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ORIGINAL ARTICLE

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Stress fractures in the central metatarsal in female patients

Fraturas por estresse nos metatarsos centrais em pacientes do gênero feminino

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ABSTRACT

Objective: To evaluate the profile and diagnostic methods of only female patients with stress fracture in the central metatarsal.
Methods: Retrospective, descriptive study of patients who were treated on an outpatient basis and diagnosed with stress fractures in the second, third or fourth metatarsals from January 2012 to June 2016. The epidemiological profile, the risk factors presented for the development of this pathology and the diagnostic imaging methods were analyzed.
Results: There were 30 patients, with a total of 32 fractures. Fifteen cases of fractures were found in the second metatarsal, 13 in the third and 4 in the fourth. The right foot had 11 fractures, and the left foot had 21. The average patient age was 44.3 years of age. Ten patients had normal body mass index (BMI), 13 were overweight and 7 had Grade I obesity. Sixteen patients were sedentary, and 14 regularly exercised. The diagnosis with radiography at first consultation was 8 cases and 2 after the second consultation. In the other 20 cases, the radiography was negative, and magnetic resonance imaging was requested for diagnostic confirmation.
Conclusion: Development of metatarsal stress fractures was observed in the majority of patients who were at least 40 years of age, an age group in which estrogen production has begun to decrease in women. Magnetic resonance imaging is the ideal test for early diagnosis of the lesion.
Level of Evidence III; Retrospective Comparative Study.

Keywords: Stress, fractures; Metatarsal bones; Diagnostic imaging.

RESUMO

Objetivo: Avaliar o perfil e os métodos diagnósticos somente de pacientes do gênero feminino com fratura por estresse nos metatarsos centrais.
Métodos: Estudo retrospectivo descritivo de pacientes que foram atendidas ambulatorialmente e diagnosticadas com fratura por estresse no segundo, terceiro ou quarto metatarsos no período de Janeiro de 2012 a Junho de 2016. Foram analisados o perfil epidemiológico, os fatores de risco apresentados para o desenvolvimento dessa patologia e os métodos diagnósticos por imagem.
Resultados: Foram avaliados 30 pacientes, que totalizaram 32 fraturas. Foram encontrados 15 casos de fraturas no segundo metatársico, 13 no terceiro e 4 no quarto. No pé direito foram encontradas 11 fraturas e 21 no esquerdo. A idade média foi de 44,3 anos. Dez pacientes apresentavam IMC dentro da normalidade, 13 sobrepeso e 7 obesidade de grau I. Dezesseis pacientes eram sedentárias e 14 praticavam exercícios regularmente. Em 8 casos chegou-se ao diagnóstico com radiografia em primeira consulta e 2 após a segunda consulta. Nos outros 20 casos, a radiografia foi negativa e foi solicitada ressonância magnética para confirmação diagnóstica.
Conclusões: Foi observado o desenvolvimento de fraturas por estresse dos metatársicos na maioria das pacientes que se encontravam em idade maior ou igual a quarenta anos, faixa etária que inicia a diminuição da produção estrogênica da mulher. Concluiu-se que a ressonância magnética é o exame ideal para diagnóstico precoce da lesão.
Nível de Evidência III; Estudo Retrospectivo Comparativo.

Descritores: Fraturas de estresse; Ossos do metatarso; Diagnóstico por imagem.

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INTRODUCTION

Stress fracture is a partial or complete fracture of a bone resulting from its inability to withstand tension applied rhythmically and repeatedly[1]. It is a common morbidity in athletes, both amateurs and professionals, dancers and military recruits, but it can affect anyone involved in daily activities[2]. Suspicion for this type of injury has become more frequent in the orthopedist's office, as its incidence is increasing. Women are more likely to develop this type of injury because they present bone (such as postmenopausal osteopenia and osteoporosis), muscle, hormonal and nutritional changes more frequently[3]. An important factor in the development of stress fractures in female patients is their short stature and the shorter relative length of their lower limbs (women have proportionally shorter legs than men). Thus, to walk a certain distance, women need to take more steps, which corresponds to more impacts.

