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Medial Gastrocnemius Strain: Clinical Aspects and Algorithmic Approach

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Abstract

Medial gastrocnemius strain (MGS), is the most common cause of mid-calf pain in athletes due to the stretch of the gastrocnemius muscle when the knee is in extension and the ankle is in dorsiflexion. Chronological age and previous calf injury are the most substantial risk factors for MGS, including high body mass index, previous lower limb injuries, L5 radiculopathy, and inadequate warm-up. The dominant presentation of MGS is a pain that can be diverse from acute to latent, which is felt in the posteromedial aspect of the calf and is often preceded by a feeling of a pop. The signs of MGS include antalgic gait, ecchymosis, swelling, local tenderness, and sometimes a palpable gap felt along the muscle. Passive dorsiflexion of the ankle or resistive ankle plantarflexion with knee extension can indicate a more severe injury, while functional tests can illicit milder injuries of calf muscles—including gastrocnemius. The diagnosis of MGS is usually made by clinical evaluation. However, imaging modalities—including magnetic resonance imaging and ultrasound—can be helpful in case of suspicion. In most cases of MGS, the cornerstone of treatment is nonoperative rehabilitation, which can be performed as a 4-phase program and should be tailored individually. Some instances of MGS are referred for early or later surgical treatment if indicated.

In this article, we review the literature about various aspects of MGS, from diagnosis to treatment and rehabilitation, and propose a structured approach to this injury.

Keywords: Orthopedics, Sports Medicine, Rehabilitation, Athletic Injuries, Gastrocnemius Muscle

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Introduction

In 1883, Powell described the term "Tennis Leg" as acute mid-calf pain primarily attributed to plantaris injury. However, further studies—including imaging modalities—showed that the most common cause of mid-calf pain among patients is the strain on the medial head of the gastrocnemius, also known as the medial gastrocnemius strain (MGS) (1).

Despite the appellation of "tennis leg" to calf injuries, a study found that only about 16% of athletes with calf injuries are among tennis players. Another study showed that this injury includes 4% of all tennis-related injuries (2, 3).

Multiple studies have studied calf strain incidence in different sports. It has been shown that the incidence per team per season can be as high as 2.9 in Australian Football, 2.3 in soccer and American football, and 1.2 in basketball, which is most probably caused by MGS (4-7).

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↑What is "already known" in this topic:
Medial gastrocnemius strain is the most common injury in the calf region among athletes, and multiple studies have been done on it. While some aspects of this injury are studied extensively, studies on other aspects are still few and sparse.

→What this article adds:
This article gathers and analyzes information on medial gastrocnemius strains from every angle, including their nature, risk factors, how they are diagnosed, and different treatments, focusing on nonsurgical rehabilitation. It aims to enhance our approach to treating this injury, providing a more comprehensive perspective.

Being the most superficial muscle of the calf, gastrocnemius is comprised of 2 heads: the more robust and thicker medial head, which originates from the posterior surface of the medial condyle and epicondyle of the femur, and the lateral head, which originates from the lateral condyle and epicondyle of the femur. The 2 heads are directed downward, and their aponeuroses merge to form a large aponeurosis, which forms the Achilles tendon in participation with soleus and plantaris aponeuroses (8, 9).

The gastrocnemius, innervated by the tibial nerve, is the primary plantar flexor of the ankle while the knee is in extension and is a secondary flexor of the knee, hence a bi-articular muscle. Compared to other lower limb muscles, this muscle comprises a relatively higher proportion of type II fibers (about 50%) and is mainly involved in explosive movements (8-10).

In this study, we review the literature on clinical aspects of MGS and then take an algorithmic approach to this injury.

Pathophysiology and Mechanism of Injury

Gastrocnemius is prone to injury more than other calf muscles for 2 possible reasons:

1- Gastrocnemius is a bi-articular (knee and ankle) muscle known to be a risk factor for a muscle to be strained since it can be stretched at more than one joint (11).

2- Compared to soleus (comprising about 30% of type II muscle fibers), gastrocnemius contains about 50% of type II muscle fibers (10). Type II (fast twitch) muscle fibers are more prone to injuries from eccentric forces than other muscle fibers (12).

Evidence shows that the medial head is more active than the lateral head of the gastrocnemius, especially in the toe-out position (13). This is probably related to the greater proximal attachment and a longer distal insertion of the medial head than the lateral head (14).

For the aforementioned reasons, the medial head of the gastrocnemius is the most vulnerable muscular structure in the calf to injury.

The posture in which the knee is in extension and the ankle is in dorsiflexion is a predisposing factor for gastrocnemius strain since this posture puts the muscle in maximal stretch. This stretch can expose the muscle to varying degrees of tear. The much more common mechanism is during the push-off phase of jumping and running, in which the muscle moves from the eccentric phase (stretched while the knee is in extension and the ankle is in dorsiflexion) to the isometric contraction phase (15, 16).

Risk Factors

According to a systematic review by Green and Pizzari, chronological age and previous calf injury are the most substantial risk factors for calf injury in the athletic population (17).

However, high body mass index, previous lower limb injuries (other than calf), L5 radiculopathy, and inadequate warm-up have shown some associations with calf strain, although with limited evidence (17-19).

Clinical Presentation

History

Referring to the mechanism, the patient may point out the feeling of a pop or snap in the calf during a sudden push-off. The presentation of pain can be diverse from acute, sudden, and sharp pain to latent (as much as 24 hours) and dull pain, which is felt in the posteromedial aspect of the calf. This pain may be present during rest but may only be manifested upon standing, walking, passive dorsiflexion, or active plantarflexion of the foot. Feeling cramps or weakness in the calf are among other possible symptoms (15, 18, 20).

Prodromal symptoms such as cramps and dull muscle pain can be seen in as much as 20% of the patients (15, 21).

