Calcaneal stress fractures in civilian patients: an epidemiological study

Pedro José Labronici¹, Robinson Esteves Santos Pires², Luiz Eduardo Cardoso Amorim³

1. Hospital Santa Teresa, Petrópolis, RJ, Brazil.
2. Universidade Federal de Minas Gerais, Minas Gerais, MG, Brazil.
3. Orthopedics and Traumatology Department, Faculdade de Medicina da Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil.

Abstract

Objective: To conduct a retrospective magnetic resonance imaging (MRI) analysis of calcaneal stress fractures and construct an epidemiological profile of these injuries.

Methods: Of 258 MRIs analyzed, nine were consistent with calcaneal stress fractures. These were evaluated by two investigators to confirm the diagnosis. The calcaneus was divided into three anatomical regions: anterior calcaneus (delimited by the angle of Gissane), mid-calcaneus (delimited by the angle of Gissane and tuberosity of the posterior facet), and posterior calcaneus (delimited by the tuberosity of the posterior facet). Fractures were classified as low-grade (grade I, when associated with periosteal edema; II, endosteal; III, muscular) or high-grade (grade IV, when there was a visible fracture line on MRI).

Results: The average patient with a calcaneal stress fracture was an overweight (66.7%) female (66.7%) amateur athlete (66.7%), with a left-sided (55.6%) grade IV fracture (77.8%) of the posterior portion of the calcaneus (66.7%), sustained while running (77.8%), and took 1 to 2 years to be diagnosed (66.7%).

Conclusion: Calcaneal stress fractures are more frequent in women, amateur athletes, middle age, and in those with overweight. Younger patients usually present with grade I, II, or III fractures, while middle-aged patients present most often with grade IV fractures; lesions tend to be more common in the anterior region than in the mid- or posterior calcaneus.

Level of Evidence IV; Therapeutic Studies; Case Series.

Keywords: Fractures, stress/epidemiology; Calcaneus/injuries; Magnetic resonance imaging.

Introduction

Calcaneal stress injuries were first reported in the German literature in 1937 (1,2). Stress fractures are the result of repetitive microtrauma to normal bone, and have an incidence of 1% to 7% among all sports activities. They are considered the second most common foot injury, accounting for 20% of all fatigue-induced fractures (3-5). These injuries occur primarily in military recruits, long-distance runners, and the obese. Women have a particularly high prevalence, with reports that these lesions may account for up to 39% of all fractures in females (3,4,6-11).

Heel pain is a common complaint in adults, and can cause discomfort and disability. However, due to the low incidence of this type of fracture and low level of suspicion, it is diagnosed rarely as compared to other conditions, such as hindfoot tendinopathy, plantar fasciitis, neuropathies, retrocalcaneal bursitis, and calcaneal (Achilles) tendinopathy (4).

Several risk factors have been associated with development of calcaneal stress fracture, including insufficient physical activity and inadequate footwear (12,13). Conventional radiography, especially in the early stages of these lesions, cannot establish a definitive diagnosis. Instead, bone scintigraphy and magnetic resonance imaging (MRI) are considered the most reliable imaging methods for the diagnosis of stress fracture. Both modalities have excellent sensitivity, but MRI also offers high specificity and is considered the optimal imaging method for diagnosis of stress fractures (14).
The objective of this study was to conduct a retrospective MRI analysis of stress fractures and outline the epidemiological profile of this injury.

**Methods**

This study was approved by the Institutional Review Board and registered on the Plataforma Brasil database under CAAE (Ethics Evaluation Submission Certificate) number: 82503418.6.0000.5245. An informed consent form was signed by the patients involved.

From January 2015 to December 2017, all MRI scans of patients presenting to the study hospital with hindfoot pain were retrospectively evaluated.

The exclusion criteria were patients who presented with acute calcaneal fracture or with any infection involving the ankle and/or foot. Patient charts were analyzed to collect data on demographic parameters and clinical history, including time from symptom onset until definitive diagnosis and type of activity that triggered heel pain. Of 258 MRIs analyzed, 11 were consistent with stress fracture, but two were excluded because the patients presented with acute trauma. Therefore, the sample consisted of nine patients (Table 1).

