



# The hypointense soft tissue tumors on T2-weighted images

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Learning objectives

LEARNING OBJECTIVES



Fig.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

# Background

BACKGROUND

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## BACKGROUND

- The most frequently seen MRI pattern of soft tissue tumors is hypointensity on T1-w images and hyperintensity on T2-w images. Unfortunately most of these lesions are indeterminate and should be biopsied.
- On the other hand, despite less frequent, some soft tissue tumors can be diagnosed based on their MRI signal characteristics. Low signal on T2-w images is such an important example of that.
- A mass that is lower in SI than skeletal muscle on T2weighted MR images is considered to be hypointense.
- Substances that appear hypointense on T2-weighted images include fibrosis, hemosiderin and calcification.

#### Fig.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

# Imaging findings OR Procedure details

**IMAGING FINDINGS** 

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*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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### 1. LESIONS CONTAINING FIBROSIS

 Lesions with fibrotic components tend to have low T2 SI because of a relative lack of mobile protons associated with their hypocellular densely collagenous matrix.

 Masses that are composed of fibrotic material represent a broad spectrum of benign and malignant lesions, including fibrotic scars, fibromas, Morton's neuroma, desmoid tumors and some fibrosarcomas.

#### Fig.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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## 1. LESIONS CONTAINING FIBROSIS

 T2 hypointensity in lesions such as giant cell tumor (GCT) of the tendon sheath, amyloid deposits, long-standing rheumatoid pannus, soft-tissue callus, leiomyoma and lymphoma has been ascribed to the presence of hypocellular fibrosis.

 However, not all fibrous masses have low T2 SI; hypercellular fibrous masses, such as desmoids and leiomyomas, may demonstrate higher T2 SI.

Fig.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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### 1. LESIONS CONTAINING FIBROSIS – Morton's neuroma



**Fig.**: Morton's neuroma. A. T1-W short-axis axial image of the forefoot. A low signal, teardrop-shaped mass (arrow) from Morton's neuroma is seen below the metatarsal heads in the third web space. B. T2-W short-axis axial image of the forefoot. Morton's neuroma (arrow) persists low signal, but is more difficult to see than on the T1W image. Location is typical for a Morton neuroma.

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#### 1. LESIONS CONTAINING FIBROSIS – Desmoid tumor



**Fig.**: Desmoid tumor. A and B. Axial and sagittal T1 images of the knee. Large, lobular, low signal intensity mass (arrows) is seen in the soft tissues of the posterolateral distal tight and proximal calf. C and D. Axial T2-W images show the infiltrative mass (arrows) to remain mostly low signal intensity. The MR imaging signal characteristics, in combination with the invasiveness of the lesion make the diagnosis of aggressive fibromatosis extremely likely in this case.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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## 1. LESIONS CONTAINING FIBROSIS – Plantar fibroma



**Fig.**: Plantar fibroma. A. And B. Sagittal and axial T1-W shows multilobulate mass (arrow) predominantly isointense to muscle, arising from the plantar fascia (arrowhead). C. Short axis T2-W shows that the mass is only slightly hyperintense to muscle. However in contains also some areas (arrow) that remains very hypointense in relation with dense fibrosis.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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## 1. LESIONS CONTAINING FIBROSIS – Dermatofibrossarcoma



**Fig.**: Dermatofibrossarcoma. A. Axial T1-W image shows a mass (arrow) located in the medial subcutaneous fat of the leg, that is mainly isointense with muscle. B. On T2-W image the lesion show inhomogeneous high signal intensity. On both T1 and T2 images, there are intra-lesional areas (arrowhead) of very low signal intensity, consistent with a fibrous tumor.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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## 1. LESIONS CONTAINING FIBROSIS – Post-surgery fibrotic scar



**Fig.**: Post-surgery fibrotic scar. In the place of the previous surgery of a sarcoma there is a mass (arrow) that is isointense on T1-W (A) and mainly hypointense on T2-W (B) images. Because of mass effect, the lesion was biopsed, that confirmed fibrotic scar. *References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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## 1. LESIONS CONTAINING FIBROSIS – Elastofibroma dorsi



**Fig.**: Elastofibroma. Axial T1-W (A) and T2-W (B) images show, in righ postero-lateral chest wall, a mass with signal intensity similar to muscle with interspersed streaks of fat that are high signal on T1.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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#### 2. LESIONS CONTAINING HEMOSIDERIN

 Hemosiderin, a non-specific end-product from the breakdown of hemorrhage, is T2 hypointense due to magnetic susceptibility.

 When present in sufficiente quantities, hemosiderin can appear more prominent (blooming) on T2\*-weighted MR images than on T2-weighted MR images.

