ISMuLT Guidelines for muscle injuries

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Summary

Muscle injuries are frequent in high demand sports. No guidelines are available in the scientific literature. ISMuLT, the "Italian Society of Muscles, Ligaments and Tendons", in line with its multidisciplinary mission, is proud to cover this gap.

KEY WORDS: muscles injuries, classification, guidelines.

Introduction

Muscle injuries are frequent in high demand sports, accounting for 10 to 55% of all acute sports injuries [1]. The muscles and muscle groups more frequently involved are the hamstrings, rectus femoris, and the medial head of the gastrocnemius. Although the diagnosis is usually clinical, imaging tools are often advocated to better identify the extent and site of lesion, which can be relevant prognostic factors predictive of recovery time, return to pre-injury sport activity, and risk of recurrence [2-5].
A number of treatments is available for muscle injuries, including the PRICE and POLICE protocols, passive and active stretching, physical therapies, functional rehabilitation and general athletic reconditioning. The present guidance includes several treatments that have been used for the management of muscle injuries, and aims to reduce the uncertainty and variations in practice that remain in some areas of their diagnosis and management. Up to date recommendations are provided on:
- Classification of muscle injuries;
- Diagnosis: clinical and at imaging;
- The most effective method of management based on type of lesion.

Patient-centred care

This guideline offers available best practice advice on the care of patients with suspected or diagnosed muscle injuries. This guideline is not meant to replace present optimal practice in experienced hands. In all health care systems, patients and healthcare professionals have rights and responsibilities; this should be taken into account when trying to apply the present guidance to one's practice. Management and care should take into account individual needs and preferences; patients should have the opportunity to make informed decisions about their care and man-

agement, in partnership with their healthcare professionals. If the patient is under 18, their family or carers should also be given information and support to help the child or young person to make decisions about their management.
Healthcare professionals should follow the local advice on obtaining informed consent on diagnosis and treatment. If someone does not have capacity to make decisions, healthcare professionals should follow the accepted code of practice in their own settings.

Information and decision support for patients with muscle injuries

- Offer patients individualized information tailored to their own needs. Ascertain the extent to which the patient wishes to be involved in decision-making and ensure that he has sufficient information to do so. This information should be given by a healthcare professional, and may be supported by written and visual media.
- Discuss all relevant management options recommended in these guidelines with patients with muscle injuries and, if athletes, their sport physicians, irrespective of whether they are available through local services.
- Tell patients:
  1) about treatment options and their risks and benefits in an objective, unbiased manner and
  2) that there is limited evidence for some treatment options.
- Adequately inform patients with muscle injuries and, if athletes, their team sport physician or carers about the effects of treatment and the consequences of inadequate management on their recovery, return to sport and daily activity, risk of recurrence, and complications.
- Offer athletes the opportunity to talk to a healthcare professional experienced in dealing with sport injuries at any stage of their management.

Classification

According to the mechanism of trauma, muscle injuries may be distinguished as direct and indirect (Tab. 1).

After direct trauma

Contusion: it is an insult due to a direct trauma against the opponent or a sport related tool, classified as mild, moderate and severe according to the functional disability which may follow. The athlete has to be re-examined 24 hours later to better assess the entity of the injury as the pain may be disabling immediately, with the risk of overestimating the lesion.
Laceration: it arises from an impact against a sharp surface.

After indirect trauma

These injuries are classified as non structural and structural[6]. In non structural injuries, the muscle fibres do not present an anatomically evident lesion; structural injuries present an anatomical lesion.
Non structural injuries: the most common, accounting for 70% of all muscle injuries in soccer players, cause of more than 50% of days of absence away from sport activity and training. When neglected, they may become structural injuries.
- Type 1A injury: caused by fatigue and changes in training protocols, running surfaces, and high intensity activities.
- Type 1B injury: from excessive and prolonged eccentric contractions.
- Type 2A injury: mainly associated with spinal disorders, often misdiagnosed, as it occurs in minor inter-vertebral disorders (MID) which irritate the spinal nerve, altering the control of the muscle tone of the "targeted" muscle.
- Type 2B injury: from an unbalanced control of the neuro-musculoskeletal system, mostly of the mechanism of mutual inhibition coming from the muscle spindles.

