Medial tibial stress syndromes chez le coureur

Dr Prist Vincent
Médecine Physique et Réadaptation
VIVALIA - Libramont
Definition:

- Medial tibial stress syndrome (MTSS) is an overuse injury or repetitive-stress injury of the shin area.

(A) Anterior and medial views of the tibia with the main features shown, with the larger insert demonstrating the deep fascial attachments.

Classification

Three types exist and may coexist:

Type I
- tibial microfracture, bone stress reaction or cortical fracture

Type II
- periostalgia from chronic avulsion of the periosteum at the periosteal-fascial junction

Type III
- chronic compartment syndrome syndrome

Fractures de stress du tibia et des métatarsiens chez le coureur
Plan

- Definitions
- Etiology and Pathophysiology
- Epidemiology
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Definitions:

- **Stress fracture**
  A stress fracture occurs when a bone breaks after being subjected to repeated tensile or compressive stresses, none of which would be large enough individually to cause the bone to fail.

From an etiologic standpoint, two types of stress fractures are encountered: fatigue fractures and insufficiency fractures.

- **Fatigue fracture**
  A fatigue fracture is caused by the application of abnormal muscular stress or torque to a bone that has normal elastic resistance.


- **Insufficiency fracture**
  An insufficiency fracture occurs when the mechanical strength of a bone is reduced to the point that a stress, which would not fracture a healthy bone, breaks the weak one.
  The condition that causes reduced bone strength typically does so throughout the skeleton (eg, osteoporosis, osteomalacia, or osteogenesis imperfecta), but may be more localized (eg, demineralization in a limb due to disuse).

  Pentecost AL, Murray RA, Brindley HH. Fatigue, insufficiency, and pathologic fractures. JAMA 1964;187:1001-1004
Etiology and Pathophysiology: Wollf’s law

- In most activities of daily living, when the force is removed, the bone elastically rebounds to its original position.
- The force that a bone can endure and still rebound back to its original state without damage is within the elastic range. (A1 to A2)
- Forces that exceed a critical level above the elastic range are in the plastic range. (B)
- Once forces reach the plastic range, a lower load causes greater deformation, permanent deformity occurs as the result of microfractures within the bone (C); it is at this level that forces summate to permanently damage the bone. (D)

Etiology and Pathophysiology:

Two competing, but not mutually exclusive, theories may explain the development of stress fractures

- **Remodeling theory** holds that during the initial increase in exercise activity, the skeleton experiences repetitive loading in its role of providing internal support to counteract the force of gravity and in forming levers for motion.

  - This damage is a natural phenomenon and is typically of little consequence as bone is capable of self-repair through targeted remodelling.

  - Determinants of damage formation in bone include the magnitude and rate of introduction of applied loads, and the absolute number of loading cycles.

  - Damage is threshold related, such that strain magnitudes above a certain level result in its formation. Influencing the damage formation is the rate at which the strain is introduced.

  - Strains that are introduced over shorter periods result in considerably greater damage formation.

  - The interaction between strain magnitude and rate ultimately reduces the number of loading cycles a bone can withstand before fatigue failure.

  - During this initial increase in exercise activity period, osteoblastic activity lags behind osteoclastic activity by a few weeks, resulting in a period during which bone is more susceptible to accumulate damages.
Etiology and Pathophysiology:
Two competing, but not mutually exclusive, theories may explain the development of stress fractures

- **Muscular imbalance theory** emphasizes bone as a dynamic architectural substance that responds to changes in the muscular activity imposed on it.

  - Increased muscular activity results in an increase in the strength of both muscles and bone. Conversely, a decrease in activity or muscular atrophy results in muscular and bony atrophy.

  - Under normal circumstances, the muscles tone up at a faster rate than the bones do.

  - Strong and repetitive stress on bone at the insertion point of muscles may provoke focal bending stresses beyond the ability of the bone to tolerate.

  - **Fatigue of opposing** muscle groups that usually prevent one group of muscles from having an overexerting effect on the bone may result in a further imbalance and lead to bone failure.
Etiology and Pathophysiology:

- **Additional factors** contribute to the increased muscular pull, producing **overload on stressed bones**
  - Poor posture, typically causes a **change in the center of gravity** for which the body compensates. This increases the effect of direct muscular pull and also leads to fatigue of opposing muscle groups.
  - The **operating conditions** in which the activity is practiced.
    - To a runner, changes in **terrain**, running **surface**, or **equipment** can cause a change or an increase in muscular pull on the bones of the leg.
    - Changing from a grass surface to a hard surface may lead to protective curling of the feet to cushion the footfall.
    - Running up or down a **hill** increases the forces by a factor of seven.

Etiology and Pathophysiology:

Example of crack initiation in bone

Epidemiology: most common locations for stress fractures

- tibia: 23.6%
- navicular: 17.6%
- metatarsal: 16.2%
- fibula: 15.5%
- femur: 6.6%
- pelvis: 1.6%
- spine: 0.6%
<table>
<thead>
<tr>
<th>Intrinsic Risk Factors</th>
<th>Modifiability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low BMD</td>
<td>potentially modifiable</td>
</tr>
<tr>
<td>Low bone turnover rate</td>
<td>unmodifiable</td>
</tr>
<tr>
<td>Decreased thickness of cortical bone</td>
<td>potentially modifiable</td>
</tr>
<tr>
<td>Lower limb malalignment</td>
<td>potentially modifiable</td>
</tr>
<tr>
<td>Foot structure</td>
<td>potentially modifiable</td>
</tr>
<tr>
<td>Height - Tall stature</td>
<td>unmodifiable</td>
</tr>
<tr>
<td>Muscle fatigue/poor overall conditioning</td>
<td>modifiable</td>
</tr>
<tr>
<td>Weakness/strength imbalance</td>
<td>modifiable</td>
</tr>
<tr>
<td>Pathologic bone states</td>
<td>potentially unmodifiable</td>
</tr>
<tr>
<td>Menstrual/hormonal irregularities</td>
<td>potentially modifiable</td>
</tr>
<tr>
<td>Genetic predisposition</td>
<td>unmodifiable</td>
</tr>
<tr>
<td><strong>Previous stress fracture</strong> - approximately 60% of persons</td>
<td>unmodifiable</td>
</tr>
</tbody>
</table>
Epidemiology: Extrinsic Risk Factors

