Imaging of myxoid-containing tumors in children and adolescents

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LEARNING OBJECTIVES

1. List representative myxoid-containing tumors involving the pediatric and adolescent age group.

2. Discuss the role of different imaging modalities used in the work-up of these lesions and describe the main imaging findings, emphasizing MRI features.

3. Recognize the characteristic MRI signal of the myxoid matrix to facilitate the differential diagnosis of soft tissue tumors.

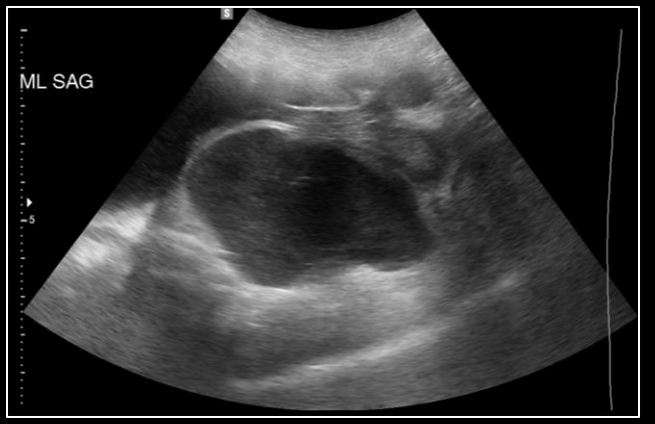
INTRODUCTION

- Myxoid-containing tumors are a rare, complex and heterogeneous group of mesenchymal lesions encompassing benign, intermediate, and malignant lesions.
- They can affect children from the first year of life until late adolescence, can be found in different parts of the body, and can have heterogeneous presentations and imaging features.
- The diagnostic imaging approach varies depending on the affected body part, but MRI is the best modality to define tissue characteristics and tumor extension.

Coffin CM, Alaggio R (2012) Adipose and myxoid tumors of childhood and adolescence. *Pediatr Dev Pathol 15*(1_suppl):239–254.

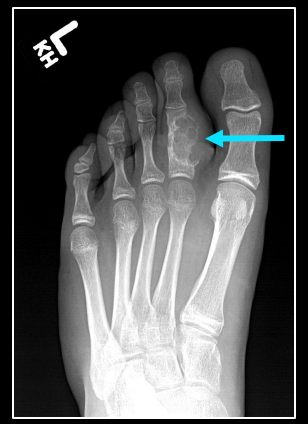
IMAGING APPROACH

- US is the preferred modality for initial assessment
- Both high-frequency linear-array transducers and lower frequency curved-array transducers will be helpful to determine the solid or cystic components of the mass, presence of calcifications, and relationship with neighboring structures
- Doppler techniques are essential to evaluate the degree of vascularity of the lesion
- US will help to plan the biopsy as most of these tumors will need to be sampled and usually guided by US



Deep pelvic Primitive Myxoid Mesenchymal Tumor of Infancy (PMMTI)

Radiographs have a role in patients with tumors involving bone

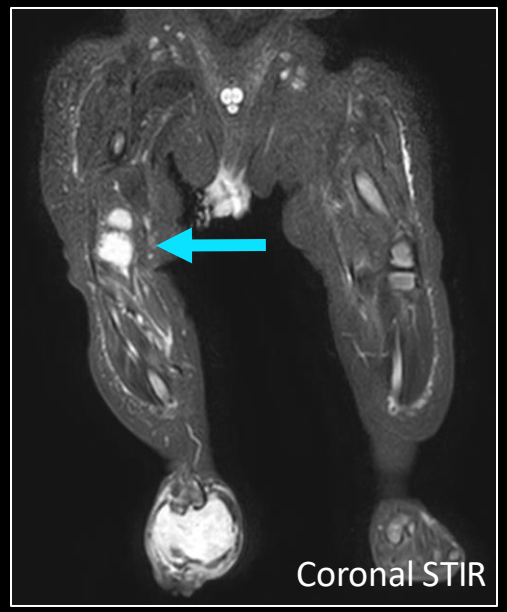


Left foot phalangeal chondromyxoid fibroma

Navarro OM (2020) Pearls and pitfalls in the imaging of soft-tissue masses in children. *Semin Ultrasound CT MR* 41:498–512.

