Tibial Stress Fractures: Specificity of Focal Tenderness to Palpation

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ABSTRACT

Introduction: Stress fractures are common among military recruits and athletes. When involving the leg, they are typically characterized by tenderness in the medial tibial region. The inconsistency and imprecision of previously described clinical examination maneuvers highlight the need for this study, which aims to evaluate the sensitivity and specificity of tibial palpatory pain patterns. **Materials and Methods:** A series of 19 patients presenting with 31 painful episodes in the leg between 2012 and 2014 was analyzed. Patients experiencing tibial pain during military training were included, while those with a history of trauma were excluded. A physical examination was performed, mapping painful tibial points using a grid divided into nine zones and classifying them into three patterns: vertical, transverse, and focal (single point). All patients underwent radiographic and scintigraphic imaging. **Results:** Of the total patients, 63% were women and 36.8% were men. A total of 31 lesions were identified (64.5% in women, 35.5% in men). Radiographs were negative in all cases, whereas scintigraphy confirmed 22 (71%) stress fractures and 9 (29%) cases of periostitis. The transverse and focal pain patterns were the most sensitive (40.91%). The focal pattern was observed in 29% of cases and was exclusively associated with stress fractures. **Conclusions:** Focal tenderness to palpation was present in 100% of cases with stress fractures, demonstrating its high specificity as a clinical sign. This finding highlights its diagnostic value in evaluating tibial stress fractures.

Keywords: Stress fractures; physical examination; tibial fractures; tibial stress.

Level of Evidence: IIIB

Fracturas de tibia por estrés: especificidad del signo de dolor puntual palpatorio

RESUMEN

Introducción: Las fracturas por estrés son comunes en reclutas y deportistas. Se caracterizan, en los casos que involucran a la pierna, por dolor en la región tibial medial. La inconsistencia e imprecisión de las maniobras semiológicas publicadas destaca la necesidad de este estudio, que busca evaluar la sensibilidad y especificidad de patrones dolorosos palpatorios en la tibia. **Materiales y Métodos:** Se presenta una serie de 19 pacientes con 31 cuadros dolorosos en la pierna, entre 2012 y 2014. Se incluyó a pacientes con dolor tibial durante el entrenamiento militar, y se excluyó a aquellos con antecedentes traumáticos. Se realizó un examen físico y se registraron los puntos dolorosos tibiales en una grilla con 9 zonas, estableciendo 3 patrones: vertical, transversal y único. A todos se les realizaron radiografías y centellografía. **Resultados:** El 63% eran mujeres y el 36,8%, hombres. Se identificaron 31 lesiones (64,5% en mujeres y 35,5% en hombres). Las radiografías fueron negativas, mientras que la centellografía mostró 22 (71%) fracturas por estrés y 9 (29%) periostitis. Los patrones transversal y único fueron los más sensibles (40,91%). El 29% de los casos tenía un patrón único, siempre asociado a fracturas. **Conclusiones:** El dolor puntual palpatorio como signo clínico estuvo asociado, en todos los casos, a fracturas por estrés, lo que demuestra su alta especificidad. Se destaca la importancia de este hallazgo en la evaluación diagnóstica de las fracturas por estrés.

Palabras clave: Fracturas por estrés; semiología; fracturas de tibia; estrés tibial.

Nivel de Evidencia: IIIB

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INTRODUCTION

Stress fracture, also known as fatigue or overuse fracture, was first described by Breithaupt[1] in 1855. Although rare, its prevalence has increased with the growth of impact sports and the intensification of training. These fractures typically occur in individuals who engage in or initiate high-impact activities without gradual progression or under inadequate conditions.

In the military field, stress fractures have a high incidence among newly recruited personnel,[1,2] often leading to prolonged periods of inactivity. The available literature indicates that physical maneuvers for diagnostic presumption are inconsistent and imprecise.

The aim of this study was to evaluate the sensitivity and specificity of palpatory pain patterns in the clinical diagnosis of stress fractures.