Structural injuries
- Type 3A injury: a minor partial lesion involving one or more primary fascicles within a secondary bundle.
- Type 3B injury: a moderate partial lesion involving at least a secondary bundle, with less than 50% of breakage surface.
- Type 4 injury: a sub-total tear with more than 50% of breakage surface or a complete tear of the muscle, involving the belly or the musculotendinous junction.

Structural injuries may be proximal (P), middle (M), and distal (D). Specifically, the prognosis of proximal lesions of hamstring muscles and rectus femoris is worse than that of same sized injuries involving the middle or distal portion of these muscles. In the triceps surae, distal injuries present the worst prognosis.

Diagnosis: clinical assessment

Diagnosis of muscle injury is mainly based on history and clinical examination.
- A contusive injury is usually characterized by immediate pain onset, direct insult, and increasing symptoms in relation with size and entity of hematoma. Active range of motion is reduced, with impossibility to train and compete.
- Non-structural injuries determine soreness, heaviness and stiffness of the muscle, usually during exercise, at times at rest. On palpation, stiffness of some muscle bundles may be appreciated.
- Delayed Onset Muscle Soreness (Type 1B) are associated with pain at rest, some hours after sport activity, and muscle stiffness.

Table 1.

INJURY		TYPE	CLASSIFICATION	DEFINITION	SIMPTOMS	CLINICAL EXAMINATION	Ultrasound MRI findings		PROGNOSIS
INDIRECT	**NON STRUCTURAL INJURY**	**I**: Fatigue Muscle Disorder	**1A**: fatigue injury	Localized increase of muscle tone, painful, within the muscle. 1B: diffusely increase of muscle tone and pain after physical activity.	Soreness, heaviness and stiffness of the muscle, usually increasing during exercise, at times present at rest.	On palpation, it is possible to appreciate stiffness of some bundles. Stretching exercises improve symptoms, except in 2A in which stretching may be painful. 1B: the whole muscle is stiff on palpation.	US: often negative; transient hyperecoic or hypoecoic changes at times, after 3-5 days; Power Doppler Us: negative. MRI: negative; evidence of limited edema at times		5 - 15 days
			1B: DOMS (Delayed Onset Muscle Soreness)						
		II: Neuromuscolar Disorder	**2A**: neuromuscolar disorder related with pelvic and spinal disorders						
			2B: muscle related neuromuscolar injury						
	STRUCTURAL INJURY	**III**: Partial muscle lesion	**3A**: minor partial lesion	Minor partial lesion involving one or more primary fascicles within a secondary bundle.	Sharp pain, evoked by a specific movement. Pain is well localized, easy to appreciate on palpation and, at times, preceded by a snap sensation.	On palpation, it is not possible to detect the structural defect as it is too small. Symptoms become more apparent when stretching and against resistance.	US: slightly hyperechoic area which, later, becomes inhomogeneous and hypoechoic, well localized, with some structural disarray; it is possible to detect a small anechoic area within the muscle. MRI: edema imbibition and mild inhomogeneous signal hyper-intensity because of the interstitial and peri-fascial edema or small hemorrhagic extravasation.	**P - M - D**	15 - 18 days

Table 1. (cont.)