Magnetic resonance imaging of the ankle was obtained in at least two different planes. Of these, the sagittal and axial planes, in T1-weighed spin-echo and fast-spin T2-weighed sequences with fat suppression, were the most common. Additional sequences were also requested, such as STIR (short-tau-inversion-recovery). All MRIs were evaluated by two investigators to certify that they represented stress fractures. To determine the location of the lesion, as proposed by Sormaa et al. (14), the calcaneus was divided into three anatomical regions: The anterior calcaneus (delimited by the angle of Gissane), mid-calcaneus (delimited by the angle of Gissane and tuberosity of the posterior facet), and posterior calcaneus (delimited by the tuberosity of the posterior facet) (Figure 1).

Calcaneal stress fractures were classified as low-grade (grade I, when associated with periosteal edema; grade II, endosteal edema; grade III, muscle edema) or high-grade (grade IV) when there was a visible fracture line on MRI (15-17) (Figures 2A, 2B). Because the calcaneus is an essentially trabecular bone, the low-grade fractures were pooled for analysis by the two investigators, as these lesions are difficult to assess.

**Statistical analysis**

Due to the small sample size, no inferential analysis of significance could be performed; the statistical analysis was descriptive, based on graphs, frequency distributions, and calculation of (mean, median, standard deviation, coefficient of variation – CV – for the age variable). The variability of age distribution was considered low if, moderate if, and high if.

Graphs were plotted in Microsoft Excel 2007. All other analyses were carried out in SPSS Statistics for Windows, Version 22.0.

**Results**

The baseline sample of this study is composed of nine patients with calcaneal stress fractures, six women (67.7%) and three men (33.3%), as shown in figure 3.

The age distribution of the patients, overall and by gender, is described in table 2. Patient age ranged from 36 to 74 years (mean, 50.8 years; median, 48.0 years; standard deviation, 11.8 years), and variability was moderate (CV=0.23). The variability of age distributions in the female and male subgroups was also moderate. Women with calcaneal stress fractures were generally older than men (4.2 years on average). A comparison of mean and median age in the male and female subgroups is shown in figure 4.

The frequency distribution of variables that characterize patients and their fractures, overall and stratified by gender, is shown in table 3. The frequency distribution of age shows that the most typical age groups for calcaneal stress fractures are between 36 and 56 years (66.6%). The typical patient with a calcaneal stress fracture was an overweight (66.7%) female (66.7%) amateur athlete (66.7%), with a left-sided (55.6%) grade IV fracture (77.8%) of the posterior portion of...
Figure 1. Calcaneus divided into three anatomical regions: A - posterior; B - medial; C - anterior.

Figure 2. A and B - Plain radiographs and MRI of a grade IV calcaneal stress fracture.

Figure 3. Gender distribution of the sample.

Figure 4. Mean and median patient age, overall and stratified by gender.

Table 2. Key statistics for the patient age variable, overall and stratified by gender

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Overall</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>36</td>
<td>41</td>
<td>36.0</td>
</tr>
<tr>
<td>Maximum</td>
<td>74</td>
<td>74</td>
<td>62.0</td>
</tr>
<tr>
<td>Mean</td>
<td>50.8</td>
<td>52.2</td>
<td>48.0</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>11.8</td>
<td>12.1</td>
<td>13.1</td>
</tr>
<tr>
<td>CV</td>
<td>0.23</td>
<td>0.23</td>
<td>0.27</td>
</tr>
<tr>
<td>Median</td>
<td>48.0</td>
<td>49.0</td>
<td>46.0</td>
</tr>
</tbody>
</table>

Table 4 shows the main statistics related patient age, stratified into subgroups determined by the variables. These findings suggest that, among patients with calcaneal stress fractures, amateur athletes are older than non-athletes; those who are overweight are older than patients with normal the calcaneus (66.7%), sustained while running (77.8%), which took 1 to 2 years to be diagnosed (66.7%).
weight; those who walk are older than those who run; those with grade I, II, and III fractures are older than those with grade IV lesions; those who presented with lesions on the left side were older than those who had lesions on the right side; the oldest patient of the sample had an injury of the anterior calcaneus, while those who presented with mid-calcaneus injuries were older than those who presented with lesions in the posterior portion. There was no substantial age difference between patients with a symptom-to-diagnosis interval of less than 1 year versus 1 to 2 years.