- Excessive volume or intensity of training
- Sporting discipline
- Change in training regimen - "New coach" phenomenon
- Rapid increase in physical training program
- Excessive physical activity with limited rest periods
- Poor preparticipation physical condition
- Change in training surface: irregular or angled surfaces
- Change in density or topography in training surface
- Worn-out training shoes
- Inappropriate footwear
- Cigarette smoking
- Inadequate nutrition including dieting, calcium, vitamin D
- Medication usage: ex: long-term steroid use
Epidemiology: Extrinsic Risk Factors

Training regimen

- Surveys report that up to 86% of injured athletes could identify some change in their training prior to a stress fracture.

- Multiple studies in runners have demonstrated that higher weekly running mileage correlates with an increased incidence of stress fractures and overall running injuries: 0.7 FF / 1000 h of training (Bennet et al., 1996).

- Recreational runners who average more than 64 km per week are at increased risk of stress fractures.
Epidemiology: Extrinsic Risk Factors

Equipment factors: shoes

- Shoe age has been shown to be a better indicator of shock-absorbing quality than shoe cost.
  - Military recruits who started training in shoes **older than 6 months** (an indicator of possible reduced shock absorptive capacity) were at a greater risk of developing a stress fracture.

Epidemiology: Intrinsic Risk Factors

Gender

- In athletic populations, most studies have found that women have a higher incidence of stress fractures compared with men.
  - FF exposure risk / 1000 h of training: **0.86 for women** / **0.54 for men**

- In the United States military, the risk of stress fractures in female recruits undergoing the same training program as men is up to **10 times higher**.
  
  

- This higher incidence is secondary at least in part to gender-associated risk factors such as
  - dietary deficiencies
  - menstrual irregularities
  - lower BMD
  - narrower bone width
  - neuromuscular control (women have a slower rate of force development in the muscle


Diagnosis: History

- The patient must be questioned closely about the sequence of events leading to the sudden onset of pain in the affected limb.

- Stress fracture should be suspected in persons with a drastic recent increase in physical activity or repeated excessive activity with limited rest.

- Even conditioned professional athletes may have stress fractures when they have broken training or decided to increase the amount of effort involved in performing their particular athletic feat.

- Many middle-aged and elderly persons are now engaged in this activity, a fact that accounts for the increasing number of insufficiency-type stress fractures that are encountered.
  - Recreational walking is a low-impact activity with excellent aerobic cardiovascular effects.
Diagnosis: History

- Pain
  - Pain is a common presenting symptom that can vary by location, such as knee pain with a proximal tibial injury, hip pain with a femoral neck injury, or groin pain with a pelvic fracture.
  - Early on, the pain typically is mild and occurs toward the end of the inciting activity (81%).
  - Subsequently, the pain may worsen and occur earlier, limiting participation in sports activities.
  - While rest may provide transient relief of symptoms in the early stages, as the stress injury progresses, the athlete's pain may persist even after cessation of activity.
  - Night pain is a frequent complaint.
Diagnosis: Physical examination

- Individuals with stress fractures typically report pain, demonstrate **focal tenderness** (65.9% to 100%) upon palpation or percussion of the affected area.

- Inspection of the site may reveal localized **swelling** (18% to 44%) and possibly, **erythema**.


Diagnosis: Physical examination

- **The hop test**
  - single leg hopping produces severe localized pain
  - is often used and cited in texts as a diagnostic test for lower extremity fractures
  - no recent literature was found to validate its accuracy

- In some studies, a positive hop test was an inclusion criterion or a common finding (70% to 100%) in patients with presumed stress fractures, but was also noted in nearly one-half (45.6%) of patients with suspected medial tibial stress syndrome (shin splints).

Diagnosis: Physical examination

- The tuning fork test
  - applying a vibrating tuning fork to the fracture site to produce focal pain
  - One small study found that the tuning fork test had a **sensitivity of 75%, a specificity of 67%, a positive predictive value of 77%**, and a negative predictive value of 63% for tibial stress fractures.
Diagnosis: Physical examination

- **No single physical examination test** is sufficiently sensitive and specific to permit the unequivocal diagnosis of a stress fracture

- As part of a thorough physical examination, the practitioner should assess
  - the athlete's flexibility
  - lower limb alignment including leg lengths
  - foot structure: pes cavus vs pes planus
  - motor function: evaluating for strength imbalances
## Diagnosis: Imagery

<table>
<thead>
<tr>
<th>Imaging Modalities for Stress Fractures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test</strong></td>
</tr>
<tr>
<td>Plain radiography^{4,11,15}</td>
</tr>
<tr>
<td>Bone scintigraphy^{10-12,16}</td>
</tr>
<tr>
<td>Magnetic resonance imaging^{10,11,15,16}</td>
</tr>
<tr>
<td>Ultrasonography^{17}</td>
</tr>
</tbody>
</table>
Diagnosis: Imagery of Metatarsal

Radiographie du pied gauche de face montant une fracture de la tête du 2° métatarsien

Bone scan of the distal second metatarsal

a: radiographie du pied gauche de face montrant un épaississement de la corticale médiale
Diagnosis: Imagery of Metatarsal

Fracture de fatigue complète de la diaphyse du deuxième métatarsien.

b : IRM, image coronale en densité de protons avec saturation du signal de la graisse ;
c : image sagittale en densité de protons avec saturation du signal de la graisse.