MATERIALS AND METHODS

This study presents a series of patients evaluated for painful leg syndromes at the health section of a recruitment center of the Argentine Army between February 2012 and December 2014. The sample consisted of 19 patients presenting with 31 episodes of acute leg pain.

The inclusion criteria were: patients in military service experiencing acute tibial pain, assessed in the health section. All underwent the same training regimen and were evaluated by the same specialist in Orthopedics and Traumatology. The exclusion criteria included any history of trauma, with or without clear signs of fracture on radiographic examination.

All patients underwent a thorough physical examination following this methodology: a complete anamnesis, evaluation of footwear, and assessment of associated lower limb deformities. Patients were asked to indicate the exact location of their pain, and a targeted palpation of the tibia was performed, documenting pain areas using a grid system consisting of three transverse and three vertical regions, establishing nine zones for pain localization (Figure 1).

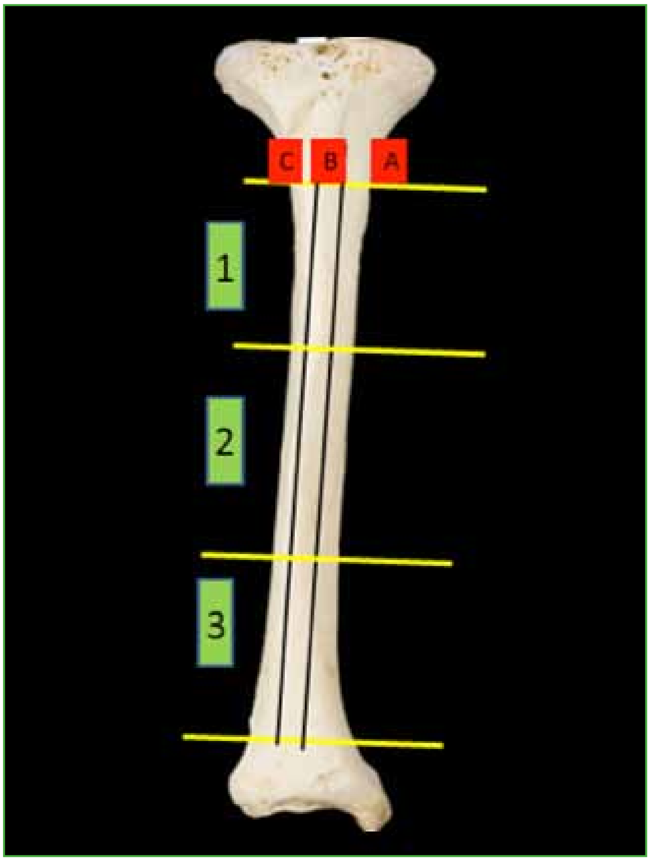

Figure 1. Grid used to locate areas and patterns of pain in the affected tibia.

The distribution of pain areas was analyzed, identifying three predominant patterns: vertical, transverse, and single (Figure 2). The transverse pattern was defined as pain affecting two or three contiguous zones in the horizontal plane. The vertical pattern was defined as pain affecting two or three zones in any of the grid columns. The single pattern was defined as pain localized to a single zone within the grid.