Figure 5 shows the frequency and mean age of patients in subgroups stratified by gender and BMI classification. The highest frequency of calcaneal stress fractures (44.4%) was found in overweight women with a mean age of 55.5 years, while the lowest frequency (11.1%) was in men with normal weight and a mean age of 36 years. Therefore, based on this sample, we estimate that an overweight woman is four times more likely to experience a calcaneal fracture than a man of normal weight.

**Discussion**

Although calcaneal stress fractures are considered unusual injuries, MRI should be considered for early diagnosis in patients with heel pain, especially in overweight, physically active women.

The diagnosis of calcaneal stress fractures can be a challenge for the orthopedic surgeon. Localization of pain and tenderness in the plantar and/or posterior region will often induce diagnostic suspicion of plantar fasciitis or other soft-tissue conditions. Due to its relatively uncommon incidence when compared to other stress fractures and other causes of heel pain, calcaneal stress fractures are often misdiagnosed or neglected[18,19]. Although the literature shows that, on physical examination, pain is usually located in the plantar or posterior portion of the foot, the clinical presentation can be variable, and MRI should be considered for early diagnosis in patients with heel pain, especially in overweight, physically active women.
According to the literature, calcaneal stress injuries are usually located in the posterior region. Sormaala et al. observed that 56% of injuries were located in the posterior region, 26% in the anterior region, and 18% in the mid-calcaneus. Other studies have observed that 95 to 100% of these lesions were located in the posterior region. However, these studies were restricted to conventional radiography. The disparity in results was attributed to the high sensitivity of MRI in locating fractures in different portions of the calcaneus. Our study confirmed the findings of Sormaala et al., with a predominance of lesions in the posterior tuberosity (66.7%). Despite the small number of patients in our study, we observed that lesions of the anterior calcaneus (11.1%) occurred mainly in elderly patients (median age 74 years), followed by mid-calcaneal injuries (22.2%) at a median age of 55 years and posterior injuries (66.7%) at a median of 44 years.

Sormaala et al. analyzed MRIs and classified 41% of lesions as low-grade, while only 15% of calcaneus fractures were detected on plain radiographs. Therefore, they concluded that, in order to ensure early diagnosis, MRI should be requested in patients who present with a complaint of heel pain, especially in military recruits, athletes, and the obese, even when radiographs are normal. In this study, probably due to the delay in obtaining MRI and consequent late diagnosis, seven of the nine analyzed patients (77.8%) had grade IV lesions. Perhaps earlier diagnosis might have led us to observe a greater number of grade I, II, and III stress lesions.

According to the literature, stress injuries of the calcaneus are more common in female and obese patients (BMI ≥ 30). Our study showed a higher prevalence in female and overweight, though not obese, patients (44.4%), as determined by BMI. However, due to the small sample size, we cannot rule obesity out as a risk factor.

This study has some limitations. We did not analyze some variables that could interfere with the development of stress fractures of the calcaneus, such as flat feet and limb discrepancies, and did not obtain data on bone mineral density or history of menopause for female patients. In addition, the small sample size is an issue, as mentioned above.

**Conclusion**

In civilians, calcaneal stress fractures are more frequent in women, amateur athletes, middle-aged non-athletes, and those with overweight. Younger patients usually present with grade I, II, or III fractures, while middle-aged patients present most often with grade IV fractures. Lesions tend to be more common in the anterior region than in the mid- or posterior calcaneus.
Authors’ contributions: Each author contributed individually and significantly to the development of this article: PJL conceived and planned the activities that led to the study, interpreted the results of the study, participated in the review process, statistical analysis, and writing up the final version; LECA interpreted the results of the study, participated in the review process, bibliographic review, formatting of the article, approved the final version. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID) 10.

References