Les images montrent un œdème de la médullaire osseuse et des tissus mous.
L’œdème est circonférentiel. La ligne en hyposignal correspond à la fracture complète de la diaphyse métatarsienne.
Diagnosis: Imagery of Tibia shaft

Fracture de fatigue de la face antérieure du tibia chez un homme de 29 ans.

a: scintigraphie au 99mTc. Hyperfixation corticale antérieure de la diaphyse tibiale;
b: scanner, image sagittale en fenêtre osseuse. Fracture transversale de quelques millimètres de longueur de la corticale tibiale antérieure, avec réaction périostée localisée.
Diagnosis: Imagery of proximal Tibia

Fracture de fatigue complète du tibia chez un jeune patient de 16 ans. La radiographie montre une ligne dense de la métaphyse tibiale proximale, à point de départ cortical et étendue à l’os trabéculaire.

Fracture fatigue tiers supérieur tibia. Cliché réalisé à 10 semaines : densification médullaire traversant toute la diaphyse.
Diagnosis: Imagery of proximal Tibia

Magnetic resonance imaging. (A) Proximal tibial stress fracture (arrow). (B) Sagittal view of same fracture (arrow).

Differential diagnosis:

- If any possibility exists that a bone lesion may represent a healing stress fracture, biopsy should be avoided unless evidence is clear-cut that the appearance of the lesion on radiographs has not changed over several weeks.

- A biopsy specimen of a stress fracture may contain immature bone cells, which are part of the healing fracture process but which may be misinterpreted by an inexperienced pathologist as representing a bone sarcoma.

Differential diagnosis: tibia

- tendinopathy
- compartment syndrome
- nerve or artery entrapment syndrome
- medial tibial stress syndrome

- osteoid osteoma
- chronic sclerosing osteomyelitis of Garré
- osteogenic sarcoma
- Ewing’s tumor
Differential diagnosis: foot

- Metatarsalgia
- Metatarsophalangeal synovitis
- Avascular necrosis of metatarsal head
- Inflammatory arthritis
- Morton Neuroma
- Jones Fracture
- Turf Toe
- Sesamoiditis
Complications:

- Concern about complications is warranted when stress fractures are displaced or do not demonstrate adequate healing, despite time and appropriate interventions.

- Stress fractures may lead to complications:
  - progression to complete fractures
  - development of avascular necrosis
  - delays in healing or non-union
  - posttraumatic arthrosis
  - persistent disabling pain


Entwistle RC, Sammons SC, Bigley RF, et al. Material properties are related to stress fracture callus and porosity of cortical bone tissue at affected and unaffected sites. *J Orthop Res.* Apr 20 2009
Prognosis:

- The prognosis for recovery is dependent on the location and severity of the fracture and on the age and underlying condition and associated comorbidities of the affected athlete.

- **Most stress fracture carry a favorable prognosis** for full recovery when appropriate treatment has been provided.

  - **Sites at LOW risk of complications:** are unlikely to have any of these complications and are generally amenable to conservative management.
    - fourth metatarsal shafts
    - posteromedial tibial shaft

  - **Sites at HIGH risk of complications:** are managed more aggressively, often surgically.
    - anterior cortex of the tibia
    - talus
    - tarsal navicular
    - proximal fifth metatarsal
    - great toe sesamoids
    - base of the second metatarsal
Treatment Recommendations: Conservative therapy

- Treatment should begin as soon as the injury is suspected, because delayed treatment has been correlated with prolonged return to activity. 

- The patient can be examined every two to three weeks to ensure pain-free functioning, monitor changes in symptoms, and evaluate improvement in provocative testing.

- When patients are pain free, they may increase activity in a slow, graduated manner.
Treatment Recommendations: Conservative therapy

R  Removal of the abnormal stress
E  Exercise to maintain cardiovascular fitness and prevent atrophy
S  Safe, pain-free return to previous level of activity
T  Time for bone maturity to catch up with increased remodeling

Figure 6. R.E.S.T. acronym for the goals of stress fracture management.
Treatment Recommendations: REST protocol

Bone remodeling activity and rehabilitation goals based within each phase of cyclic rehabilitation protocol

<table>
<thead>
<tr>
<th>Phase</th>
<th>Days</th>
<th>Remodeling Activity</th>
<th>Goals of Rehabilitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1–10</td>
<td>Haversian canal formation</td>
<td>Control inflammation, modify or remove abnormal stress, maintain cardiovascular fitness</td>
</tr>
<tr>
<td>II</td>
<td>11–24</td>
<td>Periostitis, osteocyte maturation</td>
<td>Begin ADLs* pain free, transition to functional rehabilitation, maintain cardiovascular fitness</td>
</tr>
<tr>
<td>III Functional</td>
<td>1–14</td>
<td>Haversian canal formation</td>
<td>Allow stress to facilitate normal bone remodeling, increase activity level</td>
</tr>
<tr>
<td>III Rest</td>
<td>15–21</td>
<td>Periostitis, osteocyte maturation</td>
<td>Allow healing and osteocyte maturity during “weak 3rd week” of bone remodeling</td>
</tr>
</tbody>
</table>

*ADLs indicates activities of daily living.