IMAGING APPROACH

- MRI is used as a second-line imaging modality for assessment of tumor characteristics, relation with adjacent structures and locoregional infiltrative features
- The region of interest must be covered with specific coil and images are acquired in at least two orthogonal planes
- In case of suspected malignant tumors located in the extremities, additional coverage of the proximal lymph node stations is warranted, usually with coronal short tau inversion recovery (STIR) images
- Protocols include T1-weighted images, fluid-sensitive images such as fat-suppressed T2-weighted spin-echo images or STIR images, diffusion-weighted images and post-contrast images when possible
- Dynamic contrast-enhanced (DCE) techniques have shown potential value in differentiating benign from malignant masses, tumor staging, assessment of tumor extent, and in evaluating tumor response and recurrence after treatment



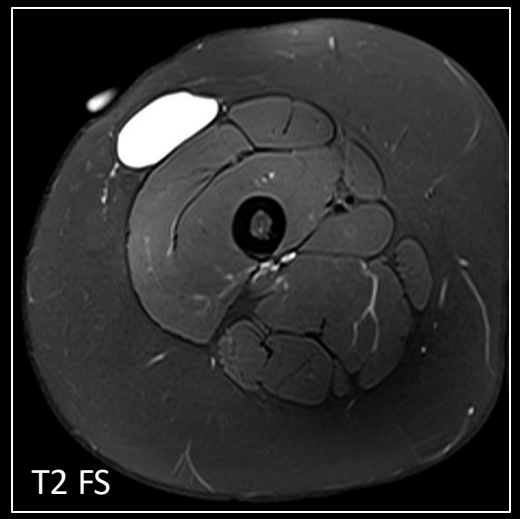
Right foot PMMTI with popliteal lymph node metastasis (arrow)

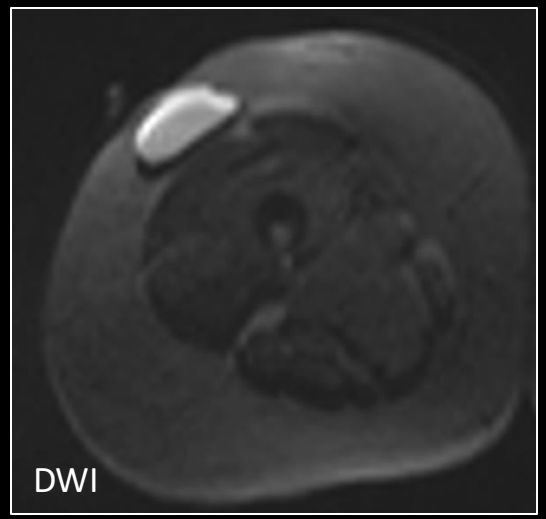
Navarro OM (2020) Pearls and pitfalls in the imaging of soft-tissue masses in children. *Semin Ultrasound CT MR* 41:498-512.

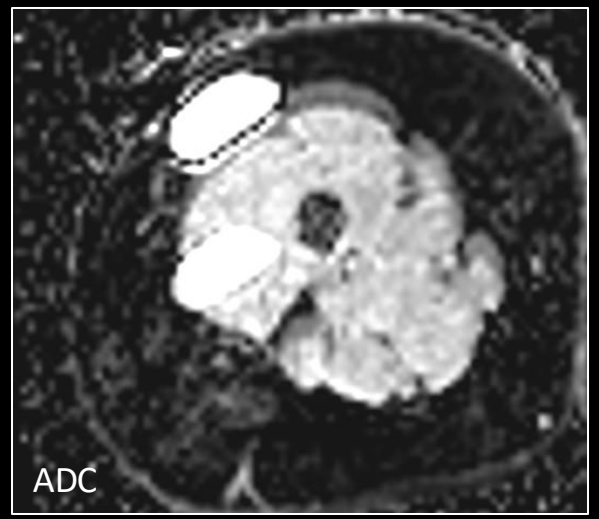
T2 AND DWI SIGNAL OF MYXOID MATRIX

All myxoid-containing lesions have one common denominator: production of extracellular myxoid matrix, which contains a high percentage of water. This matrix provides these lesions with a typical MRI appearance consisting of **high T2 signal and facilitated diffusion**

Subcutaneous myxoid liposarcoma in the thigh of an 11-year-old female.