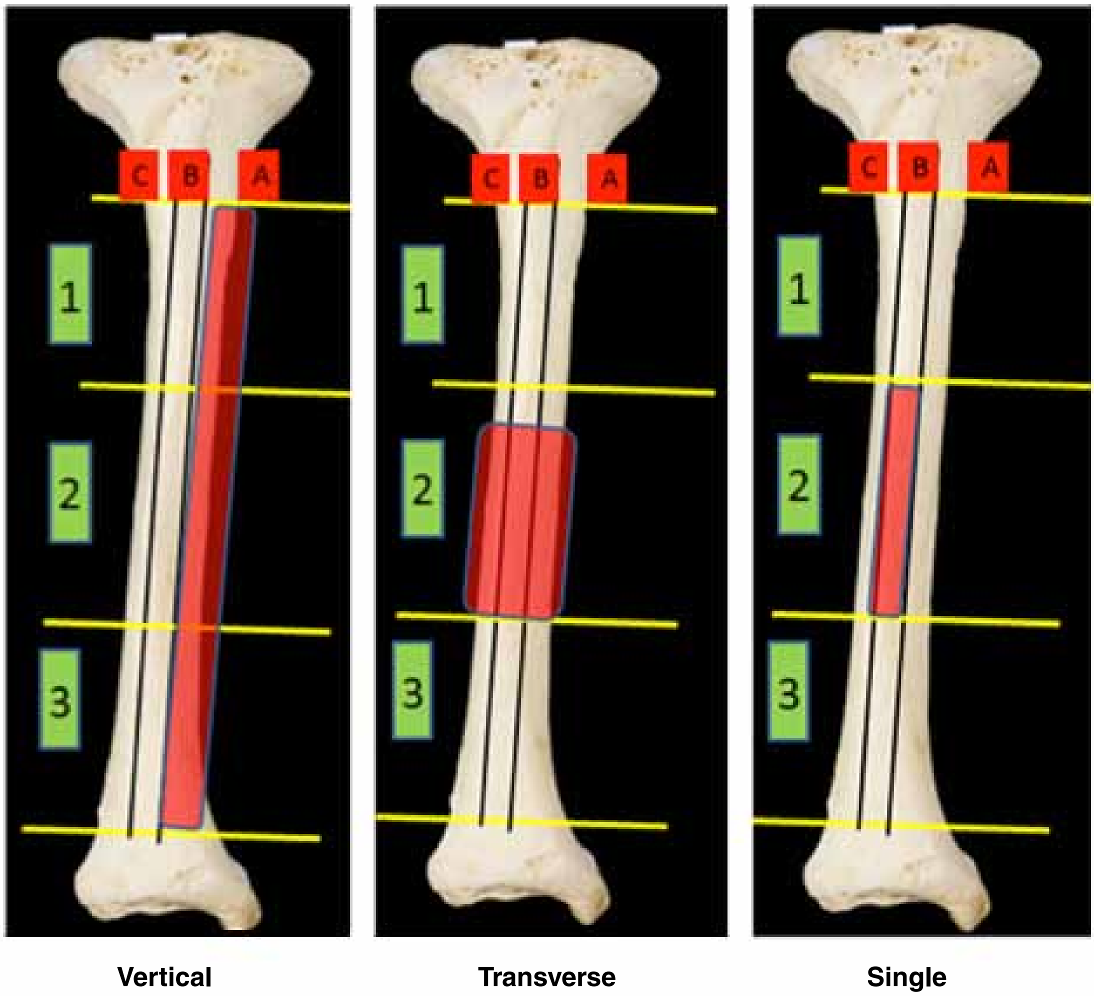

Figure 2. Pain patterns according to patient symptoms.

Initial complementary imaging included anteroposterior and lateral radiographs of the leg. Once other conditions, such as fractures or tumor lesions, were ruled out, a bone scintigraphy with Tc-99 was performed to confirm the diagnosis. The results were documented and later analyzed statistically, both manually and using the OpenEpi program. IRB approval was obtained for this study.

RESULTS

Twelve (63%) patients were female, and seven (36.8%) were male. A total of 31 lesions were identified: 20 (64.5%) in women and 11 (35.5%) in men. Pain was detected in 16 (51.6%) left legs and 15 (48.4%) right legs. All initial radiographic studies were negative. Diagnosis was confirmed by scintigraphy, identifying 22 (71%) cases of stress fractures and 9 (29%) cases of periostitis. Among the stress fracture cases, 63.8% were bilateral, while 80% of the periostitis cases also affected both legs.

Sensitivity

The transverse and single patterns were the most sensitive, with a sensitivity of 40.91% (95% confidence interval [95% CI]: 23.26–61.27). When considering only focal tenderness to palpation, sensitivity was 100%, as all patients tested positive for this maneuver, with no false-negative results.

When analyzing the test across all patterns, the diagnostic sensitivity was 70%, indicating that at least 7 out of 10 patients with tibial stress fractures would test positive in the physical maneuver (Table, Figure 3).

Table. Positive predictive value (PPV) of sensitivity, specificity and negative predictive value (NPV) according to pain pattern.