Treatment Recommendations: REST protocol

Nonsteroidal anti-inflammatory medications
TENS, HVES
Ice massage/contrast baths
Towel toe curls x 10
Upper body ergometer
Upper body, uninvolved-leg weight training
Wobble board: sitting, involved-leg ROM
Stationary bike: uninvolved leg
Involved-leg strength: isometrics
Pool: treading water
Ambulation: crutch
Full weight-bearing ADLs

Standing ROM/balance
Both legs → Interval training
Rubber tubing: 4x10 → 4x20
Toe raises: 2 ft → 1 ft
Squatting
Jog: chest/waist-deep water
Walk x 30 min

Jumping → hopping
Plyometrics (squat>1.5 x body weight)
Sprinting → jump/hop mobility
Walk/jog 0.08 km (0.5 mi) → 3.22 km (2 mi)
Jog 1.61 km (1 mi) → goal distance
Figure 8s, 1/2 speed mobility, hop
Sprint, sport-specific activity
Return to activity

Phase I

Phase II

Phase III

Treatment Recommendations: REST protocol phase I

- Initial treatment should include:
  - daily ice massages or contrast baths to decrease swelling.
  - analgesics
    - may be helpful if pain persists or becomes further limiting
    - Paracetamol may be considered for pain control
    - NSAIDs: !! inhibit the production of prostaglandins, which are demonstrated to be involved in normal bone remodeling and fracture healing.

Treatment Recommendations: REST protocol phase I

Splints

- The use of pneumatic splints: splinting, casting, stirrup leg brace, boots
  - reduce abnormal tibial loading
  - provide support around the fracture site
  - reduce the length of the rehabilitation process
  - can significantly reduce pain and healing time in tibial and fibular stress fractures

> more rapid return to sports participation [Evidence level A, meta-analysis/RCT]

Treatment Recommendations: 
REST protocol phase III

- During the functional phase of the program, the athlete continues the phase II exercises and progresses to mobility and jumping activities in the pool before their initiation on dry land.

- Once the athlete can squat 1 1/2 times body weight, higher-level plyometric training may begin.

Treatment Recommendations: REST protocol phase III

- The running portion of phase III is completed in a cyclic fashion that mimics bone growth.

- As bone is being resorbed in the first 2 weeks of activity, running is encouraged to promote the formation of trabecular channels (functional phase).

- In the third week, when the newly formed osteocytes and periosteum are maturing, running activity is decreased (rest phase).

- As the running program progresses to sprinting and sport-specific activities, the rest days between functional activities decrease, and the athlete is gradually prepared for the return to competition.

Treatment Recommendations: REST protocol phase III

**Increasing activity**

- A good guideline is to increase activity no more than **15% to 20% per week**.

- A “**walk-jog**” in which the injured person jogs the straightaways and walks the curves of a track for **0.80 km**

- Once that distance is completed without pain, the injured person can begin **walk-jogs 3 times per week**.

- Distance is added in **0.80 km increments per week** until the athlete can complete **3.22 km**.

- At this point, jogging begins for **1.61 km** and increases by **0.80 km per week** until **4.83 km** or a goal distance commensurate with the person’s activity is reached.

Treatment Recommendations: REST protocol

Treatment Recommendations: Surgery

- Indications:
  - patients with recalcitrant stress fractures
  - patients with high-risk stress fractures

Périostite tibiale chez le coureur
Plan

- Definition
- Etiology and Pathophysiology
- Epidemiology
  - Risk Factors
    - Intrinsic Factors
    - Extrinsic Factors
- Diagnosis
  - History
  - Physical examination
  - Imagery
- Differential diagnosis
- Treatment Recommendations
Definition:

- Shin splint is characterised by
  - diffuse tibial anteromedial or posteromedial surface subcutaneous periostitis
  - most often on the medial border near the junction of the mid and distal thirds of the tibia

http://www.rci.rutgers.edu/~uzwiak/AnatPhys/APFallLect8_files/image003.jpg
Etiology and Pathophysiology: to summarize

- During the landing and propulsion of running
  - repetitive contraction of the posterior tibial, soleus and/or flexor digitorum longus muscles would generate excessive stress on the tibia, resulting in inflammation from insertion of the periosteal.


- Insufficient capacity for bone remodelling
  - due to repetitive and persistent stress on the tibia caused not only by the muscle contraction but also on the vertical ground reaction during the landing phase in running.

Etiology and Pathophysiology: to summarize

- Despite different theories, clinical and research studies on the cause of MTSS II, the fact that the detailed structural cause is still unknown highlights the need for prospective longitudinal investigations.
Etiology and Pathophysiology: Cortical bone fatigue in MTSS II

- The research on cortical bone cyclic testing, both in vitro and in vivo studies, provided invaluable data on the development of fatigue injury in cortical bone.

- Like TSFs, cortical bone microtrauma occurring in MTSS II is likely the result of tensile failure causing osteon debonding at the cement lines as the tibial microstructure is unable to repair quickly enough through adaptive bone remodelling.

- However, unlike a TSF, this microdamage clearly does not extend beyond the microscopic lamellae structure, at least in many cases, so that crack development is arrested in MTSS II before a macroscopic partial fracture transversing the osteons occurs.

Etiology and Pathophysiology: Does periostitis or cortical bone microtrauma occur first in MTSS II?

- Based on their MRI study of 14 patients with 18 symptomatic legs, Fredericson et al postulated that **periosteal oedema occurs prior to the formation of cortical bone microcracks**
  - as only periosteal oedema was detected in their patients with the mild injuries
  - while those with more severe injuries had both periosteal oedema and either a partial fracture, or marrow oedema indicating bone microtrauma.

- Etherington et al studied a cohort of 40 male military recruits over 10 wk of basic training, 26 of whom completed the training, and measured a number of parameters including the velocity of ultrasound in the heel.
  - The authors found there was a mean decrease in the ultrasonic velocity from pre to post training in recruits who completed the training uninjured

→ cortical bone microtrauma occurs prior to the development of any clinical injury, and could be a precursor to periostitis.