Lesions with a large amount of myxoid matrix show markedly increased T2 signal resulting in a "pseudocystic" appearance due to the characteristic gelatinous mucopolysaccharide matrix of sulfated and non-sulfated glycosaminoglycans with a high percentage of water

For the same reason, the high percentage of molecules of water in the myxoid matrix leads to a facilitated diffusion of these molecules, and increased signal on ADC maps, even if the tumor has an aggressive histology such as myxoid liposarcoma

Maeda M, Matsumine A, Kato H et al (2007) Soft-tissue tumors evaluated by line-scan diffusion-weighted imaging: influence of myxoid matrix on the apparent diffusion coefficient. *J Magn Reson Imaging* 25:1199–1204.

T2 AND DWI SIGNAL OF MYXOID MATRIX

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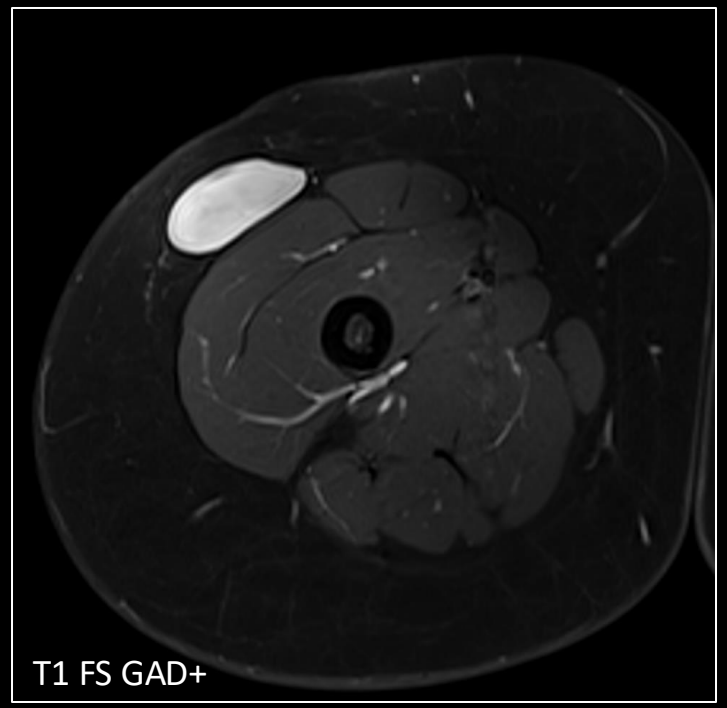


T1 FS GAD+

Homogeneous enhancement of the subcutaneous myxoid liposarcoma confirming its solid nature. Patterns of enhancement in myxoid-containing lesions are variable, from homogeneous to markedly heterogeneous, depending on the presence of other histological components.

