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Medial Tibial Stress Syndrome: Related Treatment and Prevention

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Abstract. Medial Tibial Stress Syndrome is one of the most common overuse injuries in runners. The MTSS prevalence rate is 15 to 35%, which seriously affects athletic performance and daily activities. This paper analyzes and discusses the etiologic mechanisms, effective treatments, and preventive measures of MTSS. The results of this study indicate that the main causes of MTSS are biomechanical factors like excessive internal rotation of the lower limb and gait abnormalities. Conservative treatments such as physical therapy and orthotics are effective in the early phase. Advanced treatments have potential for chronic or refractory cases, such as shock wave therapy and platelet-rich plasma (PRP). In addition, a comprehensive prevention plan that combines progressive training and correction in the lower limb biomechanics can reduce the MTSS prevalence rate. After analysis and research, this paper concluded that a diversified approach combining biomechanical correction, targeted therapeutic interventions, and preventive education will lead to the best results.

Keywords: Medial tibial stress syndrome, treatment of medial tibial stress syndrome, biomechanics, overuse injury, preventive measure

1. Introduction

Medial Tibial Stress Syndrome (MTSS), also known as tibial pain syndrome, is a common overuse injury among runners. Its prevalence rate is 15% to 35%, seriously affecting athletic performance and daily activities [1,2]. MTSS is caused by repeated stress on the tibia, causing a stress response in the bone and periosteitis. This stress can be caused by many reasons, including excessive increases in training intensity, inappropriate footwear selection, or biomechanical abnormalities [3].

Getting a deeper understanding of MTSS has an important meaning in the fields of sports rehabilitation and physical therapy. There are several reasons for this. Firstly, it directly affects an athlete's ability to participate in sports activities. If not handled this injury properly, it may lead to a longer recovery period. Secondly, the popularity of running and endurance sports has increased the risk of getting this injury. Effective management of MTSS has become a clinical issue to be faced. Moreover, MTSS is often a precursor to more serious injuries (such as stress fractures of the tibia), highlighting the necessity of early intervention [4].

Currently, there is extensive research worldwide on MTSS. Its biomechanical principles have been deeply explored. Studies have shown that tibial stress injuries in female runners are related to

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specific gait patterns and lower limb alignment abnormalities [3]. Uneven force lines in the lower limbs, such as excessive internal rotation of the ankle joint or abnormal rotation of the tibia, can increase the force applied to the medial side of the tibia, leading to MTSS.

In clinical practice, intervention include conservative treatment (such as ice compress and other physical therapy) to more advanced treatment [2]. However, despite accumulating a wealth of knowledge, there are still some gaps in certain areas, such as the optimal duration of treatment and the combination of treatment methods that have not been fully determined. In some cases, differences caused by individual biomechanical characteristics or lifestyle factors of patients have not been fully resolved.

In China, significant progress has been made in the study of the treatment of MTSS. Multiple research results indicate that combining traditional treatment methods with advanced devices such as TDP (Specific Treatment Devices) can effectively reduce the recurrence of MTSS [4,5]. However, compared with international research on different groups of people (such as leisure runners and elite athletes), personalized treatment based on biomechanics is relatively scarce. The motivation of this study is to provide practical and feasible recommendations for clinical doctors and patients by combining biomechanical analysis, clinical evidence, and a review of treatment methods. This article conducts in-depth research on biomechanics and clinical aspects, analyzes factors such as gait force lines, muscle strength, and skeletal structure that affect MTSS, and discusses conservative treatment, advanced treatment plans, and prevention strategies. Finally, this article proposes suggestions for future research directions and provides a phased summary aimed at addressing the management issues of MTSS.

2. Etiologic mechanisms of MTSS

The pathogenesis of medial tibial stress syndrome (MTSS) involves multifactorial interactions, with biomechanical abnormalities being the central driver. Disturbances in the lower limb lines of force can lead to imbalances in tibial stress distribution. Studies have shown that excessive internal rotation of the ankle significantly increases the angle of internal rotation of the tibia, exposing the medial structures (including the periosteum and myofascia) to excessive pulling and twisting forces - a constant mechanical stimulus similar to “wringing out a towel”. Repeatedly, the tissue tolerance threshold is exceeded, triggering micro-injury and inflammation in the periosteum and surrounding soft tissues. Muscle imbalances further exacerbate this process: a weak tibialis anterior muscle weakens its cushioning role as a “shock absorber”, leading to direct transmission of the impact to the tibia, while a tight gastrocnemius-flounder complex reduces the ability of the foot to dorsiflex, preventing the impact of the heel strike from being absorbed through the normal range of motion, and resulting in a sudden concentration of stress in the mid-tibia.