Physical Examination

The first observable sign by a physician is the patient's antalgic gait since the patient cannot bear weight on the affected limb. Other observational signs that can be detected are ecchymosis and swelling in the injured area (22).

On palpation, a local tenderness can be detected, and in case of complete muscle rupture and muscle retraction, a palpable gap is felt along the muscle (22, 23).

Provocative muscle tests are an essential part of the examination. Simple tests, such as passive dorsiflexion of the ankle or resistive ankle plantarflexion, can indicate a more severe injury. These 2 tests can suggest gastrocnemius strain if performed with knee extension. Functional tests such as running, jumping, and single-leg hopping can illicit milder injuries of the calf muscles, including gastrocnemius (15, 23).

Imaging

Although most MGS cases are diagnosed clinically, imaging may be used to exclude other diagnoses and surveillance of the rehabilitation process (24, 25).

Two imaging modalities used for investigating MGS are ultrasonography (US) and magnetic resonance imaging (MRI).

Being affordable and dynamic imaging are the 2 main advantages of the US. The US is indicated for locating the exact injury site, grading the injury, surveillance of the healing process and inflammation (doppler ultrasound), and ultrasound-guided hematoma or accumulated fluid aspiration (26, 27) (Figure 1). Using US for MGS diagnosis is performed with the high-frequency linear probe. Patients are placed in a prone position with a pillow placed immediately proximal to the ankle and foot hanging from the edge of the examination table to allow ankle movement if needed (28). In a case report, Chen et al described a novel gastrocnemius medial head sonography positioning. In this approach, the patient is placed in the supine position with the knees flexed at 90 degrees and the probe pointing upwards to examine the muscle. This position helps to move the fluid caused by inflammation from the depth of the muscle to its surface using gravity. This can help detect muscle injury in cases where no evidence of damage can be seen in the US despite the positive findings in the examination (29). The structure of gastrocnemius medial head should be investigated in longitudinal and transverse

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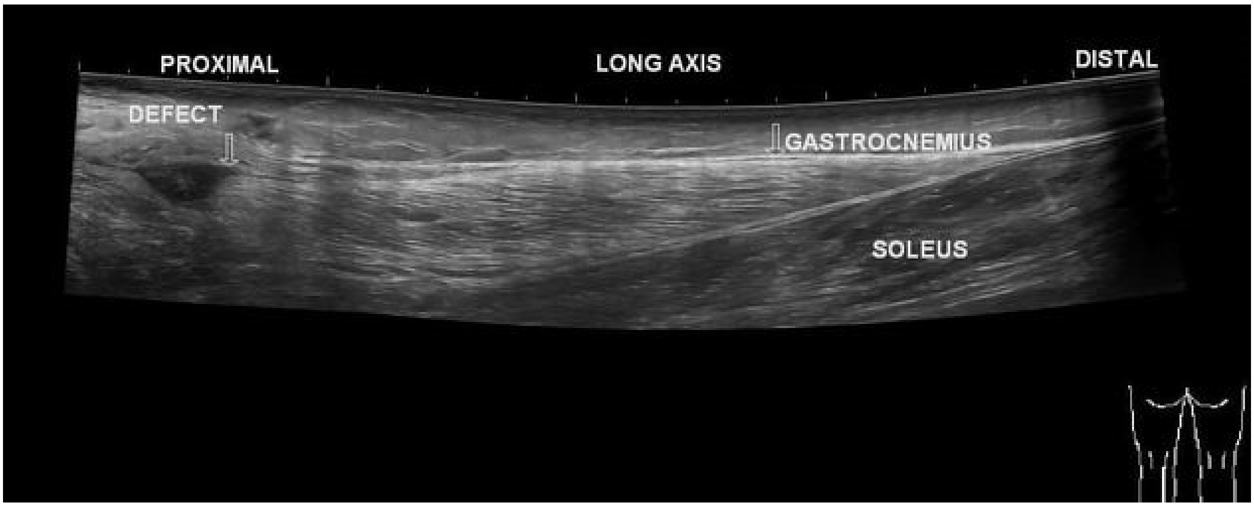

Figure 1. Panoramic ultrasound view reveals a discontinuity of proximal tendon of medial head of gastrocnemius with retraction. The defect is filled with a collection and there is overlying subcutaneous edema.
Case courtesy of Dr Maulik S Patel, rID 61865, Radiopaedia.org (with Permission).