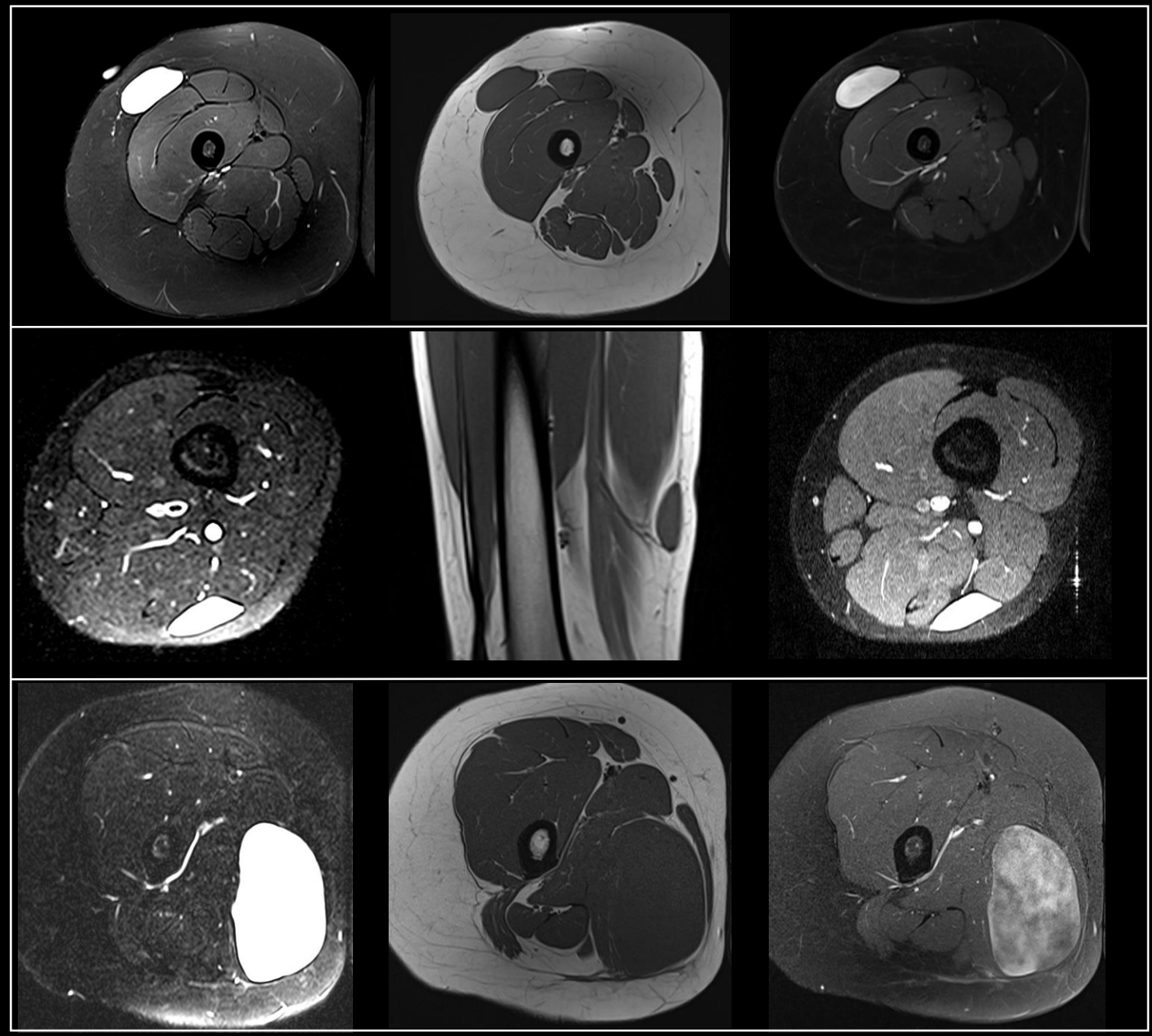
Be cautious if a lesion has a cystic appearance on MRI!
If no previous imaging confirms its cystic nature, contrast-enhanced sequences are paramount to distinguish cystic from solid lesions

Maeda M, Matsumine A, Kato H et al (2007) Soft-tissue tumors evaluated by line-scan diffusion-weighted imaging: influence of myxoid matrix on the apparent diffusion coefficient. *J Magn Reson Imaging* 25:1199–1204.

MYXOID LIPOSARCOMA

- Most common histological variant of liposarcomas in children, involving predominantly the lower extremities.
- Contrary to undifferentiated liposarcoma, which is more common in adult population, this variant has excellent prognosis

Three examples of myxoid liposarcomas involving the lower extremities in adolescent patients. Similar appearance showing well-demarcated margins, high T2WI signal (''pseudocystic'' appearance), no macroscopic fatty signal on T1WI and variable pattern of enhancement



Huh WW et al (2011) Liposarcoma in children and young adults: a multi-institutional experience. *Pediatr Blood Cancer* 57:1142–1146.

