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Not all bone overuse injuries are stress fractures: it is time for updated terminology

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Mention 'stress fracture' to an athlete or coach and there is instant concern. Frequently occurring at the beginning of an athletic season or in the lead up to a major competition, there is awareness that diagnosis invariably disrupts participation. The term 'stress fracture' has deep roots in our vernacular. Its use in the literature has risen steadily since the 1970s/80s and shows no sign of waning. But are we all talking about the same thing, and does it matter?

Most bone stress injuries are not stress fractures

Stress fractures are a type of 'bone stress injury' (BSI).[1] A BSI represents the inability of a generally normal bone to withstand repetitive loading leading to localized bone weakness and pain. A history of repetitive loading distinguishes BSIs from insufficiency-type injuries occurring with aging and disease, although some athletes share a similar phenotype of compromised general bone health.

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Stress fractures are characterized by a discernible fracture line on imaging. Only 1-in-5 athletes presenting with a BSI have a stress fracture.[2] The other 80% have stress reactions, evident by altered signal intensity within the marrow, endosteum, and/or periosteum on magnetic resonance (MR) imaging[3–5]—the gold standard modality for imaging BSIs.[6]

Bone stress injuries can be graded

Stress reactions and stress fractures are diagnostically discrete. Are they also discrete pathologies? There remains limited supportive evidence of a pathology continuum from stress reaction to stress fracture, with some stress fractures not being proceeded or coupled with stress reaction changes.[7] Nevertheless, with widening availability of MR imaging and the use of newer imaging sequences, it is possible to grade BSIs.

Fredericson and colleagues[3] proposed an MR imaging-based grading system initially for tibial BSIs, and complementary grading classifications for BSIs at other anatomical locations have been reported (Table 1).[4 5] The MR imaging grading scales are mostly based on a system of grades 1 to 4, with a higher number representing a more severe injury. For most classification systems, the first three grades are considered stress reactions. When there is a visible fracture line, the injury is typically classified as a Grade 4 BSI and considered a true stress fracture. [4 5]

Grading bone stress injuries may be prognostic

BSI grading better communicates potential severity and may be used to predict return-to-sports. In a recent systematic review and meta-analysis, return-to-sport following grade 1, 2, 3, and 4 BSIs took an average (95% confidence interval) of 41.7 (30.6–52.9), 70.1 (46.9–93.3), 84.3 (59.6–109.1), and 98.5 (85.5–112.6) days, respectively.[2] These observations indicate that ‘stress fracture’ as a blanket term to describe all BSIs can incorrectly imply a prolonged absence from activity. Recovery is indeed longer for true stress fractures (grade 4 BSI); however, lower grade BSIs recover more rapidly. Similarly, the data indicate that use of the term ‘stress reaction’ without a BSI grade is also not prognostic as not all stress reactions are equal.

Important caveats to current data describing BSI prognosis from imaging-based grading scales include treating personnel not being blind to imaging findings and a lack of consensus on a single grading scale. Knowledge of imaging findings potentially biases management and return-to-sport decisions. There is a need to execute prospective studies whereby BSIs at low risk of healing complications (e.g., BSI of the posteromedial tibial diaphysis) are clinically managed and return-to-sport determined without prior knowledge of imaging findings. Similarly, there is a need to unify grading scales via further investigation and/or international consensus.

Location contributes to prognosis

Imaging-based grading may assist in predicting recovery time, but consideration also needs to be given to BSI location. Some BSIs occur at locations prone to healing delays, non-union, and/or complete fracture. Example locations include the anterior cortex of the tibia,

neck of femur, and tarsal navicular, to name a few. BSIs at these locations require a more cautious management approach (which may include surgical fixation) and often an extended return-to-sport time beyond predicted by imaging-grade alone. BSI prognosis and return-to-sport may also be influenced by factors such as age and components of relative energy deficiency in sport (RED-s).[8] The impact of the later factors on BSI prognosis remain understudied.

Recommendations

1. The term 'bone stress injury' should be used to describe all clinically diagnosed overuse injuries to bone
2. If imaging is performed, the BSI should be assigned a grade to better communicate the degree of injury and preliminarily guide return-to-sport expectations
3. For the commonly adopted grading scales (Table 1), grade 1, 2 or 3 BSIs may be secondarily referred to as 'stress reactions' with 'stress fracture' secondarily used to describe grade 4 BSIs
4. Further investigation and/or international consensus is needed to assess the superiority of a particular grading classification scale and/or to unify the scales
5. Return-to-sport expectations based on imaging grade should also consider BSI location and other potential modulating factors (e.g., presence of RED-S)

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Table 1.

Nomenclature and commonly-used magnetic resonance (MR) imaging-based grading scales

Recommended nomenclature	Historical nomenclature	Commonly-used MR imaging-based grading scales		
		Fredericson et al.[3]	Arendt et al.[4]	Nattiv et al.[5]
Grade 1 BSI	Stress reaction	Mild-to-moderate periosteal edema on fat-suppressed T2WI; normal marrow on T1WI and T2WI	STIR positive	Mild marrow or periosteal edema on fat-suppressed T2WI; T1WI normal
Grade 2 BSI	Stress reaction	Moderate-to-severe periosteal edema on T2WI; marrow edema on T2WI	STIR positive; T2WI positive	Moderate marrow or periosteal edema and T2WI positive; T1WI normal
Grade 3 BSI	Stress reaction	Moderate-to-severe periosteal edema on T2WI; marrow edema on T1WI and T2WI	STIR positive; positive T1WI and T2WI	Severe marrow or periosteal edema on T1WI and T2WI
Grade 4 BSI	Stress fracture	Moderate-to-severe edema on T2WI; marrow edema on T1WI and T2WI; visible fracture line	Visible fracture line on T1WI or T2WI	Severe marrow or periosteal edema on T2WI and T1WI; visible fracture line on T1WI or T2WI

STIR = short tau inversion recovery; T1WI = T1 weighted image; T2WI = T2 weighted image