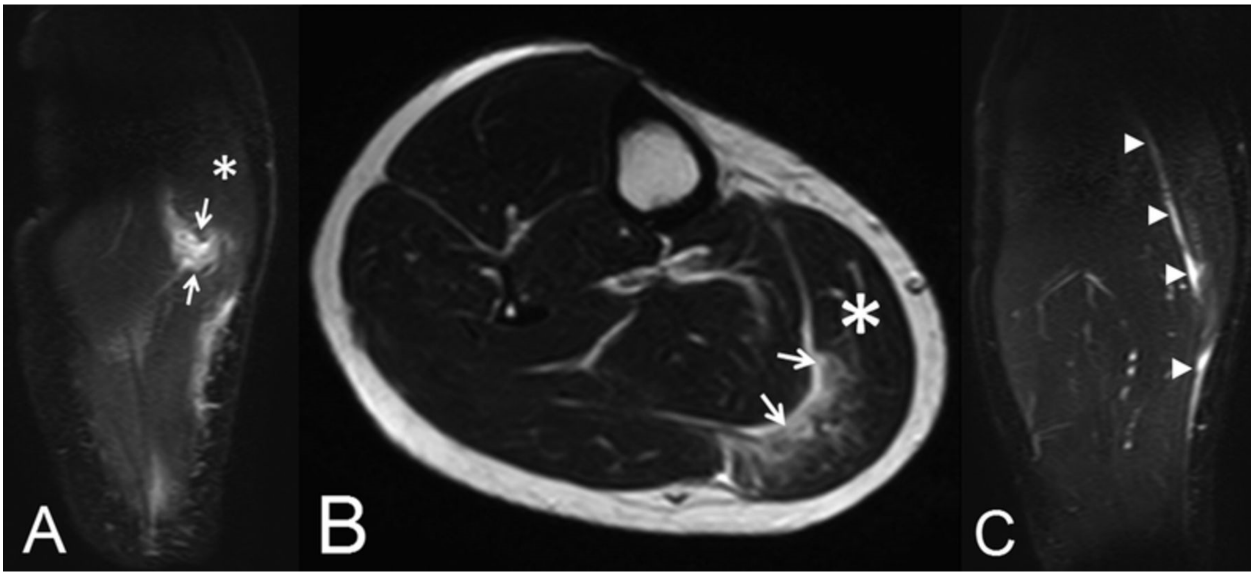

Figure 2. Coronal fat-saturated (A) and axial T2-weighted (B) MRI images reveal a partial tear (indicated by arrows) in the upper region of the right gastrocnemius muscle's medial head (marked with an asterisk). Additionally, a coronal fat-saturated T2-weighted MRI (C) displays a slight presence of fluid (denoted by arrowheads) along the surrounding fascial layer.
Source: Ozyurek, S, et al. (2013). Isolated partial rupture of the medial head of the gastrocnemius muscle (tennis leg). BMJ Case Reports. https://doi.org/10.1136/bcr-2013-009347 (with Permission).

planes. In case of doubt, the US should be performed in the planes above and other locations to exclude other diagnoses (28).

A noncontrast MRI, albeit being an expensive option relative to other imaging modalities, gives a more precise image of the soft tissue injuries and can be indicated in case of discordance between physical examination and US findings, suspicion of subtotal or complete muscle lesions, suspicion of tendon involvement or bone-tendon avulsions and looking for other structural injuries in elite athletes (26, 30). In the case of MGS, MRI should be assessed in the axial plane for muscle contours and musculotendinous junction and in coronal and sagittal planes for the extent of the injury. A normal skeletal muscle will have an intermediate to low signal intensity on T1 and T2-weighted images and short tau inversion recovery (STIR) sequences. Regarding MGS, T1-weighted imaging is suitable for assessing the gastrocnemius medial head's anatomy and degree of intratendinous injury. Like other muscular injuries, edema and fluid collection have a high signal and feathery appearance on T2-weighted and STIR sequences (Figure 2). A common place for hematoma formation is between the medial head of the gastrocnemius and soleus, which has a high signal and V-shaped appearance on sagittal T2-weighted and STIR sequences (31-33).

During the healing process, a persistent high T2 signal indicates an ongoing healing process, which can be seen for weeks to months, even after returning to play. A low T2 signal during the healing process can indicate scar formation or hemosiderin deposition due to previous hemorrhage (26).

Differential Diagnosis

MGS's most common differential diagnoses are strains of other calf muscles (soleus and plantaris) and types of calf muscle injuries—including cramps, contusions, and delayed onset muscle soreness. The different diagnoses with less prevalence include superficial and deep posterior compartment syndromes of the calf, referred pain from the knee, superior tibiofibular joint, lumbar region and other myofascial structures, vascular problems (atherosclerosis, popliteal artery entrapment and endofibrosis of external iliac artery), nerve entrapments (tibial and sural nerve), stress fractures of leg and varicose veins. Deep vein thrombosis (DVT), arterial aneurysm, cellulitis, osteomyelitis, tumors, and distal avulsion fracture of the femur due to traction force of proximal medial head of gastrocnemius, although with far less prevalence, should be taken into account according to clinical suspicion (14,34-40).

Differential diagnosis of MGS and their respective features are presented in Table 1.

Grading System

Diverse systems have been proposed for grading muscle injuries. These systems use different types of criteria for their proposed gradings. Tscholl et al have merged different grading systems based on various criteria—including signs and symptoms, pathologic correlation, and imaging—which are both simple and comprehensive and can be used to grade MGS (41). Therefore, we decided to provide a modified MGS grading based on this classification (Table 2).

Treatment

Accurate and early diagnosis and treatment of MGS can significantly reduce the duration of its related disabilities. Before returning to the previous activity level, a complete recovery of strength and flexibility should be achieved. (23). The treatment process starts with acute injury management and continues with nonoperative or operative treatment based on the clinician's decision.

Operative vs Nonoperative Treatment

Although the cornerstone of treatment in most MGS cases is nonoperative rehabilitation, some cases are referred for early surgical treatment. These early indications include complete and severe rupture of the gastrocnemius medial head, large hematomas, and compartment syndrome (20,42).

In some cases, during or after the completion of nonoperative treatment, some patients may be required to undergo a surgical operation based on some indications, which include severe loss of plantarflexion force where the injury is preventing the patient from returning to the previous level