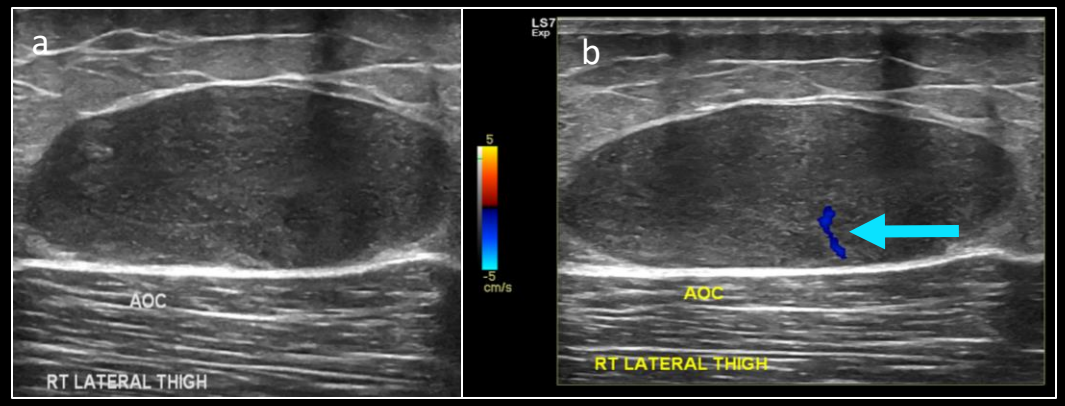
MYXOID LIPOSARCOMA vs. LIPOBLASTOMA

Myxoid liposarcoma	Lipoblastoma
Most common type of liposarcoma in children and adolescents	Second largest subset of adipocytic tumors after lipoma
Age: Rare in children younger than 10 years	Age: Typically within the first 3 years of age
Histology: Predominance of myxoid matrix with a small fatty component	Histology: Contains both mature and immature adipocytes
Most common location: Lower extremities	Most common location: Extremities (upper and lower)
US: heterogeneous hypoechoic echotexture	US: homogeneous and hyperechoic to adjacent musculature
MR: predominant T2 hyperintense myxoid tissue with little or absent macroscopic fat	MR: variable appearance, from predominantly macroscopic fatty tissue to a mixture of fatty with solid enhancing components
Prognosis: Good after resection	Prognosis: Good after resection

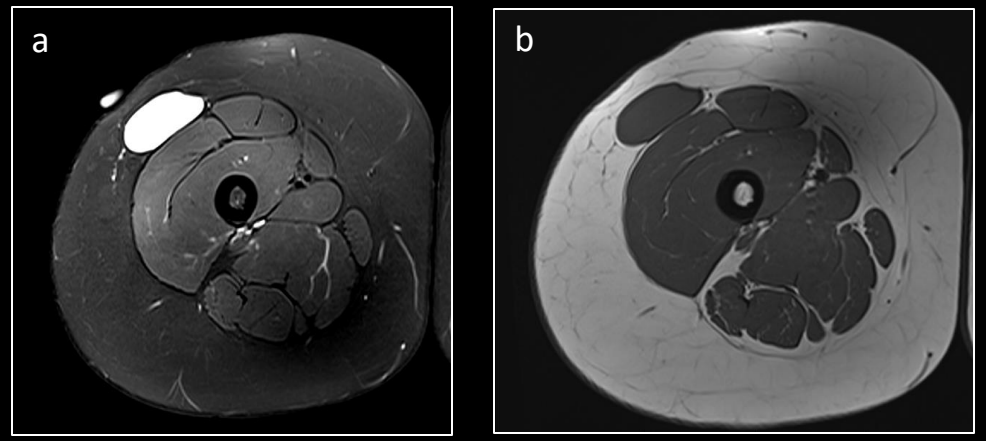
Sheybani EF et al (2016) Fat-containing soft-tissue masses in children. *Pediatr Radiol* 46:1760–1773.
Shimamori N et al (2019) Sonographic appearances of liposarcoma: Correlations with pathologic subtypes. *Ultrasound Med Biol* 45:2568–2574.

MYXOID LIPOSARCOMA

Subcutaneous myxoid liposarcoma in the thigh of an 11-year-old female.