INJURY		TYPE	CLASSIFICATION	DEFINITION	SIMPTOMS	CLINICAL EXAMINATION	Ultrasound MRI findings		PROGNOSIS
INDIRECT	**STRUCTURAL INJURY**	**III**: Partial muscle lesion	**3B**: moderate partial lesion	Moderate partial lesion involving at least a secondary bundle, with less than 50% of the muscle being involved.	Acute pain, sharp, evoked by a specific movement. A snap may be appreciated, immediately followed by localized pain and functional disability, up to induce the athlete to fall down.	On palpation, pain is localized and the structural defect may be appreciated, with possible evidence of hematoma a few days later, especially when the epymisium or perimisium are involved. Stretching test is positive, and contraction against resistance is usually impossible.	US: hyperechoic area which becomes markedly inhomogeneous, with evidence of structural disarray, and a wide anechoic area within and outside the muscle. MRI: the muscle is enlarged because of edema imbibition, with inhomogeneous hyper-intensity related to interstitial and peri-fascial edema or hemorrhagic extravasation.	**P - M - D**	25 - 35 days
		IV: (Sub)total muscle lesion	**4**: subtotal or total lesion or tendon avulsion	Sub-total tear with more than 50% of the muscle being involved, or a complete tear of the muscle or involving tendon bone junction.	Dull, oppressive pain exacerbated by a specific movement; snapping and functional disability appear immediately.	The interruption within the muscle may be palpated, and the hematoma occurs early. The function of the musculotendinous junction is lost.	US: severe inhomogeneous and disorganized areas, iso- or hyperechoic. Successively, inhomogeneity and marked structural changes, retraction of the ends of the ruptured muscle, and wide anechoic area within the muscle and between muscles and muscle ends. MRI: muscle end retraction, hyper-intense fluid caused by hemorrhagic extravasation between the 2 muscle ends.		≥ 60 days

Table 1. (cont.)

INJURY	TYPE	CLASSIFICATION	DEFINITION	SIMPTOMS	CLINICAL EXAMINATION	Ultrasound MRI findings	PROGNOSIS
DIRECT	Contusion	**Mild:** >1/2 ROM	Localized or diffuse hematoma after direct trauma associated with pain and reduced range of motion.	Dull pain at injury time, increasing pain from the pressure exerted by the increased size of the hematoma. The athlete may be able to continue sport activity.	Hematoma, pain during motion, swelling, diminished ROM, pain on palpation based on severity of the impact.	Localized or generalized hematoma of different sizes	2- 5 days
		Moderate: <1/2 e >1/3 ROM					7 - 15 days
		Severe: <1/3 ROM					15 - 25 days
	Laceration						

Legends: **P: Proximal Lesion**
M: Middle Lesion
D: Distal Lesion

- Type 2B injuries are painful: patients report cramps, often improving after adequate stretching. At times, repeated fatigue related or neuromuscular disorders may indicate subclinical muscle pathologies, unmasked by intense loading training protocols.
- The serum levels of enzymes, markers of the functional status of the muscle have to be taken into account. Increased levels of these markers may indicate cell necrosis and tissue damage related to intense acute or chronic muscle stress. Persistently high creatin kinase (CK) levels at rest may indicate a subclinical genetic muscle disorder which may be unmasked by training, with occurrence of fatigue, DOMS, and persistent contractures [7].

Structural injuries

- Type 3A injuries are characterized by sharp well localized pain, evoked by a specific movement, easy to appreciate on palpation and, at times, preceded by a snap sensation. It is not possible to detect the structural defect on palpation as it is too small; muscle contraction against manual resistance is painful.
- Type 3B injuries are associated with acute pain, sharp, evoked by a specific movement, snap sensation followed by localized pain and functional disability. On palpation, pain is localized, and the structural defect may be appreciated.
- Type 4 injuries are characterized by dull, oppressive pain exacerbated by a specific movement; snapping and functional disability appear immediately. The interruption within the muscle may be palpated, the hematoma occurs early. There is no function of the musculotendinous junction.

Imaging assessment

To help patients to decide whether to have imaging (US and MRI) assessment, discuss with them their clinical features and suspicion, possible co-morbidities, and any history of a previous sport injury.

- Give patients and their sport physicians or carers information, support and adequate time to decide whether or not they wish to undergo imaging evaluation. Include an explanation of benefits of imaging.
- If the clinical suspicion of muscle injury is high, because of the presence of a palpable defect and evidence of hematoma and functional disability, tell patients that imaging allows to assess extent and site of lesion.

Ultrasound scanning

Ultrasound scanning (US) can be used as a first level diagnostic tool, and, in concert with accurate clinical examination and subjective patient-centred evaluation, can be useful to monitor the healing process of the lesion from the fourth stage. However, clinicians should keep in mind that there could be dissociation between clinical and imaging features. It is cheap, and fast to perform. It allows staging of almost all muscle lesions, and assessment of their evolution and complications. US has a 77% sensitivity for non-structural, and a 93% sensitivity for structural injuries. US allows to diagnose a structural injury of the muscle 36 to 48 hours after the trauma, as the peak of hemorrhagic edematous collection is observed after 24 hours, and up to 48 hours, when it will start to decrease [8].