Table 1. Differential Diagnosis of MGS

Differential Diagnosis	Distinguishing Features	Other Important Points
Soleus strain	• Pain is more commonly felt at the posterolateral aspect of the calf (22). • Pain on passive ankle dorsiflexion or resistive ankle plantarflexion with the knee in the flexed position (22).	• Soleus should be evaluated in patients with suspicion of MGS. • MRI is the imaging modality of choice due to muscle depth and structure (33).
Achilles' tendon injury	• Performing Simmond's triad (Palpation, Matles' test, Thompson's squeeze test) which has 100% sensitivity when two of three tests are positive (36).	• Evaluation of this structure is mandatory in patients suspicious of MGS (20).
Referred pain (from knee, superior tibiofibular joint, lumbar region)	N/A	• Examination and imaging should be done if the patient's history and clinical presentation are suspicious of the mentioned injuries.
Nerve entrapments	• Tibial nerve: Sensory signs and symptoms in the posteromedial of lower leg, posterior and inferior of calcaneus and lateral border of foot (37). • Sural nerve: Sensory Signs and symptoms in the posterolateral aspect of the distal third of the leg and the lateral aspect of the foot, heel, and ankle (38).	• Can happen as a consequence of Hematoma (37, 38). • Motor signs and symptoms are rarely seen in case of tibial nerve entrapment (37).
Arterial Problems	• Intermittent claudication and pain which is being aggravated by walking and running and dissipates with rest (14, 39). • Abnormal peripheral pulses and arterial bruits can be present (14).	• Can be confirmed by Doppler ultrasound, ankle-brachial index and angiography (14, 39).
Deep Vein Thrombosis (DVT)	• Cyanosis, a palpable cord, superficial vein dilation and positive Homan's sign (14, 40).	• DVT can happen in isolation or as a complication of MGS (14). • The diagnosis of DVT should be confirmed by more accurate imaging modalities such as duplex sonogram (14, 22).

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Table 2. MGS Grading

Grade	Amount of Muscle Damage	Clinical Sign and Symptoms	Imaging
Mild	5 -10%	• Mild pain • Mild tenderness, spasm and swelling • Normal Function (minimal loss of strength and range of motion (< 10°)) • Usually able to continue activity	• MRI shows normal muscle structure with or without edema and hemorrhage. Feathery appearance <5% muscle fiber involvement. • US may show muscle disruption < 5%
Moderate	10 – 50%	• Moderate pain • Moderate tenderness and swelling • Palpable defect (>10-25%) • Dysfunctional sprinting (moderate loss of strength and range of motion (10°-25°)) • Unable to continue activity	• MRI shows < 50% tearing with or without retraction. Edema and hemorrhage can be seen. • US shows muscle disruption > 5% with edema and hemorrhage and possible fascial damage.
Severe	> 50%	• Severe pain • Significant palpable defect • Disability in sprinting (severe loss of strength and range of motion (>25°))	• MRI shows complete tearing with or without retraction. Extensive edema and hemorrhage can be seen. • US shows complete muscular and fascial disruption.

of activities, prolonged pain and contractures for more than 4 to 6 months, despite following the nonoperative protocol, and cases with debilitating complications such as fibrosis and heterotopic ossification (20, 43).

Nonoperative Treatment

Generally, MGS nonoperative management and physical therapy take approximately 3 to 6 weeks, depending on the patient's status and injury severity (22). Unfortunately, the literature on the MGS rehabilitation process is few and sparse. However, by summarizing different findings and opinions (18, 22, 30, 44-51), we have reached our 4-phase protocol. The details of this protocol and the rate of progression should be tailored based on the patient's physical condition and the severity of the injury.

Phase 1

• The primary management for MGS, as with other muscular injuries, is to apply the POLICE (Protection, optimal loading, ice, compression, and elevation) principle for approximately 24 to 48 hours after injury.

• Icing and compression by the sleeve (20 to 30 mmHg) should be started initially and continued for at least 1 week until the physician can detect no swelling or hematoma, either by physical examination or US imaging.

• Crutches can be used for ambulation during the first 1 to 2 weeks. Normal weight bearing and walking can be started with and without crutches as tolerated by the patient.

• Using a walking boot with a heel lift on the injured side, which minimizes the stretch on calf muscles, can be an alternative option, and a heel lift can be used for up to 12 weeks during walking. However, some experts recommend bilateral heel lifts (6 mm in height) for much shorter periods.

• Physical therapy modalities can further reduce inflammation and pain and promote the healing process. These modalities include continuous or pulsed low-intensity therapeutic ultrasound (0.5-1W/cm^2), low-level laser therapy, and electrotherapy. Recent consensus recommends against the mentioned modalities due to their endothermic effects (increasing tissue temperature) during the initial 72 hours after injury.

• Soft tissue techniques such as mobilization and massage are contraindicated at this stage, as they may cause bleeding in the injured area.

• Active and passive range of motion exercises can be implanted in pain-free range to recover flexibility (Figure 3). Stretching is prohibited in this phase, as it may exacerbate the injury.

• To restore the strength of the gastrocnemius and other calf muscles, isometric plantarflexion can be started at different angles, followed by isotonic plantarflexion in a nonweight-bearing position (Figure 3). If tolerated, double leg calf raises with extended or flexed knee can be prescribed in this phase.

• For proprioception, Biomechanical Ankle Platform System (BAPS) board training in a nonweight-bearing position is recommended.

• Level 1 core muscle exercises, providing minimal pressure on calf muscles (eg, abdominal draw-in, prone cobra, diagonal crunches) can be done for stabilization of core muscles.

• Cardiovascular fitness can be maintained by upper body ergometer training.

• Milestones for progression to the next phase:

o Resolution of initial swelling/hematoma.

o Pain-free active and passive range of motion within a safe range.

o Isometric plantarflexion without pain and discomfort.

o Walking without pain while maintaining a regular gait pattern.

Phase 2

• In addition to the physical therapy modalities mentioned, soft tissue techniques that were prohibited during the initial phase can be utilized here.

• To improve the range of motion in this phase, nonweightbearing, low load, high duration, static stretching with a towel can be done.

