Multifarious Manifestations of Muscle Disease

Sports Injury and Other Trauma

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Highlights

- The incidence of muscle injury and muscle groups affected vary by sport; the most commonly injured extremity muscles are the hamstrings, rectus femoris and gastrocnemius.
- MRI plays a pivotal role in the work-up of muscle injuries and can precisely classify and grade muscle injuries based on characteristic imaging features.
- MRI is also helpful in diagnosing chronic sequelae of muscle injury, including atrophy and fatty infiltration and scar formation.

Target Audience

Radiologists, sports medicine physicians, orthopedic surgeons, primary care physicians, and other clinical care providers who will benefit from detailed knowledge on the use of MRI for evaluating muscle injuries in sports.

Objectives

1. Recognize the role of sports injury in the pathogenesis of muscle diseases.
2. Describe the MRI appearance of normal and injured muscle from direct and indirect trauma.
3. Review the MRI classification and grading of muscle injuries.
4. Discuss chronic sequelae of muscle injury and their MRI appearance.

Background

Muscle injuries account for up to one-third of all sports-related injuries in elite sport[1-3]. Muscle injuries result from direct trauma (leading to contusions or lacerations), or indirect trauma following excessive eccentric force along the muscle–tendon–bone axis (leading to tears). MR imaging of sports-related muscle injury has been extensively described, and is pivotal in the investigation of muscle injury in establishing a precise diagnosis, guiding management and aiding with prognosis[4, 5].

Methods

MRI Indications: The precise diagnosis and severity of a muscle injury may be difficult to determine clinically. MRI may therefore aid in determining the precise location and nature of the injury, exclude other pathology (such as traumatic osseous or ligamentous lesions), and grade and classify the injury, which help in determining treatment, prognosis, and potential complications.

MRI Technique: While MR examinations should be tailored for each patient, some general guidelines about MR imaging of muscle injury include the following: 1) the appropriate coil should be chosen for the specific anatomic area. Generally, only one limb needs to be scanned. 2) While MR protocols may vary between institutions, certain common sequences are suggested. T1-weighted imaging is important for assessing the presence of blood products and the presence of atrophy or mature myositis ossificans; at least one fat-suppressed fluid-sensitive sequence such as short tau inversion-recovery or fat-saturated T2-weighted or proton density imaging is essential for detecting edema and hemorrhage in a muscle. Gradient-echo imaging may be considered since 'blooming' artifact due to paramagnetic effects accentuates hemosiderin, post-operative changes, and foreign bodies. Gadolinium contrast material is generally not indicated in the imaging of muscle injuries. Advanced techniques such as diffusion tensor imaging (which shows promise in the detection of early muscle abnormalities that are occult on conventional MRI) have been studied but are not yet standard clinical use[6].

Results

Direct Muscle Injury: This is most commonly due to blunt trauma secondary to a direct blow to the limb. (Penetrating injuries are a less common cause.) The severity of the injury ranges from a small muscle contusion to a large inter- or intra-muscular hematoma. The size of the hematoma does not always correlate with loss of function and length of recovery time. On MRI, muscle contusions have a characteristic feathery, infiltrative high signal on fat-suppressed fluid-sensitive sequences, without muscle fiber discontinuity.

Indirect muscle injury: These common injuries result in disruption of muscle fibers during eccentric muscle contraction. These injuries commonly occur in muscles that span two joints and have a high proportion of fast twitch fibers. Though the incidence and muscle groups affected vary by sport, the most commonly injured extremity muscles are the hamstrings, rectus femoris and gastrocnemius. MRI characteristics include disruption or discontinuity of muscle fibers, muscle edema, and inter- or intramuscular hematomas.

Complications of Muscle Injury: 1) The majority of muscle healing occurs by scar formation[7]. On MRI, scar tissue within muscle is hypointense on all sequences, and may be accompanied by adjacent areas of muscle atrophy. 2) Myositis ossificans, referring to heterotopic ossification within a muscle, is typically secondary to blunt trauma to the muscle; neurologic insults or bleeding dyscrasias are other known etiologies. MRI features of myositis ossificans may be non-specific and mimic a soft tissue sarcoma; radiographs or computed tomography are key to this diagnosis. 3) Muscle atrophy and fatty infiltration

are well recognized sequelae of muscle injuries or other insults. MRI hallmarks are loss of muscle bulk and increased fat signal within a muscle, respectively.

Discussion

The terms 'classification' and 'grading' refer to different processes. Classification refers to describing or categorizing an injury, whereas grading indicates the severity of an injury. Grading systems are important for muscle injuries since they (should) provide prognostic value and therapeutic guidance.

The term 'muscle strain' is the one of the most commonly used term to describe indirect muscle injuries. Both Peetrons[8] and Takebayashi *et.al*[9] proposed similar ultrasound-based three-grade classification system ranging from a grade 1 injury with less than 5% of the muscle involved, grade 2 presenting a partial tear with more than 5% of the muscle involved and up to grade 3 with a complete tear. The currently most widely used classification is an MRI-based one using 4 grades: grade 0 with no pathological findings, grade 1 with a muscle edema only but without tissue damage, grade 2 as partial muscle tear and grade 3 with a complete muscle tear[10].

Because of the lack of consistency in the use of the term 'muscle strain' and a somewhat simplistic 3-grade system of muscle injuries (thought to be lacking in diagnostic accuracy and providing limited prognostic information), there have been a number of proposals suggesting other grading systems[11]. These include the Munich consensus, which classifies injuries into either 'functional' or 'structural' in nature, and where the 'partial muscle tear' is further graded into' minor' or 'moderate'[12]. The British athletics classification is based on extent (grade 0-4) and site of injury[13].

Conclusion

Traumatic muscle lesions have a wide spectrum of injury mechanisms, imaging appearances, treatments and prognoses. MR imaging accurately depicts muscle injuries and plays a pivotal role in helping the clinician determine the precise diagnosis and help guide treatment.

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