Pattern	Sensitivity	95%CI	Specificity	95%CI	PPV	95%CI	NPV	95%CI	Test accuracy	95%CI
Single	40.91	23.26-61.27	100	70-100	100	70-100	40.91	23.26-61.27	58.06	40.77-73.58
Transverse	40.91	23.26-61.28	33.33	12.01-64.68	60	35.75-80.18	18.65	6.59-43.01	38.64	23.73-56.18
Vertical	18.18	7.31-38.52	66.67	35.42-87.94	57.14	05.25-84.18	25	12-44.9	32.26	18.57-49.86

95%CI = 95% confidence interval.

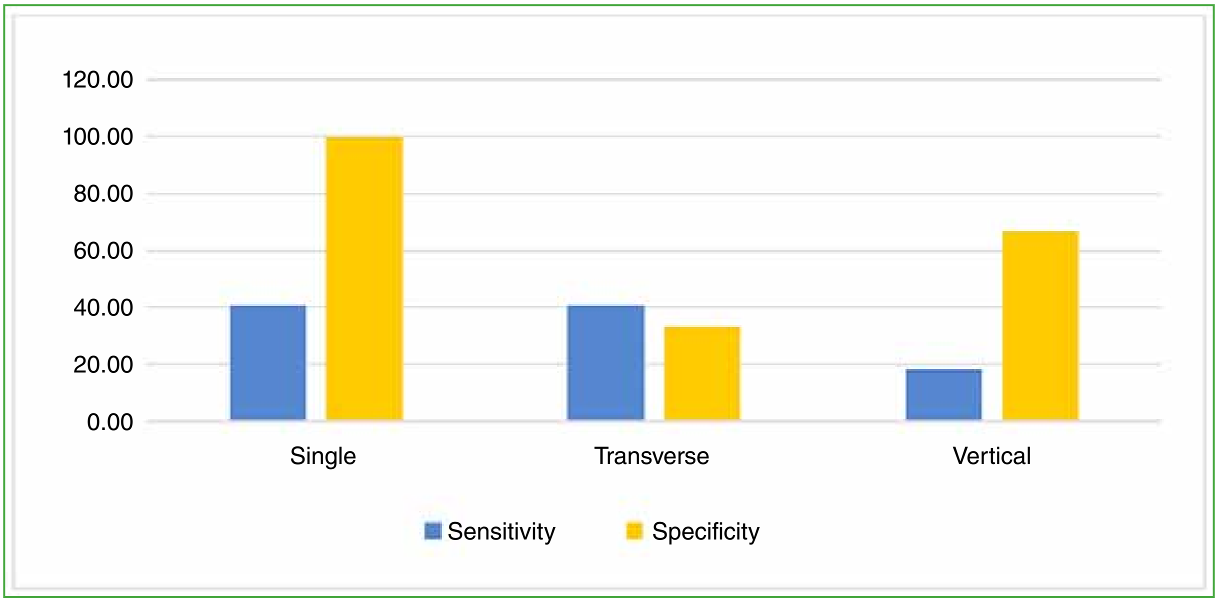

Figure 3. Comparison of sensitivity and specificity according to pain pattern.

Specificity

The single pattern was the most specific for stress fractures, with a specificity of 100% (95% CI: 70–100), as all patients exhibiting this pattern had stress fractures. The vertical pattern had a specificity of 66.67% (95% CI: 35.42–87.94), while the transverse pattern had a specificity of 33.33% (95% CI: 12.01–64.68).

This implies that the probability of a stress fracture in a patient with a negative test for the single pattern (i.e., no pain on palpation or compression in any part of the tibia) is close to 0%. However, a negative result in the other patterns does not rule out the condition; to definitively exclude a stress fracture, all patterns must yield negative results (Table, Figure 3).

Positive Predictive Value (PPV) and Negative Predictive Value (NPV)

The single pattern had a PPV of 100% (95% CI: 70–100) and an NPV of 40.91% (95% CI: 23.26–61.27), indicating that it is a strong predictor for diagnosing stress fractures. However, its absence does not provide a high degree of certainty that the patient does not have the condition.