Fig.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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#### 2. LESIONS CONTAINING HEMOSIDERIN

 Masses that contain large amounts of hemossiderin include pigmented villonodular synovitis (PVS), giant cell tumor (GCT) of the tendon sheath and a variety of hemorrhagic masses.

 Occasionally, lesions that characteristically contain extensive hemosiderin, such as pigmented villonodular synovitis, may not have bled sufficiently to appear hypointense on T2-weighted or to cause blooming on T2\*weighted MR images.

Fig.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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## 2. LESIONS CONTAINING HEMOSIDERIN

 Some masses may contain hemosiderin in a portion of the mass because of bleeding but may not contain enough diffuse hemosiderin to have low T2 SI.

 For example hematomas may demonstrate a peripheral rim of low-SI hemosiderin, and hemangiomas may contain scattered areas of low-SI hemosiderin because of intermittent bleeding, but neither entity generally manifests as a uniformly low-SI mass on T2-weighted MR images.

#### Fig.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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## 2.1. LESIONS CONTAINING HEMOSIDERIN Pigmented Villonodular Synovitis

 Pigmented villonodular synovitis is a synovial disease of unknown cause that most commonly affects the knee and results in an abnormal proliferation of histiocytes and giant cells, which usually contain hemosiderin.

 The most distinctive MRI features of this entity are masslike areas of synovial proliferation that show foci of low signal intensity on T1W and T2W images, related to the hemosiderin.

 A similar appearance may be seen with chronic hemarthrosis, chronic rheumatoid arthritis, chronic infectious arthritis (eg, tuberculosis), amyloidosis or gout.

#### Fig.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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## 2.1. LESIONS CONTAINING HEMOSIDERIN Pigmented Villonodular Synovitis



**Fig.**: A. And B. Proton density sagittal and coronal images of the knee. Extensive intermediate signal intensity fluid or tissue distends the knee joint, most prominently posteriorly where numerous low signal intensity foci (arrows) are present within it. The suprapatellar pouch is also involved C. T2\*-gradient echo coronal image of the knee. The masses remain of low signal intensity and show prominent "blooming" secondary to susceptibility effects of hemosiderin, compatible with pigmented villonodular synovitis.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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# 2.1. LESIONS CONTAINING HEMOSIDERIN Pigmented Villonodular Synovitis



**Fig.**: Pigmented villonodular synovitis (focal form). A. And B. Sagital and axial T1W images show intermediate signal focus (arrow) within the Hoffa fat pad with low signal foci within this region (arrowhead). The low signal foci represent hemosiderin. C. Axial T2W image shows the intermediate signal of the focus of pigmented villonodular synovitis. The low signal of the hemosiderin can be seen on this sequence as well, specially in the periphery (arrowhead).

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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## 2.2. LESIONS CONTAINING HEMOSIDERIN Giant Cell Tumor of the Tendon Sheath

 An extra-articular form of pigmented villonodular synovitis is called giant cell tumor (GCT) of the tendon sheath. This is typically a focal mass arising in proximity to a tendon and most commonly is found in the hand and wrist.

 Because of their similar histology to pigmented villonodular synovitis, these lesions display intermediate to low signal intensity on T1-W images and heterogeneous signal intensity on T2-W images, with areas of decreased signal related to hemosiderin.

#### Fig.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

# 2.2. LESIONS CONTAINING HEMOSIDERIN Giant Cell Tumor of the Tendon Sheath



**Fig.**: Giant cell tumor of the tendon sheath. A and B. T1 sagital and axial image of the fingers. An ovoid, predominantly low signal intensity mass (arrows) abuts and slightly deforms the underlying flexor tendons. C. T2 axial image. The mass remains of low signal intensity and contains areas of darker signal intensity that are more prominent on this sequence, related to hemosiderin in this GCT of the tendon sheath (extra-articular pigmented villonodular synovitis).

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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## 2.2. LESIONS CONTAINING HEMOSIDERIN Giant Cell Tumor of the Tendon Sheath



**Fig.**: Giant cell tumor of the tendon sheath. A. Sagital T1-W show a hypointense mass (arrow) arising from the Achilles tendon. B. and C. The mass is also hypointense on T2-W (B) and T2\*-W (C) images, related to hemosiderin.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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 Injury to soft tissues can cause subcutaneous or intramuscular hematomas. Hematomas are confined collections of blood that are well defined with a masslike character and no interspersed muscle parenchyma or stroma.

 The appearance of hematomas on MRI is highly variable because it is age dependent.

 Hyperacute blood is rarely imaged, but is intermediate SI on T1W (similar to muscle) and high signal intensity on T2W images.