• High velocity nonloaded weightbearing plantarflexion (ie, double and single leg calf raise) can be used in the

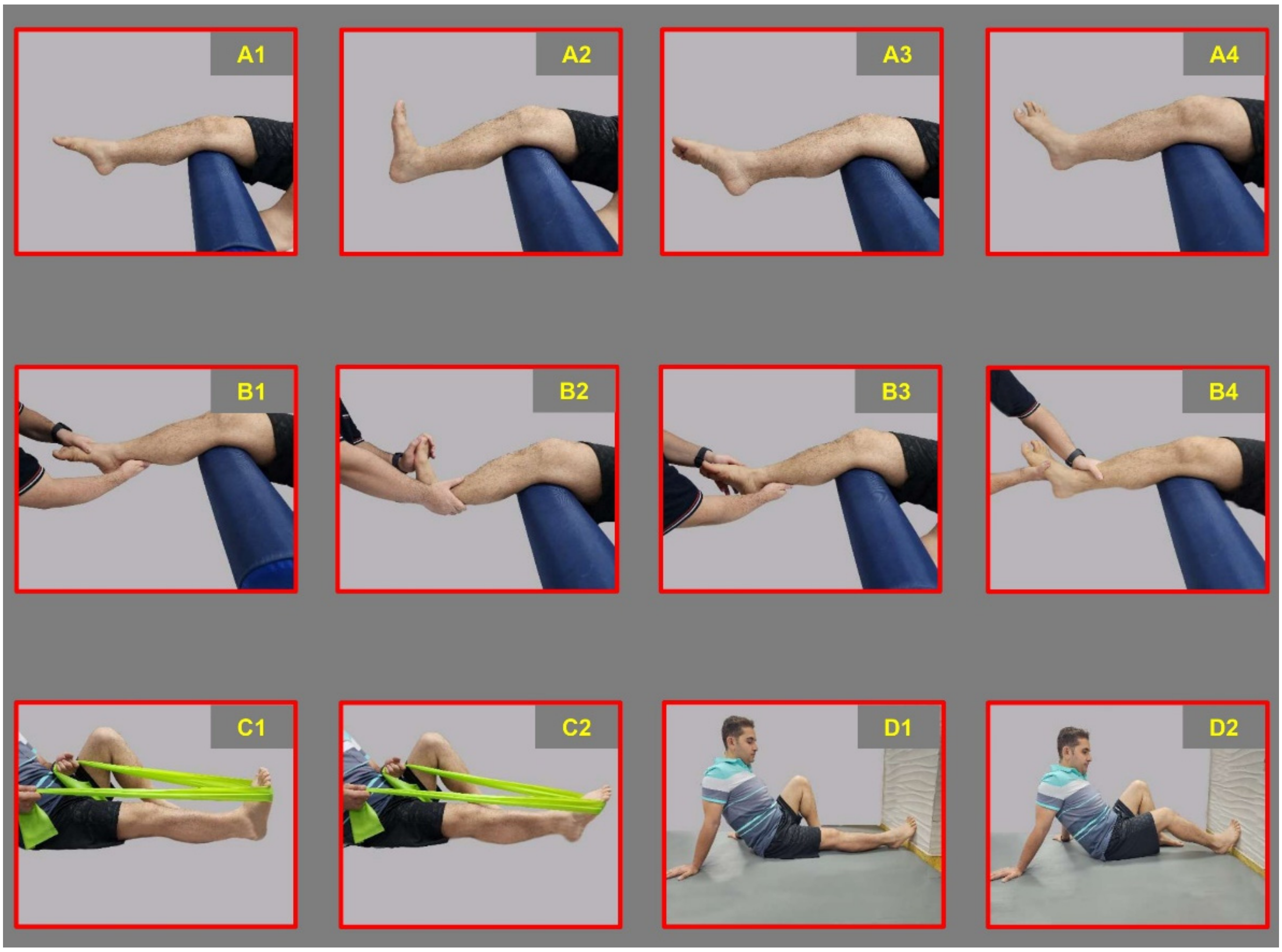

Figure 3. Examples of exercise for phase 1 of MGS Rehabilitation. A- Active ankle ROM with flexed knee (1. Plantarflexion, 2. Dorsiflexion, 3. Inversion, 4. Eversion), B- Passive ankle ROM with flexed knee (1. Plantarflexion, 2. Dorsiflexion, 3. Inversion, 4. Eversion), C- Isotonic ankle plantarflexion with elastic band (1. Starting position, 2. Ending position), D- Isometric ankle plantarflexion against the wall (1. Knee extended, 2. Knee flexed)

strengthening component of this phase, and it can be progressed to loaded exercises (Figure 4).

• Strengthening other ankle movements (eg, dorsiflexion, inversion and eversion) and intrinsic foot muscle exercises can be done in this phase (Figure 4).

• BAPS board training in partial to full weightbearing positions can be prescribed to enhance proprioception.

• Level 2 core muscle exercises can strengthen core muscles by providing mild to moderate pressure on calf muscles (eg, stability ball straight leg raising, prone hip extension, double leg bridging with and without stability ball, stability ball diagonal crunches).

• In addition to upper body exercises, walking and running on gravity-reduced devices or walking in water can be recommended to maintain cardiovascular fitness. All the walking and running exercises in this category should be done on flat and hard surfaces; therefore, inclined and uneven surfaces should be avoided. In addition to the mentioned exercises, stair climbing and stair machines can enhance cardiovascular fitness; however, stair descending is not recommended in this phase.

• Milestones for progression to the next phase:

o Demonstrate 5/5 strength in plantar flexion exercises—including both concentric and eccentric movements without pain.

o Brisk walking without pain

o Performing phase 2 exercises with minimal to no pain.

Phase 3

• Deep transverse friction massage is advised at this stage, as it can enhance the healing process and tissue regeneration.

• Weightbearing, low-load, static stretch with the knee in extended and flexed positions (wall lean stretching) is recommended for flexibility enhancement in this phase (Figure 5).

• Different types of isotonic (concentric and eccentric) exercises can be prescribed in this phase and should be progressed according to the patient's symptoms and tolerability (Figure 5).

• BAPS board training in full weightbearing position with and without posterior peg overload helps enhance proprioception in this phase.