The clinical picture is revealed by insidious, localized and severe pain not associated with a history of trauma, worsening with ambulation or when sustaining the body[4]. The collection of a careful clinical history associated with the physical examination guides the diagnosis, and complementary imaging tests can reveal the lesion.

Stress fracture is a pathology of multifactorial etiology, and the suspicion of the diagnosis depends on a good anamnesis through the identification and recognition of the risk factors associated with the physical examination. The visualization of a fracture on the radiography is a late sign and may not be present in the first weeks after the development of the lesion.

Also known as fatigue or stress fractures, they occur due to repeated microlesions on a bone surface subjected to overload. Most stress fractures occur in the supporting bones, affecting the tibia and metatarsal bones more commonly, with the latter involved in approximately 25% of all stress fractures[4]. Approximately 90% of the stress fractures of metatarsal bones occur in the central bones (2nd, 3rd and 4th metatarsals [MTTs])[4]. The first stress fractures were described in 1855 by Breihaupt, a physician in the Prussian army, affecting the metatarsals of the soldiers who had been on long marches; therefore, the condition is also known as a march fracture[5].

The risk factors can be classified as extrinsic: related to the individual's environment, or intrinsic. The individual's own intrinsic factors include bone density, skeletal alignment, body size and composition, physiological factors such as bone recovery rate, flexibility, strength and muscular endurance, hormonal condition and nutritional status[6]. Extrinsic factors include mechanical factors such as surface, footwear, external load and parameters of physical training[6]. A risk framework is composed of the individual analysis of the risk factors integrated with the information provided by the patient[6]. The lesions occur as a sum of several extrinsic and intrinsic factors at a given moment[6].

The patient has constant and variable local pain and may present with edema[7]. There is persistence of symptoms and worsening of pain with exercise or support of body weight[6,7]. The diagnosis is made through a good anamnesis, physical examination and imaging tests[1,5].

Radiographs (XR) are requested for the diagnosis; however, XRs can often be inconclusive[3]. Radiological changes may only occur within a few weeks of the onset of clinical signs[3]. Because XR is simple, low cost and easy to access, it is the most requested exam. However, a change in bone density must occur before the typical signs of stress fracture are evident. In the early stages, approximately 80% of the fractures are not evident with this complementary method, and between 1 and 3 weeks, the sensitivity increases to approximately 50%[2,3]. Occasionally, computed tomography (CT), nuclear magnetic resonance imaging (MRI) or bone scintigraphy (BS) are required to confirm the diagnosis. MRI is superior at the initial diagnosis and characterizes fracture better than BS[7,8]. BS has a high diagnostic sensitivity for stress fracture since it detects the initial phase of the pathology (>95% positive in <24 h), when there are alterations in bone remodeling, which is why it precedes the radiological diagnosis by 7 to 14 days; however, BS has lower specificity than XR[2,9].

In most cases, the treatment is conservative for stress fractures and may include cryotherapy, non-steroidal anti-inflammatory drugs, rest and physical therapy until improvement[10-12]. In addition, in the athlete, warm-up and stretching before exercise and a gradual return to activity are indicated[10,13]. Exercise replacement may accelerate recovery without loss of cardiovascular fitness[10,11]. Lightweight, trimmed footwear and smooth running surfaces are specifically recommended to avoid fracture, as is correcting predisposing biomechanical conditions using customized orthoses[10,14].

The objective of this study was to analyze the profiles of female patients diagnosed with stress fractures of the central metatarsal bones, the triggering factors of this pathology (such as metabolic or mechanical changes) and the imaging methods used to define the diagnosis.

METHODS

This study was approved by the Research Ethics Committee with registration in the Brazil Platform under the CAAE number 67768917.8.0000.5501.

From January 2012 to June 2016, all cases of stress fracture in the central metatarsal bones were evaluated in female patients attended at the University Hospital of Taubaté (HUT) and in a private practice. Exclusion criteria included cases of stress fracture secondary to neurological pathologies (1 patient) and/or fractures of the 5th metatarsal (1 patient), which coincidentally were male; therefore, we chose to exclude them from the study since, besides these 2 particularities, we could not take into account criteria such as menopause for these cases and because they did not represent a large numerical loss for the study. At the end of the study, we obtained 30 patients (out of 32 with stress fractures) that totaled 32 fractures in the central metatarsal bones. Thirty-one feet were affected, 1 patient had a bilateral fracture and 1 patient had fractures of 2 metatarsal bones in the same foot. There were no follow-up losses.

