateral and wide L-shaped lateral incisions, are becoming increasingly prevalent. In addition to lateral access, the literature also describes medial access and access through the tarsal sinus[10-13]. Minimally invasive techniques are being described mainly for patients with comorbidities (mainly peripheral obstructive arterial disease) that contraindicate open surgery[11]. Despite the large number of studies comparing techniques, postoperative images and complications, and the rehabilitation time of patients, it is observed preference for the open reduction and internal fixation for correction of joint fractures. The study sample corroborated the literature, since the lateral incision was the most used.

Fixation with plate and screw[1,2] for osteosynthesis of calcaneal fractures is predominant in the literature. Thus, the study sample was similar to the authors' descriptions, which made it difficult to search for a relation between the tomography classifications and the methods used; the tomography aided in planning, but did not determine, in this study, the technique and access route.

The study has limitations because it is a retrospective study, does not have a comparative group and has a small number of patients.

CONCLUSION

The intra-articular fracture of the calcaneus is a complex fracture and its management requires an accurate diagnosis and an adequate operative technique performed by a surgeon experienced in this area. Despite advancements in surgical instruments and techniques, the best way to treat calcaneal fractures remains a challenge for orthopedic surgeons.

The correct use of existing diagnostic imaging features, through radiographic and tomographic results, may provide the surgeon with the possibility of better preoperative planning of the intra-articular fractures of the calcaneus, although the treatment usually indicated for the majority of patients with joint fractures is the open reduction and fixation with plate and screws. In this study, the evaluation of the tomography classification did not influence the decision regarding the access route and synthesis of choice. For a better evaluation regarding the outcome, a study prospectively evaluating the clinical long-term outcome of these patients and relating classification and treatment should be carried out.

Authors' contributions: Each author contributed individually and significantly to the development of this article: GB *(https://orcid.org/0000-0001-5273-4303) conceived and planned the activities that led to the study, interpreted the results of the study and wrote the article; HCGR (https://orcid.org/0000-0003-1430-0664): planned the activities that led to the study, participated in the review process and approved the final version; RRC *(https://orcid.org/0000-0003-2241-053X) planned the activities that led to the study, participated in the review process and approved the final version. *ORCID (Open Researcher and Contributor ID).

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