• Level 2 and 3 core muscle exercises, providing mild to moderate pressure on calf muscles (eg, stability ball wall slides, single leg bridge with and without stability ball, and

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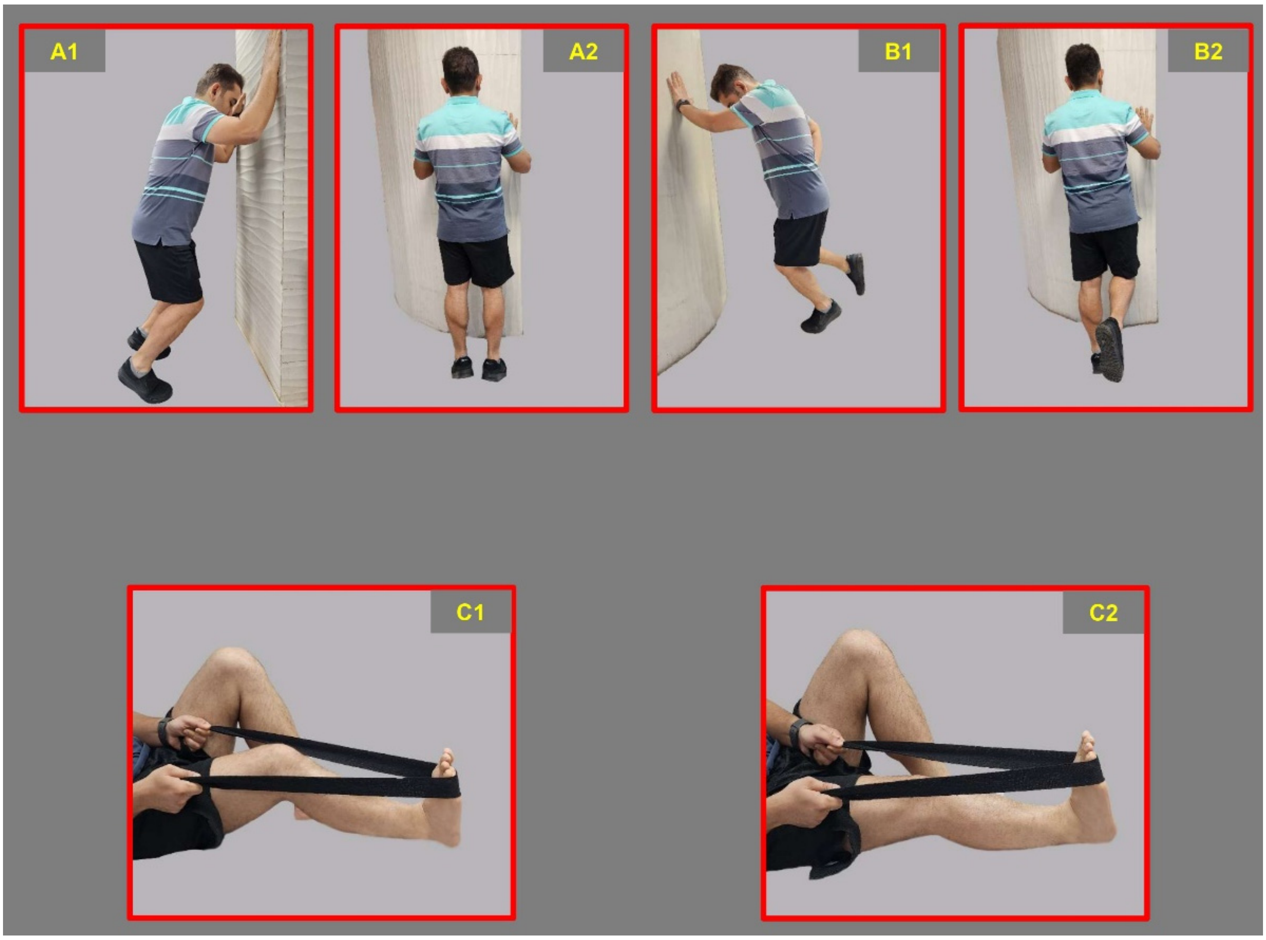

Figure 4. Examples of exercise for phase 2 of MGS Rehabilitation. A- Double leg heel raise (1. Knee flexed, 2. Knee extended), B- Single leg heel raise (1. Knee flexed, 2. Knee extended), C- Calf towel stretch (1. Knee flexed, 2. Knee extended)

stability ball pullover crunch) can be done for increasing strength and power of core muscles.

• Previous aerobic exercises, walking on uneven or inclined surfaces, stationary biking, and stair descending are recommended to enhance cardiovascular fitness in this phase.

• In addition to previous conjunctive exercises (for other ankle movements and intrinsic foot muscles), other lower limb stretches should be commenced in this stage.

• Milestones for progression to the next phase:

o A plantarflexion to dorsiflexion strength ratio of 3-4:1

o Maintain dynamic balance and support on the affected leg.

o Jog or prform light running activities without pain.

o Performing phase 3 exercises with minimal to no pain.

Phase 4

• Flexibility exercises can be done with a combination of static, dynamic, and ballistic stretching exercises.

• Plyometric and functional exercises should be initiated in this phase and should be progressed toward sport-specific exercises.

• Different types of neuromuscular, balance and proprioception exercises (eg, single leg stance on BAPS board, single leg windmill touches, single leg Romanian dead lift, single leg two arm chest press, etc) should be implemented and progressed depending on the patient's condition and function.

• Level 3 core muscle exercises (eg, weighted ball single and double leg jump and weighted ball forward jump from squat) can be done to increase power of core muscles.

• A gradual 5% increase in duration, frequency, and intensity of exercises should be considered.

• Return to running is a crucial part of this phase. Stair exercises such as stair climbing in phase 2 and stair descending in phase 3 can be considered a bridge between walking and normal running.

In this phase, slow running exercises on flat surfaces should gradually progress to running on even and uneven surfaces, followed by sprinting, cutting, acceleration, and deceleration exercises.