The remaining patterns had PPVs close to 60%, with an overall PPV for the maneuver of 70.97% (95% CI: 53.41–83.9), representing a high predictive value (Table, Figure 4).

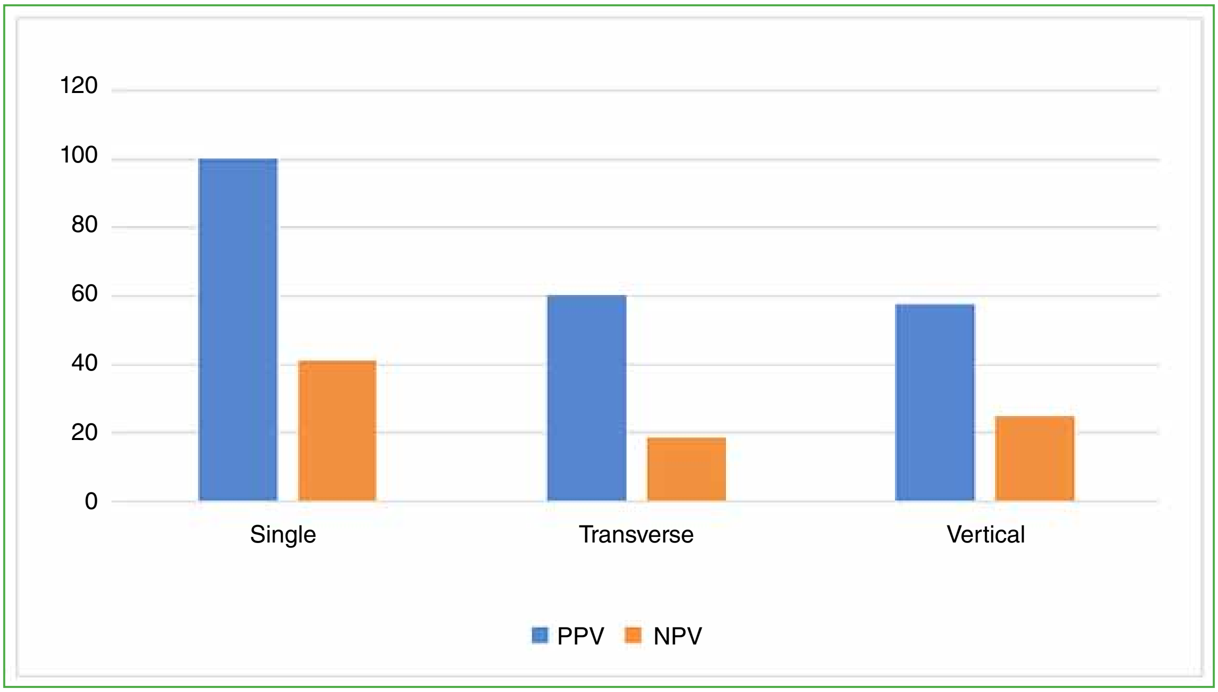

Figure 4. Positive and negative predictive values according to pain pattern.

Pattern Distribution

Seven cases (22.6%) presented with a vertical pain pattern, associated with 4 (12.9%) stress fractures and 3 (9.7%) periostitis cases confirmed by scintigraphy. Fifteen cases (48.4%) exhibited a transverse pain pattern, associated with 9 (29%) stress fractures and 6 (19.35%) periostitis cases. The single, focal palpatory pain pattern was found in 9 (29%) cases, always associated with stress fractures (Figure 5).

None of the periostitis cases confirmed by scintigraphy were associated with focal pain in a specific area of the grid or "one-finger pain."