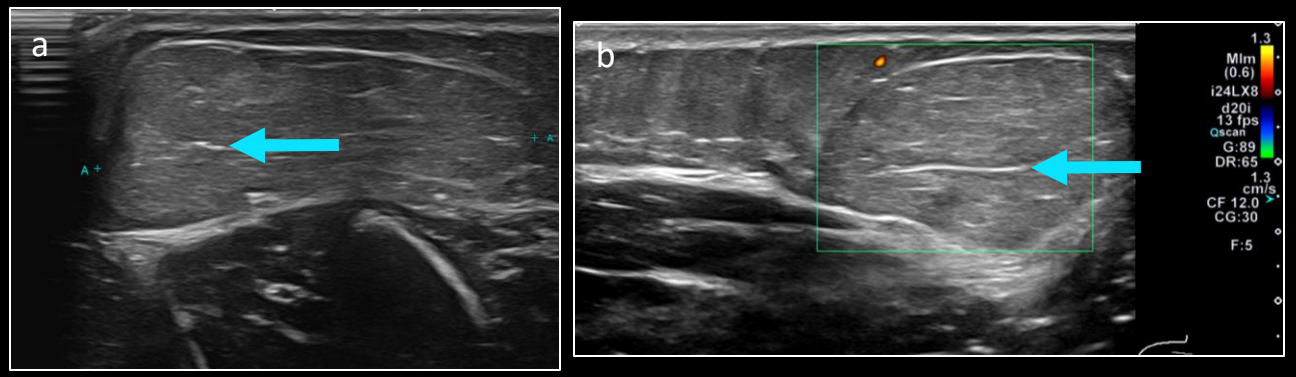
Well-delineated ovoid-shaped hypoechoic lesion in the subcutaneous space of the thigh (a), showing trace but present peripheral vascularity on doppler interrogation (arrow in b)



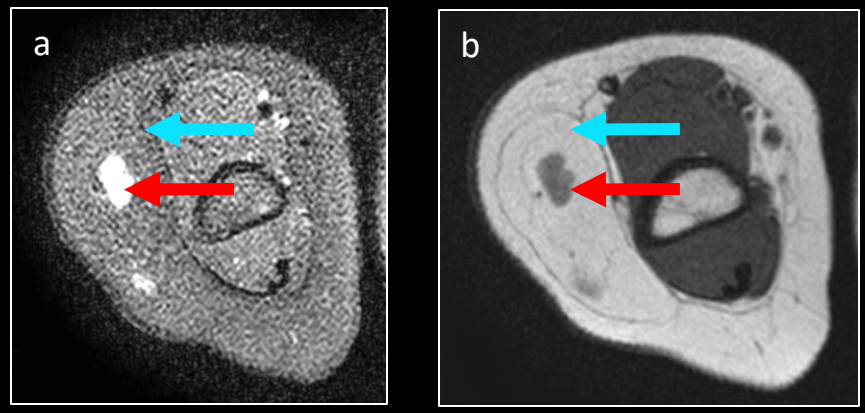
Well-delineated ovoid-shaped lesion in the subcutaneous space of the thigh showing a 'cystic-like' hyperintense fat-saturated T2-WI signal (a), and isointense signal to muscle on T1-WI (b)

LIPOBLASTOMA

Subcutaneous lipoblastoma in the arm of a 10-month-old male.



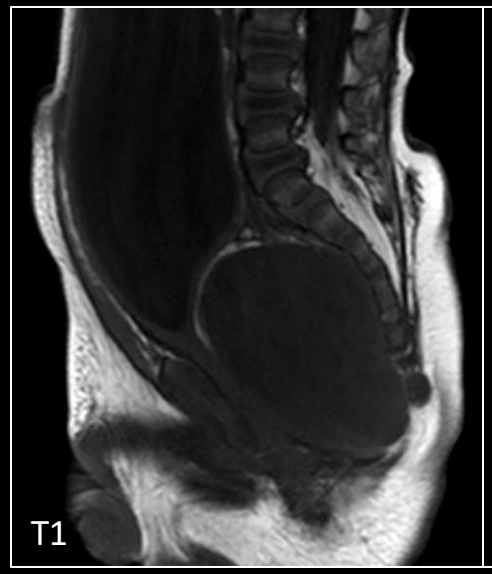
Well-delineated ovoid-shaped hyperechoic lesion in the subcutaneous space of the arm (a), showing no internal vascularity on doppler interrogation (b). Note the hyperechoic fibrous strands parallel to the skin (arrows), characteristic of lipomatous lesions as lipoma or lipoblastoma