Epidemiology:

- Shin splint is the main general Running-Related Musculoskeletal Injuries
  - incidence ranging from 13.6% to 20.0%
  - prevalence of 9.5%

**Epidemiology: Intrinsic Risk Factors**

- There is level I evidence for *excessive pronation* and *female sex*.

- Level II evidence is available for the risk factors
  - increased internal and external hip ranges of motion
  - higher BMI
  - leaner calf girth

- Studies on BMD and cortical bone geometric parameters demonstrate that patients with MTSS II have
  - lower BMD at the injury site than exercising controls
  - lower values of various cortical bone geometric factors (cross-sectional area and section modulus) than aerobic control subjects

Epidemiology: Extrinsic Risk Factors

- Level II evidence is present for previous history of MTSS II

Epidemiology: Risk factors and associations with MTSS II

<table>
<thead>
<tr>
<th>Outcome or subgroup</th>
<th>Studies</th>
<th>n</th>
<th>Statistical method</th>
<th>Effect estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Navicular drop</td>
<td>4</td>
<td>565</td>
<td>SMD (IV, random, 95% CI)</td>
<td>0.26 (0.02–0.50)</td>
</tr>
<tr>
<td>Navicular drop &gt;10 mm</td>
<td>2</td>
<td>164</td>
<td>Risk ratio (M-H, fixed, 95% CI)</td>
<td>1.99 (1.00–3.96)</td>
</tr>
<tr>
<td>Foot type</td>
<td>3</td>
<td>448</td>
<td>Risk ratio (M-H, random, 95% CI)</td>
<td>1.61 (0.37–6.98)</td>
</tr>
<tr>
<td>Orthotic use</td>
<td>3</td>
<td>403</td>
<td>Risk ratio (M-H, fixed, 95% CI)</td>
<td>2.31 (1.56–3.43)</td>
</tr>
<tr>
<td>BMI</td>
<td>5</td>
<td>753</td>
<td>SMD (IV, fixed, 95% CI)</td>
<td>0.24 (0.08–0.41)</td>
</tr>
<tr>
<td>BMI &lt;18.5</td>
<td>3</td>
<td>257</td>
<td>Risk ratio (M-H, fixed, 95% CI)</td>
<td>1.16 (0.79–1.73)</td>
</tr>
<tr>
<td>Ankle DF ROM (soleus)</td>
<td>4</td>
<td>886</td>
<td>SMD (IV, fixed, 95% CI)</td>
<td>-0.06 (-0.21–0.10)</td>
</tr>
<tr>
<td>Ankle DF ROM (gastrocnemius)</td>
<td>5</td>
<td>785</td>
<td>SMD (IV, random, 95% CI)</td>
<td>0.05 (-0.18 to 0.28)</td>
</tr>
<tr>
<td>More years of running</td>
<td>2</td>
<td>182</td>
<td>SMD (IV, fixed, 95% CI)</td>
<td>-0.79 (-1.15, -0.44)</td>
</tr>
<tr>
<td>Previous history MTSS</td>
<td>5</td>
<td>515</td>
<td>Risk ratio (M-H, random, 95% CI)</td>
<td>3.74 (1.17–11.91)</td>
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<tr>
<td>Female gender</td>
<td>8</td>
<td>1226</td>
<td>Risk ratio (M-H, random, 95% CI)</td>
<td>1.91 (1.11–3.28)</td>
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<tr>
<td>Male hip IR ROM</td>
<td>2</td>
<td>268</td>
<td>SMD (IV, random, 95% CI)</td>
<td>0.36 (-0.31 to 1.03)</td>
</tr>
<tr>
<td>Male hip ER ROM</td>
<td>2</td>
<td>268</td>
<td>SMD (IV, random, 95% CI)</td>
<td>0.67 (0.29–1.04)</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index; CI, confidence interval; DF, dorsiflexion; M-H, Mantel-Haenszel test; IR, internal rotation; ER, external rotation; ROM, range of motion; SMD, standard mean difference; MTSS, medial tibial stress syndrome; IV, inverse variance.

*Pronated foot type
*Cohort studies have identified altered kinematics in MTSS sufferers, which may partly explain the link between previous history of MTSS and future MTSS, but to date no prospective trial has identified a specific kinematic risk factor.
Diagnosis: History

- The most common complaint of patients with MTSS II is **vague, diffuse pain** of the lower extremity, along the middle-distal tibia associated with exertion.

- In the early course of MTSS II, pain is worse at the beginning of exercise and **gradually subsides** during training and within minutes of cessation of exercise.

- As the injury progresses, however, pain presents with less activity and may **occur at rest**.

Diagnosis: History

- A comprehensive history should be obtained to evaluate:
  - the athlete’s weekly exercise routine and running mileage, intensity, pace, terrain, and footwear, with careful attention to recent changes in training regimens.
  - training errors appear to be the most common factors involved in MTSS II, especially as athletes attempt to do “too much, too fast”.
  - common training errors include a recent onset of increased activity, intensity, or duration.
  - running on hard or uneven surfaces is also a common risk factor.

- Individuals with previous lower extremity injuries and running more than 30 km per week are especially predisposed to overuse injuries of the lower extremity, including MTSS II.

Diagnosis: Physical examination

- The medial ridge of the tibia, origin of the tibialis posterior and soleus muscles is often tender to palpation, especially at the distal and middle tibial regions.

- Examine for any subcutaneous oedema, which indicates periostitis is present and probable associated microfractures.

- The anterior tibia, however, is usually nontender.

- Neurovascular symptoms are usually absent.
Diagnosis: Physical examination

- Physicians should carefully evaluate for possible knee abnormalities (especially genu varus or valgus), tibial torsion, femoral anteversion, foot arch abnormalities, or a leg-length discrepancy.


- Ankle movements and subtalar motion should also be evaluated:
  - hyperpronation of the subtalar joint is one of the most common and well-documented risk factors for MTSS.