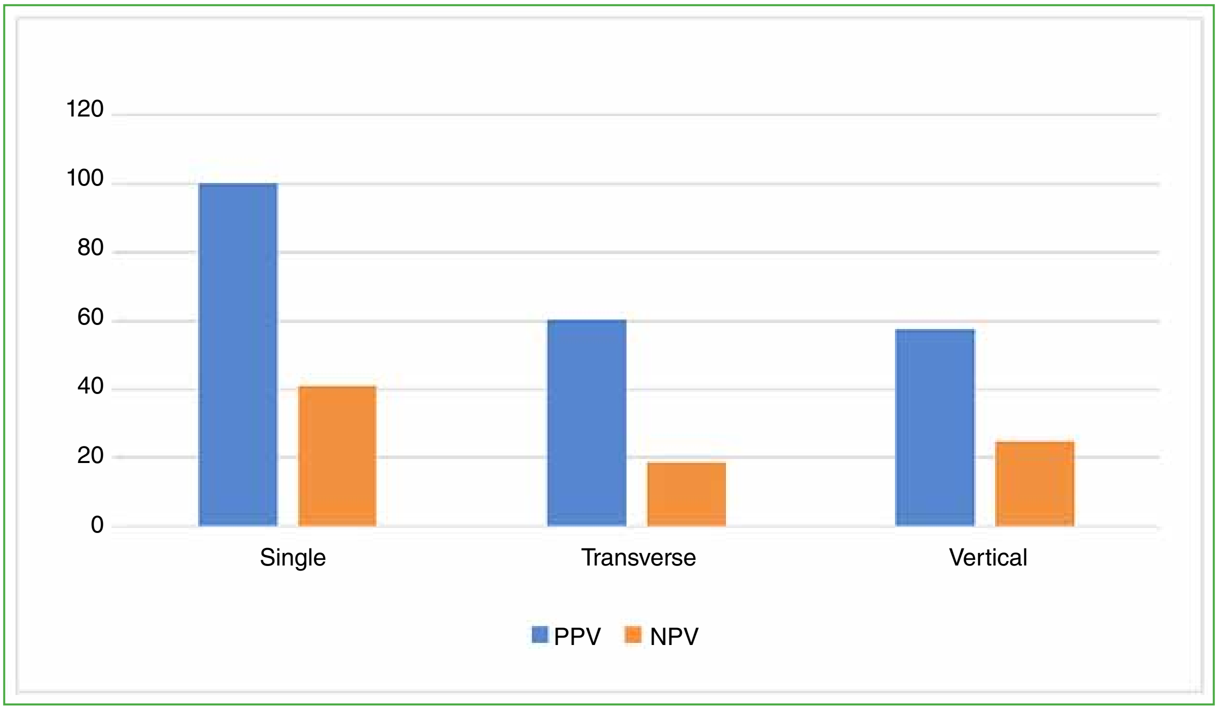

Figure 5. Number of patients according to pattern and condition.

DISCUSSION

It is well known that running promotes good health,[3] but under certain circumstances, it can predispose individuals to injuries,[3] particularly when running more than 65 km per week,[4] training on inadequate surfaces or footwear,[3,5,6] or abruptly increasing the intensity of training.

Leg pain syndromes are among these issues. The differential diagnoses of these conditions include tibial periostitis, stress fractures, painful myotendinous insertion syndromes, and chronic exertional compartment syndrome, among the most common.[4]

There are very few published studies on the clinical presentation of stress fractures, and those available are not highly specific. In general, they report only pain localized to the anteromedial aspect of the tibia.[7,8]

Periostitis is the most challenging condition to differentiate from stress fractures, as both share a sudden onset triggered by high-impact activities or sustained physical exertion over time, without a history of trauma. The underlying cause of periostitis is abnormal traction of the flexor digitorum longus and soleus muscles, which generates excessive stress on the medial tibial cortex. In contrast, stress fractures result from repetitive overload on bone tissue, surpassing its regenerative capacity. Cancellous bone is typically the first to be affected.[3] According to the literature, stress fractures are significantly more prevalent in females, with a reported 2:1 female-to-male ratio,[9,10] a finding that aligns with our study results.

Diagnosis

The diagnosis is initially clinical. The most common reason for consultation is nonspecific pain in the anterointernal aspect of the tibia. If the patient does not rest or continues engaging in high-impact activities, the symptoms progress. Initially, the pain is felt at the end of physical activity, but as the condition worsens, it persists throughout the activity and, in severe cases, continues even at rest.

