STRESS FRACTURE TREATMENT

A protocol for treatment of stress fractures derived from the Israeli Defense Forces Medical Corps is presented. The protocol selects treatment on the basis of extent of stress fracture microdamage, stage of healing, and the bone involved. These factors can be assessed with physical examination, radiographs, and bone scintigraphy.

Nous présentons un protocole de traitement des fractures de fatigue utilisé par le corps médical des Forces de Défense Israéliennes. Le choix du traitement repose sur l’extension des micro-lésions de la fracture de fatigue, le stade de consolidation et l’os concerné. Ces éléments peuvent être déterminés par l’examen clinique, les radiographies et la scintigraphie osseuse.

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ABSTRACT

Se presenta un protocolo para el tratamiento de las fracturas de estres, procedente de los Servicios Médicos de las Fuerzas de Defensa Israelíes. El protocolo selecciona el tratamiento en base a la extensión del daño microscópico de la fractura de estres, estadio de la cicatrización, y el hueso afectado. Estos factores pueden ser valorados mediante la exploración, radiografías y escintografía ossea.

Translated by Antonio Saez, MD

Viene presentato un protocollo di trattamento delle fratture da durata sviluppato all’Ospedale “Israeli Defense Forces Medical Corps.” Il protocollo seleziona il tipo di trattamento sulla base dell’entità dei microtraumi, della fase di guarigione, del tipo di segmento osseo colpito dalla frattura da durata. Questi fattori possono essere inquadrati con la valutazione clinica, radiografica e scintigrafica.

Translated by Pier Giorgio Marchetti, MD

イスラエル防衛医療隊で作成された、疲労骨折治療のためのプロトコールを紹介する。このプロトコールでは、範囲疲労骨折の微細損傷、治癒のステージ、罹患した骨のちがいによって治療を選択する。これらのが要因は理学検査、x線、骨シンチグラフィーによって評価することができる。

Translated by Katsuji Shimizu, MD
Since the first description of a stress fracture more than 100 years ago in the Prussian Army, only a few works have appeared that discuss treatment of stress fractures. Published treatment protocols usually consist of little more than a brief paragraph in articles whose main focus is something other than stress fracture treatment.

The principles of stress fracture treatment should be to achieve healing in the shortest possible time, using a rest regimen that limits activities that can result in exacerbation of stress fracture or inhibit healing, while allowing nonharmful activities that can help preserve the fitness of the trainee. To achieve this, stress fractures must be considered individually according to the bone involved, the anatomic area within the involved bone, and the extent of the stress fracture.

The Israeli Army has been described as a virtual laboratory for the study of stress fractures. Both the documented high incidence of stress fractures among Israeli infantry recruits and the unique relationship among the medical corps, the academic community, and the soldiers make the Israeli infantry recruit an ideal model for studying stress fractures. As a response to the stress fracture problem within the Israeli Army, a stress fracture treatment protocol was developed. This treatment protocol has been used successfully to treat many hundreds of soldiers during the past 5 years. The treatment protocol as modified for athletic trainees is present here.

The hallmark of the Israeli stress fracture treatment protocol is early detection. This is accomplished by educating trainees, medics, and staff about the pathophysiology and presenting symptoms of stress fractures. Trainees with symptoms consistent with stress fractures have rapid access to the medical staff. Physicians are trained to perform a comprehensive stress fracture examination. After taking a history, the physician not only palpates the anatomic site(s) stated to be symptomatic by the trainee, but in addition routinely palpates the entire lengths of the tibiae, femora, and metatarsals for tenderness. The femora, being well padded, are palpated by the “fist test.”

Trainees with clinical suspicion of stress fracture are evaluated by radiographs, technetium-99m MDP scintigraphy, or both. Areas of increased scintigraphic uptake are graded according to a 1–4 system, based on the size and intensity of the scintigraphic foci. Diagnosis and treatment are according to separate protocols for metatarsal (Fig 1), tibial (Fig 2), and femoral (Fig 3) stress fractures. Femoral neck stress fractures are not treated by the protocol and these patients are referred to the hospital. Asymptomatic stress fractures are seen primarily in the femur and are diagnosed on the basis of a bone scan done to evaluate a clinical suspicion of stress fracture at other anatomical sites. Asymptomatic stress fractures are treated according to the protocol.

Discussion

Stress fractures are considered to arise from cyclical overuse of the bone. This overuse may be secondary to high strains, high repetition of strains, or loads inappropriate to the bone's geometry or quality. The strains that occur during normal or exertional activity in the most
common human stress fracture sites—the metatarsals, tibiae, and femora—are not known. For several animal species the strains during peak physical activity have been measured and found to be in the range of 1200 to 1500 microstrains (0.12% to 0.15%) in tension and 2000 to 3000 microstrains (0.2% to 0.3%) in compression.6 At these peak habitual strains, Schaffler et al7,8 have shown that bone sustains microscopic fatigue damage quite readily and early in its loading history, though this damage does not progress to fatigue fracture after more than one million cycles of continuous loading.