Diagnosis: Physical examination

Hyperpronation of subtalar joint. (A) Medial, (B) anterior views.

Diagnosis: Physical examination

- The Navicular Drop Test (NDT) was first described as a means of quantifying the amount of foot pronation in runners.

- It's intended to represent the sagittal plane displacement of the navicular tuberosity from a neutral position to a relaxed position in standing.

Measurement of navicular drop. The height of the navicular tuberosity is measured in neutral (A) and relaxed (B) stance positions, and the amount of excursion is measured.

<table>
<thead>
<tr>
<th>Normal</th>
<th>Abnormal/Excessive</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-8mm</td>
<td>≥10-15mm</td>
</tr>
</tbody>
</table>

Diagnosis: Physical examination

- **Muscle imbalance and inflexibility**, especially tightness of the triceps surae (gastrocnemius, soleus, and plantaris muscles), is commonly associated with MTSS II.


- A weakness in one or more muscle compartments or in a myotome may indicate lumbar spinal nerve compression or other isolated motor nerve pathologies including rare entrapment syndromes.
  - A full strength/power assessment of all the muscles of the leg should be performed

Diagnosis: Physical examination

- Weakness of **core muscles** is an important risk factor for lower extremity injuries.
  - Hip and pelvis muscle strength are an important link in maintaining control and proper mechanics between the “core” and lower extremity.
  - Core and pelvic muscle stability may be assessed by evaluating patient’s ability to maintain a controlled, level pelvis during a pelvic bridge from the supine position, or a standing single-leg knee bend.

Diagnosis: Physical examination

- The physician should perform a standing **postural examination** to evaluate the entire kinetic chain, especially if the symptoms are recurrent.
  
  
  

- Abnormal **gait patterns** should be evaluated with the patient walking and running, either in the office hallway or on a treadmill.
  
  
Diagnosis: Imagery

- Imaging is usually not necessary for the diagnosis of MTSS II.

- However, if the patient fails to improve with conservative management, **plain film radiography** may be considered.

- X-rays are usually negative within the first 2–3 weeks after the onset of injury.

- Long-term radiographic changes of those with chronic MTSS II with periosteal involvement may show periosteal exostoses.

- Those that progress from MTSS II to stress fracture may develop a dreaded black line on radiograph, which indicates a more ominous sign.


Diagnosis: Imagery
Diagnosis: Imagery

- A **triple-phase bone** scan demonstrates evidence of a stress fracture with a diffuse, longitudinal uptake along the posterior tibia, seen only on the delayed phase of the scan.

- Bone scans have been the gold standard for diagnosing stress fractures in the past, but now are often replaced by magnetic resonance imaging (MRI).

Diagnosis: Imagery

Blood pool and delay images show linear uptake increase in the cortical aspects of tibia in the two sides. Rest of exam was normal.

Diagnosis: Imagery

MRI has many advantages over a bone scan and plane radiography. MRI is better able to identify other soft tissue injuries.

MRI can show progression of injury in the tibia, starting with periosteal edema, progressive marrow involvement, and finally cortical stress fracture.

With better accuracy, MRI can grade tibial injuries according to extent of involvement.

Grading tibial injuries may help clinicians make more accurate recommendations for rehabilitation, though no literature data exist about MRI findings and specific return-to-play guidelines.

Diagnosis: Imagery

Coronal T2-weighted magnetic resonance imaging images of a 17-year-old female hockey player who was training on a concrete pitch covered with Astro Turf® for approximately 2 mo and was subsequently diagnosed with medial tibial stress syndrome. A white longitudinal line of periosteal oedema on the medial cortex can clearly be seen on the enlarged view (right), which was consistent with the region of pain and tenderness.

Diagnosis: Imagery

MRI image of bilateral shin splint (T2 fat sat) : limited juxta cortical hypersignal
Differential diagnosis:

- Traditional differential diagnosis and classification of medial tibial stress syndrome.


Differential diagnosis:

- Physicians should also be aware of less common causes of lower extremity exertional-pain:
  - muscle tears
  - fascial defects
  - occult fracture
  - infection
  - neoplasms
  - effort-induced venous thrombosis
  - peroneal nerve entrapment
Treatment Recommendations:
Conservative therapy - Goals

Summary of treatment goals for MTSS II

- Rest and ice in the acute phase
- Modify training program: decrease intensity, frequency, and duration
- Use low-impact and cross-training exercises during rehabilitation period
- Gradually return to sport with pain-free activity
- Perform regular stretching and strengthening exercises
- Wear proper-fitting shoes with good shock absorption
- Change shoes every 250–500 miles
- Consider orthotics if indicated
- Female athletes may have special considerations
- Treat key dysfunctions of the entire kinetic chain; use manual therapy
- Consider other treatment options: ESWT, injections, acupuncture
- Surgery for recalcitrant cases
Conservative therapy: 4 stages program

PHASE 1 - Acute Phase:

- decrease acute pain and inflammation:
  - absolute rest- NWB with crutches
  - relative rest- WB boot or walker
  - "ICE": ice; compression; elevation
  - NSAIDS and Acetaminophen depending on the severity of their symptoms

Conservative therapy – Acute Phase

Rest

- Most literature supports “rest” as the most important treatment in the acute phase of MTSS II.


- Patients may require “relative” rest and cessation of sport for prolonged periods of time (from 2 to 6 weeks)
Conservative therapy – Acute Phase

- It is the opportunity to discover other completely complementary sports, soft and “low gravity”:
  - swimming
  - cycling
  - roller

- For all these sports, it is possible to realize as well sessions of endurance as session of strong cardiac request
Conservative therapy – Acute Phase

- It is even possible, with precaution (strapping), to realize sessions of ascents of staircase to make cardiovascular workout.