Additionally, hormonal disorders, sleep deprivation, psychological stress, vitamin D deficiency,[11] and associated limb disease should be investigated, as they are linked to a higher incidence of stress fractures in recruits.[10] Progressive weight loss during training, with a decrease in tibial mineral mass but no loss in other locations, is considered another predisposing factor.[12]

Physical Examination

Currently, there are few descriptions of physical examination maneuvers for this condition and limited data on their validity. Different authors mention that pain, edema, or erythema may be present in the affected area.[3,7] Milgrom et al. base the differential diagnosis on palpation of the medial border of the tibia, establishing that pain localized within a longitudinal strip no greater than one-third of the tibia's length is suggestive of a stress fracture.[13] Thus, the presumptive diagnosis is based on physical examination and clinical history.[2,13]

Devas[14] describes edema (present in 16–44% of patients) and pain on ambulation (reported in 81% of patients) as signs of a stress fracture. All patients in our study experienced pain upon impact.

It is important to note that some authors consider localized pain a pathognomonic sign of stress fractures.[7,15-17] Their studies report that 65–100% of patients experienced pain, a finding that aligns with our results. However, these studies do not specify how the patient or examiner localizes the pain, nor do they evaluate the diagnostic value of this sign.

Authors such as Harrast et al. describe the "single hop test" as a diagnostic tool,[3] while Milgrom et al. combine it with the "fulcrum test," which elicits pain by applying tension to the affected bone surface.[13] However, these authors do not mention other maneuvers or signs, such as those assessed in our study. They do emphasize the importance of evaluating intrinsic predisposing factors, such as lower limb imbalances and muscle shortening.

Complementary Studies

The first step is always to request radiographs of the leg, including anteroposterior and lateral views, to rule out differential diagnoses such as fractures or tumors. However, stress fractures typically do not show radiographic findings until the tenth week.[15]

Once other conditions have been excluded, additional imaging studies with greater sensitivity and specificity should be performed to diagnose stress fractures. The most sensitive and specific modality is MRI (100% sensitivity and 85% specificity), compared to scintigraphy, which has a sensitivity of 74–100% but lower specificity. Despite this, both MRI and scintigraphy provide high diagnostic accuracy when combined with clinical examination.

MRI is preferable due to its higher sensitivity, its ability to differentiate stress fractures from other conditions, and its capacity to detect small or asymptomatic lesions.[8]

Tc-99 scintigraphy shows localized hyperenhancement in all three phases. During healing, the first phase normalizes first, but the later phases may take longer, making this modality unsuitable for monitoring disease progression. Scintigraphy should be used when a stress fracture is suspected, but it cannot reliably distinguish between a fracture and other conditions, such as infection or neoplasia.

Early recognition of a stress fracture should prompt evaluation of the contralateral limb, even if asymptomatic. Milgrom et al. reported that 60% of patients with a diagnosed stress fracture had asymptomatic contralateral fractures, suggesting that scintigraphy should be performed even in cases with positive radiographic findings to assess bilaterality.[18]

In our study, 63.8% of stress fractures were bilateral. However, unlike Milgrom et al.'s findings,[18] our patients were symptomatic. Additionally, 80% of cases of periostitis were bilateral.

CONCLUSIONS

Stress fractures and tibial periostitis often present with similar symptoms, and patient history frequently provides overlapping information, making differential diagnosis challenging. However, focal tenderness to palpation was consistently a specific clinical sign associated with stress fractures.

In our study, this clinical sign and the proposed palpation maneuver demonstrated high sensitivity and specificity. While a positive maneuver strongly indicates the presence of a stress fracture, we recommend confirming the diagnosis with MRI or bone scintigraphy for greater precision.

No published studies were found that evaluated both the sensitivity and specificity of commonly used physical maneuvers. A limitation of this study is the small sample size. We believe that further comparative, prospective, and randomized studies are necessary to confirm our findings and enhance the diagnostic accuracy of these conditions.

Conflict of interest: The authors declare no conflicts of interest.

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