2.1. Biomechanical perspective

Abnormal biomechanical structures are the key factors in the cause of MTSS. As Milner et al. said, abnormal force lines in the lower limbs can lead to uneven stress distribution on the tibia and lead to MTSS [3]. For example, excessive internal rotation of the ankle joint will increase the angle of internal rotation of the tibia and cause excessive pressure on the medial structures, including the periosteum and muscle fascia. This inward rotation applies a twisting force on the tibia, similar to wringing out a towel. Over time, this repeated twisting can irritate the periosteum (a thin layer of connective tissue covering the bone). With each step, the medial side of the tibia is pulled and

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stretched more than it can handle, causing microtrauma in the tissue. Such repetitive microtrauma can trigger inflammation of MTSS.

Muscle imbalance can also lead to the onset of MTSS. Weakness of the anterior tibial muscles or tightness of the calf muscles will alter the shock absorption capacity of the lower limbs when subjected to impact. During the foot heel landing on the ground during running, the anterior tibialis muscle functions like a “shock absorber”. If these muscles are weak, they cannot effectively cushion the impact of the foot strike, resulting in excessive stress being placed on the tibia. Similarly, tight calf muscles are like a stiff spring---they do not absorb the impact force but instead transfer more force to the tibia. For example, excessive tension of the gastrocnemius-soleus complex will decrease the dorsiflexion ability of the foot, thereby increasing the load transmitted to the tibia during the support phase of walking [5,6]. When the foot cannot dorsiflex normally, the heel will strike the ground with heavier force, and the tibia will have to suddenly bear the weight of the body instead of gradually absorbing this force through the normal range of motion.

2.2. Clinical evidence

Clinical studies have clarified that the pathological progression of MTSS is characterized by stages. In the early stages, periosteal inflammation is predominant, with pain occurring during and after activity. As the disease progresses, the inflammation may involve the bone and the pain may advance to the early stages of activity or even persist at rest. Diagnosis is based on clinical history and physical examination, with emphasis on recent changes in training load (e.g., sudden increase in running mileage and intensity) and the location of medial tibial tenderness (usually in the middle 1/3). Imaging (e.g., ultrasound) can assist in the visualization of periosteal thickening (normal thickness of 1-1.5 mm, increasing to 3 mm in patients with MTSS) and soft-tissue inflammation, but imaging is usually not necessary to confirm the diagnosis in typical cases. It is important to note that without timely intervention, MTSS can progress to tibial stress fractures - when the tibia is subjected to repeated stresses that exceed its ability to repair itself, microfractures can occur, which are acutely painful and worsen with light activity, and have a significantly longer healing period than MTSS, emphasizing the importance of early intervention. A study pointed out that MTSS includes several stages, from periosteal inflammation to early pain responses of bone [1]. In the first stage, only the periosteum is inflamed, causing pain mainly during and after activity. In later stages, the inflammation can spread to the bone. and causing pain that starts earlier in the activity and even persists at rest. The diagnosis mainly relies on clinical methods, based on the patient's medical history (overuse, pain symptoms) and physical examination (tenderness on the inner side of the tibia) [1]. Doctors will often ask about recent changes in training. Such as increases in running distance, intensity, or changes in running field, as these are strong clues. They will also check for other things like redness or swelling, to make sure there are no infections or blood clots. Imaging examinations such as ultrasound or magnetic resonance imaging can assist diagnosis by observing nodules in the periosteum or soft tissue edema, although for typical cases, these examinations are unnecessary [7].

If it's not controlled, the development process of MTSS may evolve into more serious conditions. long-term MTSS may develop the risk of stress fractures of the tibia, emphasizing the necessity of taking proper intervention measures in time [8]. Stress fractures occur when the repeated stress on the tibia overwhelms the bone’s ability to repair itself, causing small cracks in the bone. Unlike MTSS, stress fractures often cause sharp pain that gets worse with even light activity, and may require weeks or months of complete rest to heal. This is why treating MTSS in time is so critical.

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3. Treatment strategies for MTSS

3.1. Conservative treatment

Conservative treatment is the first line of treatment for MTSS and centers on multidimensional interventions to reduce tibial loading and promote tissue repair. Activity control is fundamental, with avoidance of high-intensity weight-bearing exercise (e.g., running) for at least two weeks, during which time low-intensity activities (e.g., swimming, stationary bicycling) are substituted to maintain fitness and reduce tibial stress - freestyle or backstroke elevate the heart rate without weight bearing on the legs, and stationary bicycling requires adjusting the seat height to avoid excessive bending of the knee and increasing stress on the lower leg. Increased calf stress.

Physical therapy plays an important role in conservative treatment. Stretching exercises (e.g., static stretching of the calf gastrocnemius and soleus muscles) improve dorsiflexion of the foot and relieve tibial tension, usually done in a standing position facing a wall for 30 seconds several times a day. Strengthening exercises focus on the tibialis anterior, hip abductors and core muscles, such as resistance bands to strengthen the tibialis anterior, side-lying clams to strengthen hip external rotation to minimize ankle over-rotation, and planks to improve core stability to reduce lower extremity stress transfer. Proprioceptive training (e.g., single-leg stand with eyes closed) further optimizes lower extremity stability by improving neuromuscular control.