Self-made compression sockets

http://tapingshinsplints.com/category/download/page/156/
Conservative therapy – Acute Phase

Cryotherapy

- is also commonly used in the acute period. Ice may be applied to the affected area directly after exercise for approximately 15–20 min.
Conservative therapy – Acute Phase

Physical therapy modalities:
- ultrasound
- whirlpool baths
- phonophoresis
- augmented soft tissue mobilization
- electrical stimulation

Conservative therapy – Acute Phase

Notes:

- Depending on the severity of the problem the acute phase can be bypassed but should always be considered especially if clinical symptoms are significant.

- When palpation of the involved shin area exhibits minimal to no discomfort the rehabilitation phase can be initiated.
Conservative therapy: 4 stages program

PHASE 2 - Rehabilitation Phase:

- Further decrease pain and inflammation:
  - ultrasound
  - phonophoresis
  - neuroprobe
  - contrast baths

- Decrease scar formation:
  - transverse friction/deep tissue massage
  - augmented soft tissue mobilization

- Maintain/increase flexibility of injured (and surrounding) tissue:
  - active > passive joint range of motion
  - stretching exercises

- Strengthen fascial/bone interface:
  - open to closed chain therapeutic exercise (isometric > isotonic > isokinetic)
Conservative therapy – Rehabilitation Phase

Stretching and strengthening exercises

- Literature has widely supported a daily regimen of calf stretching and eccentric calf exercises to prevent muscle fatigue.

- Other exercises focus on strengthening the tibialis anterior and other muscles controlling both inversion and eversion of the foot.

Conservative therapy – Rehabilitation Phase

Stretching and strengthening exercises

Conservative therapy – Rehabilitation Phase

- Patients may also benefit from strengthening **core and hip muscles**.

- Developing core stability with strong abdominal, gluteal, and hip muscles can improve running mechanics and prevent lower-extremity overuse injuries.


Notes:

- When patient can complete these exercises without symptoms then the functional phase can begin.

- The techniques used to decrease scar formation can initially exacerbate the condition especially when using augmented soft tissue mobilization.
Conservative therapy:

4 stages program

PHASE 3- Functional Phase:

- Functionally strengthen fascial/bone interface and surrounding tissue
  - continue open to closed chain therapeutic exercise
  - plyometric training: trampoline > jumping rope > "vertical jumps"

- Protect injured area during functional activity:
  - shin taping
  - neoprene shin sleeve
  - consider leg brace (Air Cast)
  - orthoses PRN
  - appropriate athletic foot gear
Conservative therapy – Functional Phase

Footwear

- Shoes should fit properly with a stable heel counter.
- Some physicians recommend alternating running shoes especially when one pair is wet, as this compromises the shoe’s integrity.
- Runners should also change running shoes every 400–800 km, a distance at which most shoes lose up to 40% of their shock-absorbing capabilities and overall support.
- Athletes should seek out shoes with sufficient shock absorbing soles and insoles, as they reduce forces through the lower extremity and can prevent repeat episodes of MTSS II.


☐ Level I evidence is available
Conservative therapy – Functional Phase

Orthotics

- Individuals with biomechanical problems of the foot may benefit from orthotics.


- Often, over-the-counter orthosis (flexible or semi-rigid) are sufficient to help with excessive foot pronation and pes planus.

- Mal-alignments caused by forefoot or rearfoot abnormalities may benefit from custom orthotics.

Conservative therapy – Functional Phase

Lower leg braces

Data analysis of the effect of lower leg braces versus control

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Experimental</th>
<th>Control</th>
<th>Std. Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Total</td>
</tr>
<tr>
<td>Johnston 2006</td>
<td>13.43</td>
<td>4.5</td>
<td>7</td>
</tr>
<tr>
<td>Piantanida (unpublished)</td>
<td>26.91</td>
<td>28</td>
<td>37</td>
</tr>
<tr>
<td>Moen 2010</td>
<td>58.8</td>
<td>27.7</td>
<td>8</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>52</td>
<td>53</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Heterogeneity: \( \chi^2 = 0.22, \text{df} = 2 (P = 0.89); I^2 = 0\%

Test for overall effect: \( Z = 0.30 (P = 0.76) \)

Fig. 3 Data analysis of the effect of lower leg braces versus control. CI confidence interval, IV inverse variance, SD standard deviation, Std. standardized, square size indicates the size of the population investigated in each study; diamond estimated pooled effect: width indicates the 95 % confidence interval

Conservative therapy – Functional Phase

Notes:

- This is probably the most important phase because it prepares the patient for their return to activity.

- Care needs to be taken at this stage not to allow the patient to overdo these exercises and stay within their limits as re-injury can easily occur.
Conservative therapy:
4 stages program

PHASE 4- Return To Activity

- Return to desired sport activity:
  - gradual, systematic, "to tolerance"

- Initiate preventive strategies:
  - orthoses PRN
  - appropriate athletic shoewear
  - functional exercises (i.e., Pilates, plyometrics)
  - revise training program
Conservative therapy –
Return To Activity Phase

- Graded Running Program, Stretching/Strengthening and Sports Compression Stockings

- RCT study performed in an athletic population n=74
- The study design was randomized and multi-centered
- Primary outcome measure was: time to complete a running program (able to run 18 minutes with high intensity)
- Secondary outcome was: general satisfaction with treatment