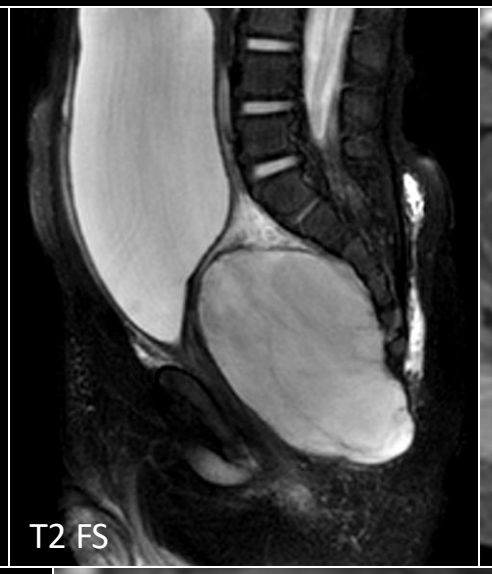


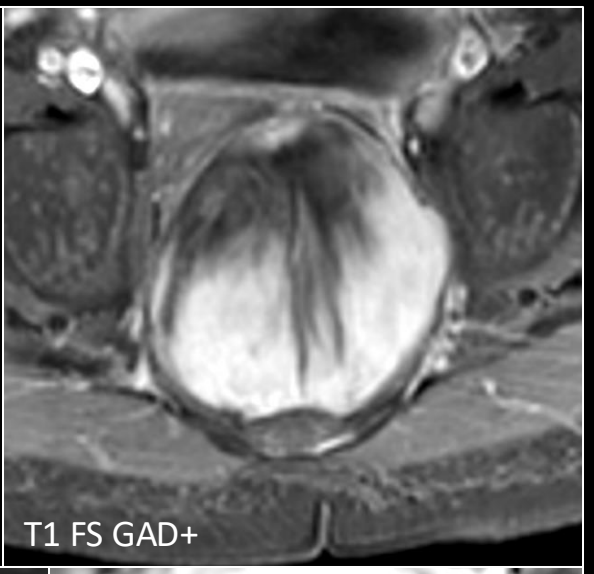
Predominant macroscopic fatty tissue which appears suppressed on fat saturated T2-WI (a) and hyperintense on T1-WI (b) (blue arrows). Central T2 hyperintense and T1 hypointense immature tissue characteristic of lipoblastomas (red arrows)

PRIMITIVE MYXOID MESENCHYMAL TUMOR OF INFANCY (PMMTI)

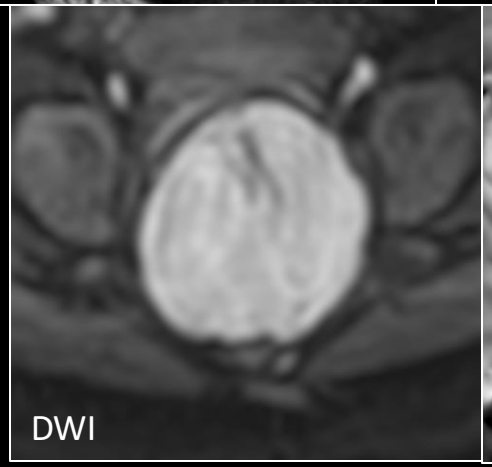
- Rare mesenchymal tumor, likely congenital
- Found in the neck, trunk or extremities
- Characterized by a proliferation of primitive immature mesenchymal cells
- Similar pathologic features to the congenital-infantile fibrosarcoma but presenting with a distinctive myxoid background and mild cytologic atypia
- Aggressive local course, with multiple relapses and poor response to treatment
- Metastases are infrequent

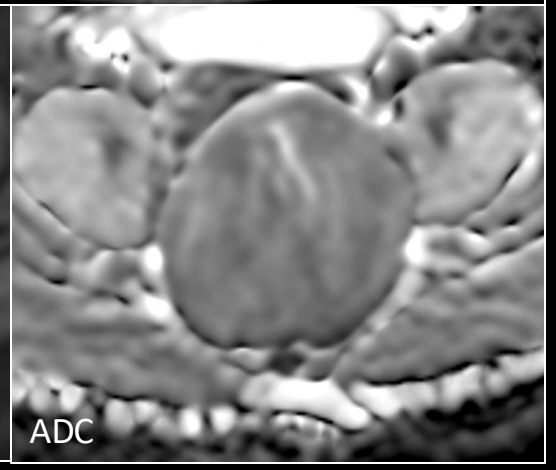






Presacral PMMTI in an 8-month-old male. It presents as a well-defined solid mass, isointense to muscle on T1WI, high T2 signal, heterogeneous enhancement and diffusion restriction.