How does a stress fracture occur? One possibility is that the bone experiences brief periods of higher strains. With cyclic loading at strains approximately double to triple those measured in habitual vigorous activity, the bone fatigue very rapidly to failure. Carter et al9 showed that bone may fail within 1000 to 10000 loading cycles at strain ranges of 5000 to 10000 microstrains. The extent and frequency with which bone is loaded at “supraphysiological” strains is unknown. However, Nunamaker et al10 have shown that peak compressive strain in some young racehorses can exceed 5000 microstrains; well above the threshold for rapid progression of fatigue in bone. The reported high incidences of both third metacarpal stress fractures in young North American thoroughbred racehorses (70%)10 and stress fractures among Israeli infantry recruits (24% to 31%)11 may reflect the generation of high strains in their training.

The strain magnitude and number of loading cycles during training are not the only factors important in the etiology of stress fractures in bone. The bone’s strength as reflected in its structural geometry and resistance to bending (area moment of inertia) and torsion (polar moment of inertia) have been identified as being important.11 These two factors are proportional to the radius to the fourth power (r⁴) of bone and account for the fact that an increase of bone radius from 12 mm to 14.5 mm more than doubles the bone’s bending and torsional strength. Other factors that may be important are bone quality and local bone resorption caused by the loading of training. Burr et al12 have shown that a small amount of microdamage caused early in fatigue loading at moderate, habitual strains stimulates a burst of remodeling and repair activities in the bone. These reactive processes alter local bone quality; superimposing these qualitative changes on the loading conditions adds to the stress fracture response.

The Israeli stress fracture treatment protocol is designed to allow the affected bone to heal sufficiently and the trainee to return to full activity. This is accomplished by lowering the magnitude and repetition of strains on the stress fracture area. As such it recognizes different treatment regimens according to the specific bone involved and an estimate of the amount of bone weakening caused by the stress fracture.

Roub et al13 first introduced the concept of bone’s response to stress as a continuum. The continuum ranges from initial microcracking, to reactive bone resorption, to coalescence of microcracks into microfracture, to extension of microfractures to macrofracture. Complete fracture (macrostress fracture) is the least frequently encountered manifestation of the continuum process of stress fracture. Repair and reaction depending on loading circumstances may potentially occur at any point in this damage continuum. Bone scintigraphy is considered to mirror these responses and can detect microdamage and associated biological reaction before it progresses to macrodamage, the stage at which stress fractures are detectable on radiographs. The size and intensity of the scintigraphic focus in a suspected stress fracture is taken to repre-

Fig 2: Israeli stress fracture treatment protocol: tibia.
Fig 3: Israeli stress fracture treatment protocol: femur. 

Although it cannot be stated with certainty that a specific scintigraphic focus represents a known amount of microcracks, bone reabsorption, microfracture, or macrofracture, the severity of the lesion increases with increased grade of the scintigraphic focus. Zwas et al² found that 100% of Grade 4 but only 21% of Grade 1 scintigraphic stress fracture foci had radiographic evidence of stress fracture. It should be emphasized that local reabsorption, microfracture, and macrostress fracture all represent local weakening of the bone and require treatment, although not of the same magnitude. Therefore, according to the stress fracture protocol, the higher the grade of the scintigraphic focus, generally, the more rest required for healing.

The stress fracture treatment protocol also recognizes the importance of radiographs in assessing the extent of bone damage and the stage of healing. A positive radiograph for stress fracture implies the presence of a macrostress fracture rather than a microstress fracture. If the area already is buttressed by mature callus, then no treatment is required; on the other hand, if no callus is present, rest must be given until sufficient callus is present. A normal radiograph in the presence of a Grade 1-4 scintigraphic focus should not be taken to mean there is no microdamage present. It only means the amount of damage (ie, microdamage) is below the threshold that the radiographic technique can detect.

The quantity but not the quality of the rest to be given in treating any specific stress fracture is given by the protocol. The quality of the rest to be prescribed depends on the estimation of how much the bone has been weakened. A stress fracture with an unbuttressed cortical break may require near total rest, whereas a Grade 2 tibial focus, in which the stress fracture is at its microdamage and remodeling reactive phase of evolution, requires only refraining from activities that can produce high strains or high repetitive strains on the stress fracture site to allow intrinsic processes to enact their repair.

The Israeli stress fracture treatment protocol was designed to serve as a guideline for initial diagnosis and treatment of stress fractures. For the majority of recruits it suffices as their only treatment. Stress fracture patients, however, are no different from fracture patients in that some may require less and some more than the average treatment regimen. Trainees should therefore be monitored during their return to activity. The key to the stress fracture protocol is early detection and treatment while the microdamage is still small and healing can occur with relatively brief periods of rest.

REFERENCES

9. Carter DR, Caler WE, Spengler DM, Frankel VH.