- US monitoring: assess again the lesion 2, 4 or 5 days after the trauma.
- Dynamic US examination: for assessment of both elongation and dislocation of tertiary bundles, and the extent of the lesion [9].
- Use Colour Doppler and Power Doppler:

1) to visualize the course of arteries and veins, and quantify the amount of blood within the muscle.
2) to depict the hypervascularity within the scar tissue of the lesion: this would be indicative that the reparative scar tissue in the site of lesion is unstable.

Magnetic Resonance Imaging

Magnetic Resonance Imaging (MRI) is a multi-parametric diagnostic tool, for detection of also minimal changes. It has a 92% sensitivity for non-structural injuries[10]. MRI allows wide evaluation of deeper muscles difficult to examine at US [9].

- Use MRI to measure changes in volume, structure, and signal intensity of the muscle, and define properly the extent of the lesion [11].

MRI indications:

1) prognosis of non-structural injuries in professional and high level athletes;
2) exclusion of a structural injury in professional high level athletes when clinical and US findings are discordant;
3) assessment of muscles difficult to examine at US;
4) in subtotal or complete muscle lesions, when suspecting tendon involvement or bone-tendon avulsions.

Contrast medium MRI (Gadolinium): for monitoring stability of scar tissue after structural injury.

Imaging features

Non structural injuries: US: often negative; transient hyperecoic or hypoecoic changes at times, after 3-5 days;
Power Doppler Us: negative.
MRI: negative; evidence of limited edema at times[6].

Structural injuries: Tell patients that it may be difficult to differentiate mild from moderate partial injuries, es-

pecially when the lesion is small. Given the presence of liquid, MRI methodic may overestimate the entity of the injury [6].

Type 3A

US: slightly hyperechoic area which, later, becomes inhomogeneous and hypoechoic, focalized, with some structural disarray; it is possible to detect a small anechoic area in the context of the muscle.
MRI: edema imbibition and mild inhomogeneous signal hyper-intensity because of the interstitial and peri-fascial edema or small hemorrhagic extravasation.

Type 3B

US: hyperechoic area which becomes markedly inhomogeneous, with evidence of structural disarray, and a wide anechoic area within and outside the muscle.
MRI: the muscle is enlarged because of edema imbibition, with inhomogeneous signal hyper-intensity related to interstitial and peri-fascial edema or hemorrhagic extravasation.

Type 4

US: severe inhomogeneous and disorganized areas, iso or hyperechoic. Successively, inhomogeneity and marked structural changes, retraction of the ends of rupture and wide anechoic area within and between muscles.
MRI: muscle end retraction, hyper-intense fluid caused by hemorrhagic extravasation between the 2 muscle ends.

Management

- Advise patients that most muscle injuries respond well to conservative management. The main indication to surgery, depending on the sport activity and the muscle group involved, is a subtotal or complete lesion of the muscle belly or an avulsion of the tendon[12].

First stage (first 2-3 days after injury)

- Inform patients that local therapy using heat or ice and heat may be combined with moderate exercise (active and passive stretching) as tolerated. Short applications of heat aim to reduce muscle contracture, neural tension, and increase flexibility[13]. It is important however not to apply heat on the muscle, as long as a structural injury is not excluded.
- Recommend athletes with severe lower limb lesions to walk with crutches and avoid excessive lengthening of the injured muscle.

1) PRICE protocol (Protection Rest Ice Compression Elevation): indicated in the early stage, before the structural lesion has been documented.
2) “POLICE” (Protection Optimal Load Ice Compression Elevation) protocol[14].

- Optimal load: the injured muscle rests, but a balanced progressive rehabilitation program should gradually introduce controlled mechanical stresses, different according to the affected site, and athletic feats determined by involved muscles [14].