Footwear modifications and orthopedic interventions can be targeted to correct biomechanical abnormalities. Running shoes with TPU or carbon fiber plates limit pronation and provide rigid support to the arch to balance stress distribution. Overweight individuals can choose shoes with thick, soft foam soles or customized orthotic insoles to precisely address individual biomechanical deficiencies. In addition, combined physical therapy (e.g., specific electromagnetic spectrum heat therapy) can accelerate the repair of damaged tissues by promoting local blood circulation, which has shown positive results in the treatment of MTSS in new recruits.

3.2. Advanced treatment

For chronic or refractory MTSS that is ineffective with conservative treatment, advanced treatment means can be considered. Shockwave therapy stimulates tissue repair mechanisms and reduces inflammation by emitting high-intensity sound waves to the site of injury. These sound waves are delivered at frequencies between 16 to 20 Hz. They create controlled microtrauma in the target tissues, triggering the body's innate healing response, such as increased blood flow and the recruitment of repair cells. Preliminary studies have shown it to be effective in relieving pain. Many patients reported a 30 to 40% reduction in discomfort after 3 to 5 sessions, each lasting 10 to 15 minutes. Long-term efficacy needs to be supported by more clinical data, particularly regarding sustained improvement beyond 6 months.

Platelet-rich plasma (PRP) injections, which utilize growth factors released by platelets to accelerate tissue healing, are suitable for cases that do not respond well to conventional treatments. The process includes drawing a small sample of the patient's blood and spinning it in a centrifuge to concentrate platelets (5-8 times their normal concentration). The concentrated solution is then injected directly into the tender medial tibial area under ultrasound guidance to ensure precision. This focus on targeted delivery of healing factors aligns with broader research into biological approaches for tissue repair, which have explored various methods such as gene therapy to enhance regenerative processes at the cellular level [9]. However, the complexity and high cost of the procedure limit its widespread use, and it is often used as a second-line option. Additionally, patients

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typically need to avoid high-impact activities for 1 to 2 weeks after injection to allow the growth factors to take effect.

4. Prevention of MTSS

The prevention of MTSS is centered on reducing the risk of overuse and optimizing the function of the lower extremity, with the core being the construction of a scientific training and protection system. The key is to develop a progressive cycle training program, in which the weekly increase in training intensity (mileage, speed, time) should be limited to 15% or less, so that the bones, muscles and connective tissues have sufficient time to adapt to the change in load - for example, the gradual increase from 10km to 13km per week will take 2-3 weeks, to avoid the accumulation of stresses caused by the sudden increase in volume. Avoid accumulation of stress due to sudden increase in volume.

Footwear selection and maintenance are critical to prevention. Footwear should be adapted to the foot type (e.g., flat feet, high arched feet) and landing pattern, with medial support pillars designed to limit overpronation. Studies have highlighted that proper cushioning and support in footwear, such as shock-absorbing features, play a significant role in reducing lower limb overuse injuries, including MTSS [10]. Replace running shoes regularly (usually every 300-500 miles) to maintain cushioning and support structure and to avoid abnormal stress distribution due to heel wear and decreased forefoot flexibility.

Strengthening the lower extremity and core muscles and improving flexibility are the foundation of prevention. Training such as single-leg deep squat and forward lunge can enhance the stability of the lower limbs, and dynamic stretching and static stretching of the calves can improve muscle elasticity and reduce biomechanical abnormalities caused by tension. In addition, running posture education is also indispensable. Keeping the trunk upright, avoiding excessive forward leaning or striding, and consciously controlling the range of internal rotation of the foot can significantly reduce the torsional and pulling forces on the tibia, thus reducing the risk of injury at the level of movement patterns. The synergistic effect of multidimensional preventive measures can effectively reduce the incidence of MTSS in repetitive weight-bearing activities.

5. Conclusion

This paper provides an in-depth study on the pathogenesis, clinical manifestations, treatment, and prevention methods of medial tibial stress syndrome (MTSS) worldwide. By simulating classic clinical case studies, this article has gained a deeper understanding of the practical application of MTSS treatment. Biomechanical factors, such as abnormal gait and muscle imbalance, have been identified as the key factors that lead to MTSS. Conservative treatment method (involving rest, physical therapy, and sneaker selection) remains the main treatment approach, which has been approved by international studies from various countries. Although advanced treatment methods have not been fully verified, they still hold potential and expectation for stubborn cases. Prevention methods emphasize that a progressive periodic training plan and biomechanical optimization are necessary. This study provides reference and contribution to the field of physical therapy in sports medicine, sports rehabilitation, and MTSS treatment. It integrates existing knowledge about MTSS, provides advanced and practical treatment and prevention methods, and emphasizes the importance of diversified treatments such as biomechanical optimization, targeted therapy, and prevention education. MTSS remains a major challenge in the field of sports medicine, and through continuous research and comprehensive management and prevention measures, its negative impact on the

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majority of the population can be effectively reduced. Although this study has made some contributions to the field, there are still some limitations and controversies that need to be resolved. In addition, some advanced treatment methods (such as PRP injection) are also controversial and lack clinical experience, requiring more clinical trials to verify their actual effects.

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