All of the patients sought out the service after pain and edema began in the region of the central rays in the dorsum of the forefoot and without history of trauma. In the anamnesis, risk factors for stress fracture (considered in this study: age, body mass index [BMI], physical activity, smoking, medication use and / or hormonal disorders) were investigated. The questionnaire to which the patients were submitted contained the following: weight, height, time of diagnosis, previous pathologies and medications in use and habits. In view of the history and physical examination suggestive of the pathology of the study, all patients underwent radiography of the affected foot in the anteroposterior, profile and oblique incidences at the first visit. In the cases of radiographs without evidence of fracture, MRI was performed to confirm the diagnosis.

With the established diagnosis, we analyzed the variables mean patient age, laterality and location of the fracture, BMI (for BMI analysis, we used the table recommended by the World Health Organization: ideal weight [18.6-24.9], overweight [25-9.9], obesity grade I [30-34.9], obesity grade II [35-39.9] and morbid obesity [> 40]), physical activity practice (walking, running or other specified by the patient), smoking, medications in use, menstrual regularity and foot overload factor to trace the epidemiological profile of the group. Due to the difficulty of evaluating and guaranteeing the credibility of the information on sun exposure time, this criterion was not considered in this study, nor were the cost and logistics to obtain the vitamin D dosage.

For generating tables and graphs and performing calculations (such as average and percentage), Microsoft Office Excel 2007 was used.

RESULTS

Table 1 shows all patients in the study and the variables analyzed.

The most affected bones were the second and third metatarsals, corresponding to 15 cases (46.7%) and 13 cases (40.6%), respectively. The fourth metatarsal bone was affected in 4 cases (12.5%). In relation to laterality, there were 21 fractures in the left foot (67.7%) and 11 in the right foot (35.4%). As to the location of the fracture in the bone, we found 1 case (3.1%) of fracture at the base of the metatarsal, 23 (71.8%) metadiaphyseal and 8 (25.0%) diaphyseal.

The mean age of the patients was 44.3 years (20-60 years), and more than 70% of the patients were older than or equal to 40 years. Regarding BMI, 10 women (33.4%) were of ideal weight, 13 (43.3%) were overweight and 7 (23.3%) had grade I obesity.

In the study group, 8 women were menopausal, 1 had been oophorectomized in hormone replacement therapy, and 4 had menstrual irregularities at the age compatible with climacteric symptoms. The others presented menstrual cycles without alterations.

Of the total of 30 patients, 14 (46.7%) practiced regular low-intensity physical activity such as walking and light exercise (work-related gymnastics) 2 to 3 times a week. All of the others were sedentary.

We isolated 2 patients with a history of smoking (1 pack /day) and 1 patient with a previous history of osteoporosis using bisphosphonate and calcium replacement.

Analyzing the triggering factor of forefoot pain, we found 21 cases of patients who walked a lot during the day at work or spent a large part of the day in orthosta-