3) Manual therapy: specific massages, aiding the drainage of the tissues compromised, close to the site of injury to improve the disposal of inflammatory catabolites.
4) Functional compressive bandages: to reduce local pressure, improve pain, and optimize the effects of physiotherapy and rehabilitation.
5) Low Level Laser Therapy (LLLT), pulsed ultrasound therapy, and electroanalgesia.

Second stage

- At this stage, recommend patients to undertake training and rehabilitation protocols supervised by an experienced physiotherapist. Recommend that all the protocols must be administered in the absence of pain, respecting the healing process, and time of recovery. Muscle stretching: passive, assisted or active for muscle lengthening and muscle flexibility.

1) Neural mobilization (neurodynamics) for de-tension of peripheral neural structures, and to increase local flexibility of the muscle.
2) Isometric, isotonic, concentric and eccentric training: to start when isometric training against resistance is possible without any pain. Recommend to start undertaking these exercises without resistance, to increase the load progressively[13], and to start eccentric exercises after concentric training is painless.
3) Sensorial motor training: balance exercises on stable or unstable surfaces, different in size and shape, with or without request of additional cognitive tasks, with or without the support of the visual system.
4) Core stability exercises: to improve postural and neuromuscular control, and prevent recurrences.
5) Instrumental physical therapy modalities: termotherapy, High Level Laser Therapy (HLLT), and continuous ultrasound.

Third stage

- Functional rehabilitation and general athletic reconditioning. An experienced physiotherapist is needed.

1) Sport specific rehabilitation which involves the metabolic system, specific and individualized training protocols, fitness and strength training.

2) Multi-modal approach to improve sensitive and motor abilities, muscle resistance and strength[15]. Isokinetic and complex "multi task" exercises (including cognitive tasks) are started[15].

Fourth stage

- Athletic reconditioning and specific strength. An experienced physiotherapist is needed.

1) Start high intensity training protocols based on strength, athletic reconditioning, and sport specific abilities[16].
2) Plyometric, ballistic and isonertial exercises are started.
3) Ability to repeat series of sport specific movements, which had caused the traumatic insult.

Fifth stage

Return to competition

1) Gradual return to full activity
2) Rehabilitation training to prevent recurrences or new injuries.

The role of non steroidal anti-inflammatory drugs is controversial. Since these drugs inhibit the initial inflammatory responses, their use is not recommended as they may alter the natural healing, with a negative impact on the repair process [17,18].

Surgery

Surgery can be required in some patients with complete or subtotal muscle tears. We point out that this type of intervention is specialized, and few centres have experience in the management of this particular type of patients. These guidelines do not cover the actual techniques used to repair surgically complete/subtotal muscle tears. In general:

- Muscle sutures:
  - simple: Kessler and eight matress configurations
  - complex: modified Kessler, Masson-Allen, perimisial and epimisial sutures.
- Complex sutures are more resistant to traction and tensile loading, with lower risk of pullout [19].

New products

This is an expanding area. We are aware that a greater number of health care professionals is using biological factors to favour healing of muscle injuries. However, we point out that, despite relatively widespread use, the scientific evidence behind such products is scanty, and the results probably less dramatic than what reported in the lay literature.

Platelet-rich plasma (PRP) is used to promote the healing[20].

Losartan is an angiotensin II receptor antagonist drug used mainly to treat hypertension. When used 3 to 7 days after the injury, it reduces the process of fibrosis, and promotes healing by stimulating regeneration and angiogenesis [21,22]. Large studies are however lacking.

Return to sport:

The following are guidelines only, and we strongly suggest that the injured individual is assessed serially by fully trained health care professionals with a special interest in these injuries.

Direct Injuries:

Contusion
- Mild: 2 - 5 days;
- Moderate: 7 - 15 days;
- Severe: 15 - 25 days

Laceration: variable.

Indirect Injuries:

Non Structural: 5 - 15 days.

Structural

- Type 3A: 15 - 18 days;
- Type 3B: 25 - 35 days;
- Type 4: ≥ 60 days.

These guidelines will be updated on a regular basis to reflect the expanding body of knowledge in this field.

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