Conservative therapy –

Return To Activity Phase

Group 1

**Graded Running Program**

<table>
<thead>
<tr>
<th>Running phase</th>
<th>Surface</th>
<th>Minutes</th>
<th>Total</th>
<th>Speed/intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Treadmill</td>
<td>2 2 2 2</td>
<td>16 minutes</td>
<td>2 = running at 10 km/hour, 2 = walking at 6 km/hour</td>
</tr>
<tr>
<td>2</td>
<td>Treadmill</td>
<td>2 2 2 2</td>
<td>16 minutes</td>
<td>2 = running at 12 km/hour, 2 = walking at 6 km/hour</td>
</tr>
<tr>
<td>3</td>
<td>Concrete</td>
<td>2 3 2 2</td>
<td>20 minutes</td>
<td>Intensity 1-2 (*)3 = running, 2 = walking</td>
</tr>
<tr>
<td>4</td>
<td>Concrete</td>
<td>2 3 2 2</td>
<td>20 minutes</td>
<td>Intensity 2-3 (*)3 = running, 2 = walking</td>
</tr>
<tr>
<td>5</td>
<td>Concrete</td>
<td>Continuous running</td>
<td>16 minutes</td>
<td>Intensity 1-2 (*)</td>
</tr>
<tr>
<td>6</td>
<td>Concrete</td>
<td>Continuous running</td>
<td>18 minutes</td>
<td>Intensity 2-3 (*)</td>
</tr>
</tbody>
</table>

(*): Intensity 1: running speed; light jogging; Intensity 2: running speed; jogging while able to speak; Intensity 3: running speed; jogging while speaking becomes difficult

The first four phases of the graded running program consisted of interval training in which duration was increased from 16 to 20 minutes and intensity increased from light jogging to a running speed where speaking became difficult.

When “meters run at 10 km/hour” was between 0-400 meters, the athlete started the running program in phase one.

When 401-800 meters could be run, the athlete started in phase two.

When 801-1200 meters could be run the athlete started in phase three.

When 1201-1600 meters could be run, the athlete started phase four.

When 1600 meters or more could be run, athletes started phase five.

In phases 5 and 6, continuous running was performed for 16 and 18 minutes, respectively, and the intensity was increased from light jogging to running at a speed where speaking became difficult.

A new phase of the running program was commenced when a phase was finished without a pain score of 4 or higher on the 1–10 VAS.

Training was performed three times a week, on non-consecutive days.

Conservative therapy – Return To Activity Phase

Group 2:

- Graded Running Program
- + Exercises with 5 days a week stretching of the calf and strengthening
- + Stabilizing exercises of the ankle

Conservative therapy – Return To Activity Phase

Group 3

- Graded Running Program
- + Compression Stockings

Conservative therapy – Return To Activity Phase

- Graded Running Program, Stretching/Strengthening and Sports Compression Stockings

<table>
<thead>
<tr>
<th></th>
<th>Running program (SD, 95% CI)</th>
<th>Running program and exercises (SD, 95% CI)</th>
<th>Running program and compression stocking (SD, 95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to complete the running program</td>
<td>105.2 (54.6, 80.4-130.1)</td>
<td>117.6 (64.2, 86.7-148.6)</td>
<td>102.1 (52.3, 76.9-127.2)</td>
<td>NS</td>
</tr>
<tr>
<td>Satisfaction with treatment in general on 1-10 scale</td>
<td>6.5 (1.3, 4.5-8.6)</td>
<td>5.9 (1.6, 4.6-7.3)</td>
<td>6.8 (2.0, 5.7-8.0)</td>
<td>NS</td>
</tr>
</tbody>
</table>

Abbreviations: NS not significant (p > 0.05), SD standard deviation, 95% CI 95% confidence interval

➔ No differences were found between the groups for the time to completion of the graded running program.
Conservative therapy –
Return To Activity Phase

Modify the training routine

- Decreasing weekly running distance, frequency, and intensity by 50% will likely improve symptoms without complete cessation of activity.

- Runners are encouraged to avoid running on hills and uneven or very firm surfaces.
  - **Synthetic track** or a uniform surface of moderate firmness provides more shock absorption and cause less strain on the lower extremity.

- During this time, athletes can benefit from cross training with other **low-impact exercises**, such as
  - pool running, swimming, using an elliptical machine, or riding a stationary bicycle.

References:

Conservative therapy –
Return To Activity Phase

Notes:

- There is an approximate one month window after the patient returns to their activity where the chance of reinjury is great.

- Patients must realize their limits and be patient!
Treatment Recommendations:

Conservative therapy - shock wave therapy

- Non-randomized clinical trial studied the effect of radial ESWT in addition to a 12-week home training program, relative rest and ice appliance compared with a 12-week home training program, relative rest and ice appliance only.

- *radial ESWT in addition to an exercise home training program was found to improve global perceived effect and severity of pain when compared with a home training program only.*

- Non-randomized clinical trial studied the effect of a six-phase graded running program compared with the same running program with the addition of focused ESWT This study was performed in an athletic population.

- *focused ESWT in addition to a graded running program reduced time to completion of a graded running program significantly more than a graded running program alone.*
Treatment Recommendations:
Conservative therapy - Injections

- Newer methods, such as dry-needling, autologous blood injection, platelet-rich plasma, and prolotherapy, seek to stimulate a local healing response in injured tissues.

- Some physicians have proposed injecting the spring and short plantar ligaments to treat laxity and poor mechanics of the foot arch, which are common factors contributing to hyperpronation.

- However, no RCTs have been performed with these different injection techniques for MTSS II.
Treatment Recommendations:
Conservative therapy - Acupuncture

- Studies identified benefit of acupuncture for MTSS II, but had a small sample size and various methodological shortcomings.

Treatment Recommendations:

Surgical options

- Surgery for MTSS II is usually reserved for recalcitrant cases who do not respond with conservative treatment.

- A “posterior fasciotomy” is the common procedure performed.
  - This may include cauterization of the posteromedial ridge of the tibia.

- Surgical results are variable and not likely to cause complete resolution of symptoms but may improve pain and function.

- Intramedullary nail placement has been used for those with stress fractures in season.

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Merci de votre attention!