It is recommended that before athletes start running in athletic conditions, they be without any signs or symptoms, have normal calf muscle strength, and have normal hopping function.

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Figure 5. Examples of exercise for phase 3 of MGS Rehabilitation. A- Seated heel raise with dumbbell (1. Starting position, 2. Ending position), B- Squat to heel raise (1. Starting position, 2. Ending position), C- Wall lean stretch, D- Tip toe walking, E- Eccentric heel raise

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Operative Treatment

Following acute management of the injury, an early surgical operation is accompanied by a better prognosis relative to chronic cases in patients with surgical indications (42).

Concisely, the operation consists of making a longitudinal incision on the center of the defect and reattaching the proximal and distal ends of the ruptured muscle by sutures with the foot being held in a plantar flexion position (43).

After the surgery, the lower limb is immobilized in a long leg cast for 3 weeks with 60 degrees of flexion of the knee and approximately 30 degrees of plantar flexion of the ankle. This period of immobilization is followed by another 3 weeks of short leg casting with the same degree of ankle plantar flexion. Gradual rehabilitation, in a similar fashion to nonoperative management, should be started after surgery, and weightbearing should be commenced after about 4 to 6 weeks of using crutches (14, 42).

Adjunctive Treatment Methods

Kinesio Taping

Several studies have attributed potential effects to Kinesio taping (KT) with regard to its manipulative effects on mechanoreceptors, nociceptors, proprioceptors, and local blood circulation. These potential effects include motor neuron facilitation, pain reduction, and improved blood circulation (52-54).

Despite these potential effects, clinical evidence about the effect of KT on musculoskeletal injuries is still lacking and is not currently recommended as an adjunctive tool for rehabilitation (55, 56). However, since no serious adverse effects have been reported in KT users and because of its noninvasive nature, it can be offered to athletes who wish to use them.

Dry Needling

Although it has not been evaluated by any study, dry needling, theoretically, may have some benefits in the case of MGS treatment and rehabilitation.

Trigger points are defined as taut points of skeletal muscle, which can be palpated as tender small nodules in muscles. These trigger points are divided into 2 subtypes: active trigger points that cause local and referral pain spontaneously and latent trigger points that may cause stiffness, restriction of range of motion, and muscle fatigue and elicit pain only upon stretch or compression (57, 58).

Muscle stiffness and dull calf pain may be the prodromal symptoms of MGS. Therefore, it is very likely that people at risk or sufferers of MGS have trigger points, especially latent type, in their gastrocnemius muscle.

The use of dry needling to relieve these trigger points not only reduces the pain associated with these trigger points but also enhances the mechanical aspects of the gastrocnemius. Therefore, this procedure can be used to help with preventing, treating, and rehabilitating MGS.

Other mechanisms by which dry needling may help with MGS treatment and rehabilitation include enhancement of perfusion in the injured tissue due to resultant local vasodilation, relaxation of the injured muscular tissue, and short-term peripheral and long-term central analgesic effects (59).

Non-steroidal Anti-inflammatory Drugs

Although controversial, the use of nonsteroidal anti-inflammatory drugs (NSAIDs), especially inhibitors of cyclooxygenase-2, is not recommended for the first 48 hours after injury, as they may slow down the healing process. It has also been hypothesized that NSAIDs may increase the rate of injury recurrence due to their pain-masking properties. Therefore, the better choice for controlling the pain and congestion would be to apply ice and use acetaminophen (46, 60).

Platelet Rich Plasma Injection

Platelet-rich plasma (PRP) is a biological agent which is obtained by centrifuging blood and extracting its plasma with a high concentration of platelets. Containing various types of cytokines and growth factors, the effects of PRP on the repair of various injured tissues have been the focus of many studies (61).

Multiple studies have evaluated the effect of PRP on acute muscle injuries. Despite significant heterogeneity among their methods and outcome measures and controversial results, PRP injections have shown potential benefits on multiple treatment outcomes such as reduction of pain and swelling, acceleration of the healing process, and faster return to play with the last one being the most promising (62, 63).

Regarding the particular effect of PRP on MGS, a retrospective study by Borrione et al showed that 3 PRP injections at the first visit and then 1 and 3 weeks later, may have beneficial effects on immediate pain and discomfort of the patients, which in turn can help with the acceleration of rehabilitation process. This study also showed that injured patients may recover faster and return to play compared with patients who went under standard rehabilitation protocol without PRP injections (64).

Corticosteroid Injection

The potential effects of corticosteroids on the inhibition of inflammation and consequent reduction of pain and swelling have made it an available option for the acceleration of the rehabilitation process, although few studies have been in favor of this theory (65).

In contrast to hypotheses, most studies have shown a detrimental effect of corticosteroids on muscle injuries and their healing process, especially in the long term, because of multiple mechanisms such as myotoxicity, irreversible damage to the structure and function of the healing muscle fibers, hindering the absorption of hematoma, and adverse effects on neuromuscular properties (66, 67).

In conclusion, corticosteroid injection is not recommended in the case of MGS.

Hyaluronic Acid Injection

Hyaluronic acid positively affects muscle proliferation in vitro and animal models (68-70). Although it has been shown that hyaluronic acid can improve function and pain in certain musculoskeletal and soft tissue injuries, its certain effect and superiority to other types of treatments remain a doubt to date (71). Therefore, hyaluronic acid injection is not recommended for MGS treatment at this time.

Prolotherapy

Prolotherapy consists of multiple injections of irritant solutions such as hypertonic saline or dextrose into degenerated or injured musculoskeletal tissues to start an inflammatory process and release mediators that eventually lead to healing and recovery of the target tissue (72, 73).

In vitro and animal studies have shown that prolotherapy may trigger cell proliferation and neovascularization, and even theoretically, it may have analgesic properties. (74, 75).