 An acute hematoma (roughly up to 1 week old) is typicaly isointense to skeletal muscle on T1W images and of lower signal intensity than muscle on T2W images.

### Fig.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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 Subacute hematomas show hyperintensity on T1W images, similar to that of fat. Early subacute hematomas have low signal intensity on T2W images, whereas older subacute (and chronic) hematomas have high signal intensity on T2W images.

 Chronic hematomas may have low signal intensity (T1W and T2W images), especially around their rims, because of hemosiderin deposition and fibrosis.

 There often is heterogeneity of the hematoma, probably from repeated bleeding from recurrent injury.

Fig.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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 At a minimum, any hematoma detected with RMI must be followed to resolution, either clinically or with serial imaging.

 Gadolinium administration may reveal na enhancing tumor mass; however, this must be interpreted with caution because fibrovascular tissue within an organizing hematoma also may enhance. In questionable cases, image-guided biopsy should be considered.

Fig.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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**Fig.**: Chronic hematoma. A. T1 axial image of the calf. Diffusely increased signal is seen within this medial gastrocnemius hematoma surrounded by a thick rim of low signal intensity (arrow). B. T2 FS axial image of the calf. The internal blood products show more pronounced heterogeneous signal intensity, and the marginal low signal intensity is more apparent (arrows), typical of a chronic hematoma with fibrosis and hemosiderin deposition.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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**Fig.**: Hematoma with blood at various stages. A. And B. Axial and coronal T2. Masslike tissue (arrows) replaces the normal muscle architecture at the site of intramuscular hematoma formation. Note the heterogeneous signal within the hematoma indicating blood products of various ages. C. Axial T1 shows that the mass contains areas of faintly increased signal intensity. D. Axial T1 after gadolinium administration demonstrated geographic areas of internal enhancement (arrowhead) due to fibrovascular tissue within the organizing hematoma. This lesion was biopsed and followed to resolution, confirming the diagnosis of hematoma.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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#### 3. LESIONS CONTAINING CALCIUM

 Calcifications are typically T2 hypointense because the protons are immobilized within a crystal-line structure and cannot contribute to the signal.

 Paradoxically, calcifications may appear as higher SI when calcium crystals are surrounded by a hydratation shell, which provides a source of mobile protons.

 Masses that are diffusely calcified may also appear to have low T2 SI. However, the SI will depend on the extent and distribution of calcification, whether the calcification is hydrated, and wether there is associated edema or inflammatory reaction.

#### Fig.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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### 3. LESIONS CONTAINING CALCIUM

 Gouty tophi also may show low to intermediate signal intensity on T1W and T2W images, with or without associated bone erosions.

 These signal characteristics may be related to fibrous tissue, hemossiderin deposition or calcification.

 However, images of tophi occasionally are increased signal intensity.

#### Fig.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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## 3. LESIONS CONTAINING CALCIUM - Gout



**Fig.**: Gout. A. And B. Coronal and short-axis T1-W images. The tophy (arrows) are isointense with muscle. C. Short-axis T2-W image. The lesions are of relatively low signal.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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## 3. LESIONS CONTAINING CALCIUM – Myositis ossificans



**Fig.**: Myositis ossificans. A. T1-W sagittal image. There is a mass (arrow) involving the anterior elbow, with central signal intensity that is isointense with fat. B. T2-W axial image. The central signal is heterogeneous, but is surrounded by a low signal intensity rim (arrowhead). The MRI appearance of this lesion is somewhat confuse. However the X-ray (C) shows that the low signal intensity rim is due to mineralization, making the diagnosis of myosities ossificans much more clearer.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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## 3. LESIONS CONTAINING CALCIUM – Hemangioma



**Fig.**: Soft tissue hemangioma with phleboliths. In the right masseter muscle there is a mass (arrows), isointense on T1-W (A) and very hyperintense on T2 (B). Inside it there are some "nodules" (arrowheads) that are hypointense on both T1-W and T2-W. X-Ray (not shown) confirmed the presence of phleboliths, a finding pathognomic for hemangioma.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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#### 4. LESIONS CONTAINING ARTIFACTS

 Substances that have intrinsic low proton density, such as air and some foreign bodies also can appear to be T2 hypointense.

 The most common air-containg lesions are abscesses. These are fluid-filled cavities that are bright on T2W images, with a thick rim. The center does not enhance with intravenous (IV) contrast material, whereas the rim typically does.

 Foreign bodies can be deceptive, as small foreign bodies may be surrounded by a hyperintense area from reactive fluid or inflammatory tissue, which can obscure the underlying foreign body and mimic a neoplasm.