Table 1. Results

Patient	Age (years)	BMI	Metatarsal	Fracture location	Laterality	Menopause	Smoking	Medications in use	Radiography	MRI
1	52	30.4	2nd MTT	Metadiaphyseal	Right	Yes (6 years ago)	Negative	Negative	Normal	Positive
2	46	21.2	2nd MTT	Diaphyseal	Left	No	Negative	Negative	1st Nl. / 2nd Pos.	Not performed
3	43	23.7	2nd and 3rd MTT	Metadiaphyseal	Left	No/Climacteric	Negative	Negative	Normal	Positive
4	38	26.7	2nd MTT	Metadiaphyseal	Right	No	Negative	Negative	Normal	Positive
5	40	27	3rd MTT	Diaphyseal	Right	No	Negative	Negative	Normal	Positive
6	54	24.4	3rd MTT	Metadiaphyseal	Left	Yes (4 years ago)	1 pack / day	Clonazepam and Statin	Positive	Not performed
7	43	31.3	3rd MTT	Metadiaphyseal	Left	No/Climacteric	Negative	Negative	Normal	Positive
8	38	34.8	2nd MTT	Metadiaphyseal	Right	No	Negative	Negative	Normal	Positive
9	53	29.7	3rd MTT	Metadiaphyseal	Left	No/Climacteric	Negative	Negative	Normal	Positive
10	37	22.5	4th MTT	Metadiaphyseal	Right	No	Negative	Calcium alendronate	1st Nl. / 2nd Pos.	Not performed
11	20	22.3	3rd MTT	Metadiaphyseal	Left	No	Negative	Negative	Positive	Not performed
12	50	25.7	3rd MTT	Diaphyseal	Left	Yes (5 years ago)	Negative	Negative	Normal	Positive
13	60	23.9	2nd MTT	Base	Left	Yes (8 years ago)	Negative	Negative	Normal	Positive
14	55	25.8	2nd MTT	Metadiaphyseal	Left	Oophorecto-mized	Negative	HRT (22 years ago)	Normal	Positive
15	41	25.7	3rd MTT	Diaphyseal	Left	No	Negative	Negative	Normal	Positive
16	42	23	2nd MTT	Metadiaphyseal	Right	No	Negative	Negative	Positive	Not performed
17	34	21	4th MTT	Metadiaphyseal	Left	No	Negative	Negative	Normal	Positive
18	25	29.4	2nd MTT	Metadiaphyseal	Right	No	Negative	Negative	Normal	Positive
19	49	26.3	2nd MTT	Metadiaphyseal	Right	No/Climacteric	Negative	Negative	Normal	Positive
20	44	23.6	2nd MTT	Metadiaphyseal	Left	No	Negative	Negative	Normal	Positive
21	54	29.0	2nd MTT	Metadiaphyseal	Right	Yes (7 years ago)	1 pack / week	HRT	Normal	Positive
22	58	24.8	2nd and 3rd MTT	Diaphyseal	Left	Yes (10 years ago)	1.5 packs/day	Corticotherapy	Positive	Not performed
23	60	26.6	4th MTT	Metadiaphyseal	Left	Yes (20 years ago)		HRT	Positive	Not performed
24	33	29.4	3rd MTT	Metadiaphyseal	Left	No	Negative	Negative	Positive	Not performed
25	52	32.0	2nd MTT	Metadiaphyseal	Right	Yes (6 years ago)	No	Negative	Positive	Not performed
26	52	28.7	2nd MTT	Diaphyseal	Left	No	No	Negative	Positive	Not performed
27	33	30.9	3rd MTT	Diaphyseal	Right	No	Negative	Negative	Uncertain	Positive
28	41	31.4	4th MTT	Metadiaphyseal	Left	No	Negative	Negative	Positive	Positive
29	35	32.8	3rd MTT	Metadiaphyseal	Left	No	Negative	Negative	Normal	Positive
30	48	28.1	3rd MTT	Metadiaphyseal	Left	No	Negative	Negative	Normal	Positive

MTT = Metatarsus; Nl. = Normal; Pos. = Positive; HRT = Hormone replacement therapy.
Source: Prepared from research data.

sis, 2 cases of patients who started having pain after a long barefoot walk on a sandy beach, 3 cases that began after wearing high heels to a party, 2 cases that started after a long walk in a low shoe, an obese patient who started walking for weight reduction and a patient who developed the condition after an ankle sprain and a change in their gait type.

Eight patients (26.6%) presented signals of stress fracture in the radiography performed at the first consultation; these patients had pain complaints for less than 4 weeks. The positive predictive value of radiography with less than 4 weeks was 15.8%. All of the other 22 patients (73.3%) presented a normal first radiograph. Two of them had a new radiograph in a second consultation, with a history of pain for more than 6 weeks; these new radiographs presented fracture signs. For the other 20 patients (66.7%), an MRI was requested, identifying the lesion.