Although prolotherapy has shown promising positive effects on pain and function in different types of tendinopathies and osteoarthritis, investigations are few and restricted to chronic cases (73, 75).

Until further studies on the effects of prolotherapy, especially on acute muscle injuries, prolotherapy is not recommended in the case of MGS.

Actovegin

Injection of highly purified deproteinized calf serum derivate, also known as Actovegin, has shown promising effects in muscle repair because of its antioxidant, antiapoptotic, proliferative, and endothelial enhancing aspects. However, because of the lack of sufficient evidence to support its benefit in treating muscle injury, experts do not recommend this method (47, 76, 77).

Traumeel

Traumeel, a mixture of herbal and mineral extracts, is a homeopathic agent believed to have comparable anti-inflammatory and analgesic properties to NSAIDs with fewer adverse effects. It can be administered as tablets, drops, injection solution, ointment, and gel (78). Since studies on the effect of Traumeel on muscle injury are still sparse, use of this agent is not recommended in patients with MGS.

Return to Play

The literature on the time and criteria of return to play among those who suffered from MGS is few to date; nonetheless, some recommendations for athletes to return to play after MGS can be stratified as follows:

• Full resolution of self-reported symptoms, for example, pain, tightness, and cramps, et cetera.

• Full resolution of clinical signs, for example, tenderness.

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• Psychological readiness and acceptable self-confidence.

• Recovery of strength, power, endurance, and dorsiflexion range of motion with less than 10% asymmetry compared with the uninjured side.

• Ability to perform sport-specific tasks and return to full training for at least 1 session (45).

MGS Algorithmic Approach

Figure 6 provides an algorithmic approach, which can be a helpful guide for clinicians in the case of MGS.

Ethical Considerations

None.

Acknowledgment

Declared none.

Conflict of Interests

The authors declare that they have no competing interests.

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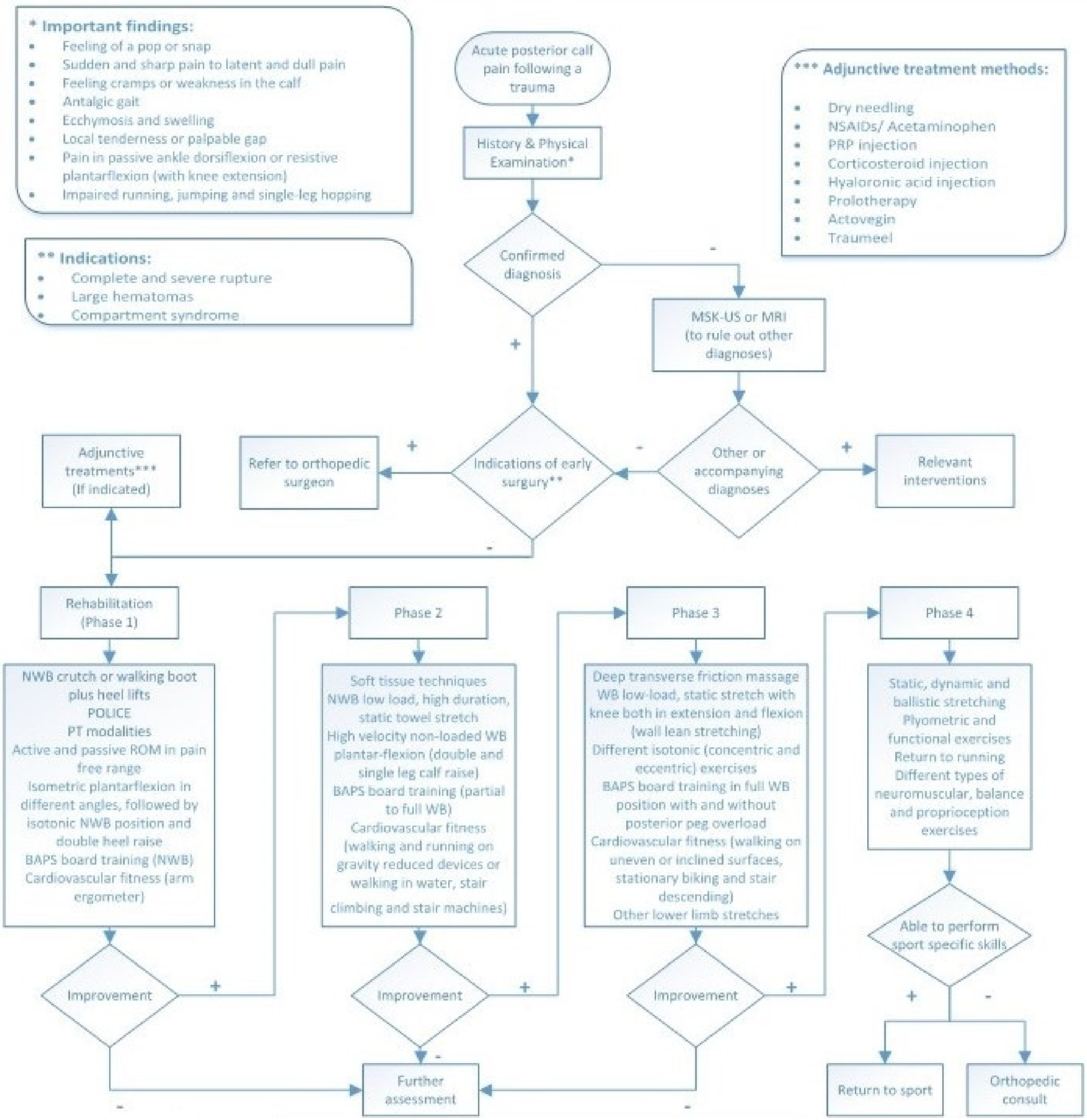

Figure 6. Algorithmic approach to MGS

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