Fig.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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#### 4. LESIONS CONTAINING ARTIFACTS

 Arteriovenous malformations/hemangiomas may be composed of large, high flow vessels, which result in dark intraluminal flow voids on T1W and T2W images and increased signal intensity on "flow-sensitive" gradient echo images. Large feeding arteries and draining veins also may be evident in the adjacent soft tissues.

 Scattered foci of decreased signal intensity corresponding to calcified phleboliths, thrombosed channels, or septa seen on end also may be seen on T2W images.

 On T1W images, they are predominantly isointense to muscle, but often show variable amounts of increased signal intesity related to fat content.

Fig.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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## 4. LESIONS CONTAINING ARTIFACTS - Abscess with gas



**Fig.**: Abscess with gas. A. And B. Axial T1-W and T2-W images show a thick-walled focal fluid collection in left postero-lateral chest wall, compatible with na abscess. Inside the lesion, there are multiple foci of low signal intensity on both T1 and T2, thought to represent signal voids from gas bubbles. C. CT confirmed the existence of multiple gas bubbles.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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## 4. LESIONS CONTAINING ARTIFACTS – Post-drainage gas collection



**Fig.**: Gas collection inside the psoas muscle. This patient had an intramuscular (psoas) abscess that was drained by CT. After CT-guided drainage, MRI shows a hypointense lesion (arrows) inside the left psoas on both T1 (A) and T2 (B and C), with some fluid in dependent location (arrowhead). D. CT confirmed the existence of an abundant gas collection inside the left psoas.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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## 4. LESIONS CONTAINING ARTIFACTS - Hemangioma with flow-voids



**Fig.**: Hemangioma. A. T1-W axial image shows a left submandibular mass (arrows) with the characteristic "can of worms" appearance of hemangiomas. There is also high signal due to the fatty stroma within the lesion. B. and C. T2-W axial and coronal images, show that inside the lesion there are low signal intensity tubular structures (arrowheads), due to the presence of high-flow vessels which result in dark intraluminal flow voids on T2-W (and T1-W) images.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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## LESIONS CONTAINING MACROMOLECULES - AMYLOID

 Amyloid is a protein-like substance that is deposited throughout musculoskeletal tissues as part of a primary disorder or related to other chronic diseases (secondary amyloidosis).

 The secondary form is most common in patients with endstage renal disease who are undergoing hemodialysis.

 Amyloid deposition can occur in bone, intervertebral disk or other soft tissues, with the hip and shoulder being the most commonly affected joints.

 The tissue shows low to intermediate signal intesity on T1W and T2W images, probably caused by its collagen-like composition.

#### Fig.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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## 5.2. LESIONS CONTAINING MACROMOLECULES - MELANIN

 Malignant melanoma shows variable signal intensities on MRI, but may display low signal intensity on T2W images, probably because of paramagnetic compounds within the tumor.

Fig.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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## LESIONS CONTAINING MACROMOLECULES - Amyloid



**Fig.**: Amyloid. A and B. T1 sagittal images of the knee. Prominent low signal intensity tissue is seen both within (arrows) and outside (arrowhead) the knee joint. C and D. T2 sagittal images of the knee. The tissue remains of relatively low signal intensity. The patient had a history of end-stage renal disease and biopsy demonstrated amyloidosis. *References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

# Conclusion

CONCLUSION

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# CONCLUSIONS

In evaluating a mass with low T2 SI, the first step is to review the radiographs for the presence of calcifications, which are often difficult to identify on MR images alone. On radiographs, calcifications may have a characteristic pattern, such as the cloudlike paraarticular calcifications seen in gout or the flocculent calcifications seen in tumoral calcinosis.
If there are no calcifications on the radiographs, then a mass with low T2 SI will most likely either be focal fibrosis or a tumor with substantial fibrous content. In these cases, lesion location can be helpful for further characterization.

#### Fig.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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# CONCLUSIONS

 Single or multiple masses within a joint may reflect the presence of pigmented villonodular synovitis.

 Similarly, if a well-circumscribed noncalcified mass abuts a tendon, it may be a GCT of the tendon sheath.

 A history of prior surgery at the lesion site could suggest the presence of fibrous scar tissue.

 A nodular mass that is adjacent to the plantar fascia of the foot most likely is a plantar fibroma.

 Similarly, a mass along the superficial palmar fascia of the hand can suggest Dupuytren disease.

## Fig.

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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**Fig.**: Flowchart of lesions that are hypointense on T2-weighted MR images. GCT-TS = Giant cell tumor of tendon sheath; Post-op = postoperative; PVNS = pigmented villonodular synovitis

*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

# **Personal Information**

PERSONAL INFORMATION

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*References:* M. Seco; Clinica Universitária de Imagiologia, Hospitais Universidade Coimbra, Coimbra, PORTUGAL

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