DISCUSSION

The mean age of the patients was 44.3 years, a period compatible with the climacteric period, in which there is a gradual decrease in estrogen production[13]. Interestingly, 8 (26.6%) patients reported hypoestrogenism during the questionnaire, but no laboratory tests were performed; we relied on the information provided by the patient, which may be considered a study bias. Hypoestrogenism is responsible for decreased bone mass and loss of muscle mass, two important risk factors for the development of fatigue fractures[6]. Bone density decreases with age and reduces the capacity of bone to withstand repetitive loading in older individuals[15]. Studies have shown that the accumulation of micro-damage in the human bone matrix increases with age, especially in women, and occurs faster than the intrinsic processes of bone repair[15].

In the analysis, we observed a higher incidence of fractures of the second and third metatarsal bones, which represented 87.5% of the total cases, as the most common sites of stress fracture[1].

In the study, no patients were involved in physical activities of average (more than 3 times a week) and high intensity, such as athletes, military recruits in training or professional dancers. Patients were sedentary or practiced light physical activity and developed stress fractures after some daily activity that required greater effort. The pathological picture developed after prolonged efforts with repetitive local stress.

In a state of fatigue, people change their gait as a compensatory strategy that can cause momentary external dorsiflexion[16]. This adaptive change of the forefoot and midfoot has been suggested as a potential mechanism for the development of stress fracture[17]. Increased fatigue load on the forefoot may be responsible for disturbed remodeling of the metatarsals, which would increase the likelihood of developing a fracture[18]. When fatigued, muscles experience decreases in the absorptive effects of shock during exercise/loading by increasing the pressure in the second and third metatarsals and the medial midfoot[19].

Most women in the study group (70%) spent a large part of the day in orthostasis and walked a lot during work or often wore inadequate and uncomfortable shoes that overload the feet. Two patients developed fractures after a long walk in the sand, an uneven surface which, because it is soft, demands more muscular effort to walk. These patients were not conditioned to this type of activity and practiced it acutely. Three cases occurred after the patients wore high heels during an event. The heel changes the support pressure of the feet and overloads the forefoot[20].

A case of ankle sprain was accompanied by a compensatory change in gait pattern, which led to an overload of the forefoot and metatarsal fracture.

An obese and sedentary patient endeavoring to lose weight began the practice of daily walks. Excessive loading, acute onset of activity and lack of conditioning led to fracture development.

All of the patients had pain at the fracture site, with worsening of the body and relief of rest. The patients sought medical attention 1 to 3 weeks after the onset of pain, and radiographs were requested for all patients. Of the 30 cases, 3 (15.7%) had stress fracture signals on the radiograph performed at the first visit. Delay in seeking medical help and late evidence of stress fracture on radiographs have led us to suspect that stress fractures represent an underdiagnosed lesion.

The evidence of stress fracture may never be revealed or may take 2 to 10 weeks to appear on radiography after the onset of symptoms[7,12]. MRI is highly specific and sensitive for the early detection of stress fractures and is currently considered the "Gold Standard" for this diagnosis[15,21-24]. In this study, 74% of the patients presented a negative first radiograph, that is, without evidence of fracture during the period of pain and local edema in the forefoot. Of these, 73.4% obtained confirmation of the lesion after MRI, as shown in Figures 1 to 4. Early diagnosis with MRI was beneficial since it reduced morbidity and allowed the initiation of appropriate treatment in advance[22,24,25].

Interestingly, 33.4% of the patients presented normal-weight BMIs. Overload is a risk factor for the development of the lesion under study, but we did not find studies that specifically analyzed BMI changes as a risk factor for stress fractures.

CONCLUSION

Stress fracture in the central metatarsal bones was more common in the second and third metatarsals. MRI was necessary for early confirmation of the diagnosis in most cases. Early diagnosis allowed the early initiation of treatment and, consequently, relief of patient suffering. In our study, mechanical overload was the main risk factor for lesion development. Smoking and obesity have not been shown to be risk factors suggestive of pathology.

In the sample, we were unable to identify a pattern of risk factors that could determine the occurrence of this pathology, which may be associated with the low number

Figure 1. Initial radiograph with no visible changes and pain, female patient, 34 years old.
Fonte: Hospital Universitário de Taubaté.

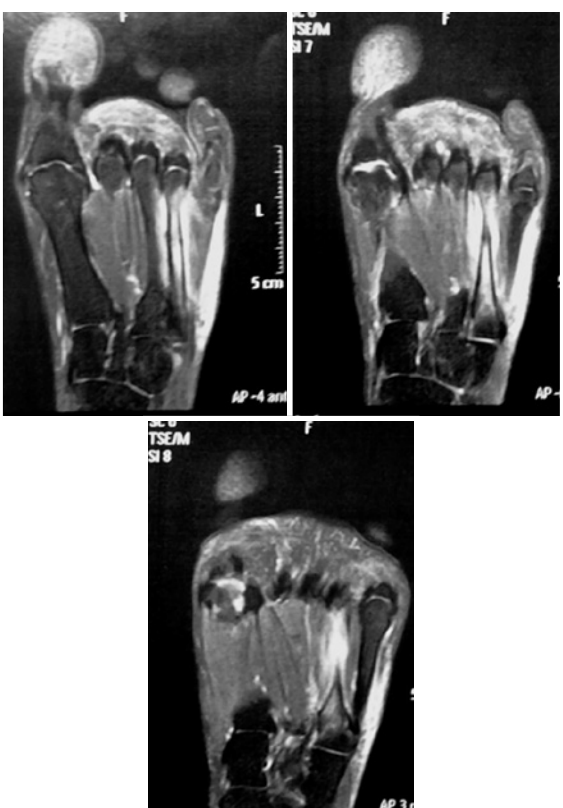

Figure 2. MRI: Axial cut with hypersignal in the fourth metatarsus, 3 weeks after the onset of pain.
Fonte: Hospital Universitário de Taubaté.

of patients documented or with the factors considered as having no association and/or statistical significance with a diagnosis of stress fracture.

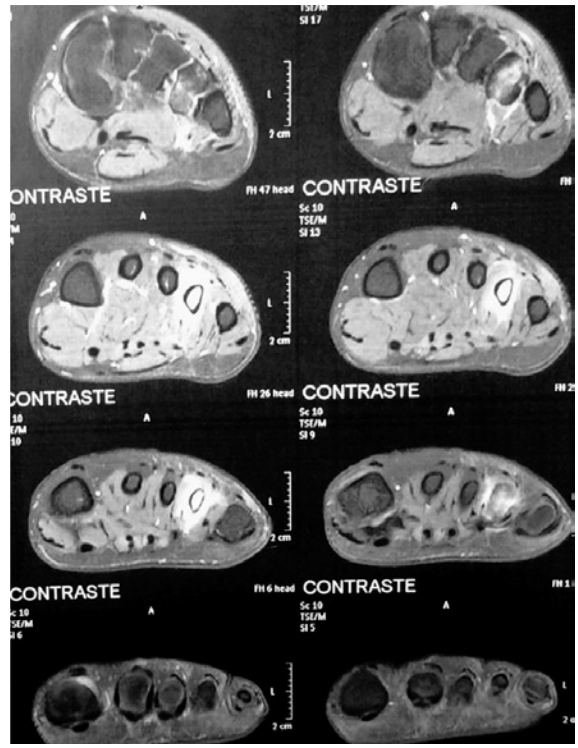

Figure 3. MRI: Coronal section with hypersignal in the fourth metatarsus.
Fonte: Hospital Universitário de Taubaté.

Figure 4. Radiography at 5 weeks after pain onset. Bone callus in fourth metatarsus.
Fonte: Hospital Universitário de Taubaté.

Authors' Contribution: Each author made significant individual contributions to this manuscript: FRL (https://orcid.org/0000-0001-9696-8697)* has written the article, interpreted the study results; GLFC (https://orcid.org/0000-0001-5470-8379)* has conceived and planned the activities that led to the study, has written the article and participated in the review process, has approved the final version; LCAT (https://orcid.org/0000-0002-0778-2506)* has interpreted the study results and participated in the review process; LCRL (https://orcid.org/0000-0003-1158-2643)* has participated in the review process; RPV (https://orcid.org/0000-0002-1775-6870)* has interpreted the study results. *ORCID (Open Researcher and Contributor ID).

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