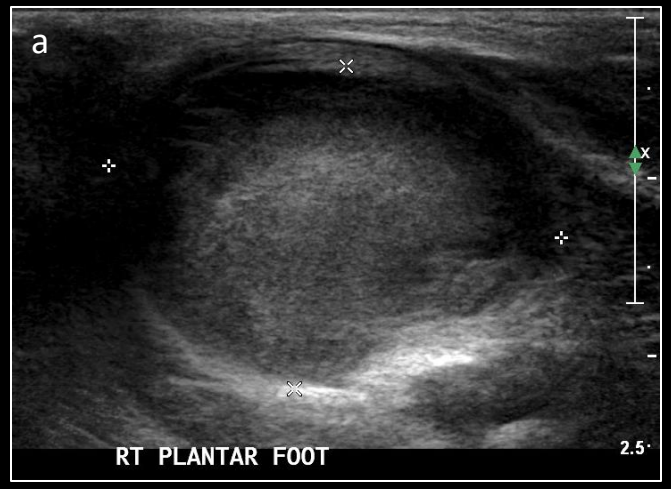


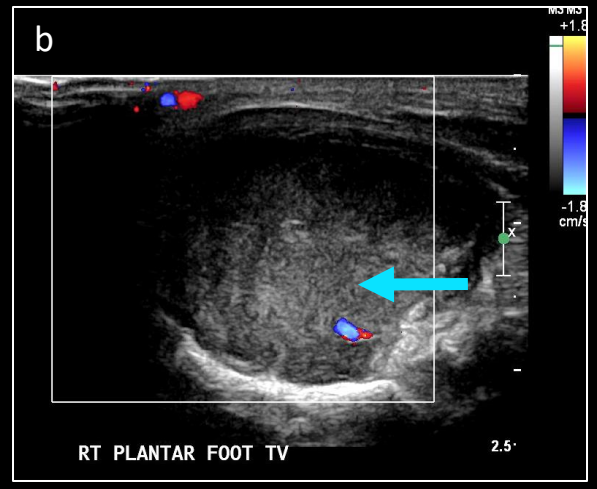


No specific MRI findings have been described for this type of tumors and, as in this case, the differential diagnosis includes other types of sarcomas such as rhabdomyosarcoma and congenital-infantile fibrosarcoma

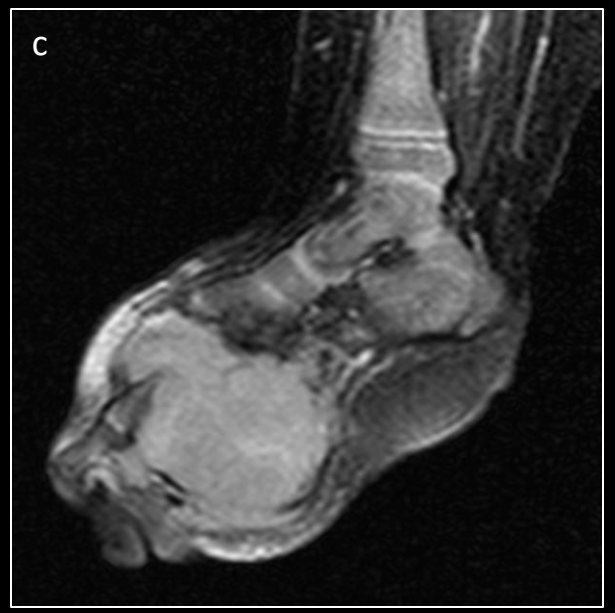
Alaggio R et al (2006) Primitive myxoid mesenchymal tumor of infancy: a clinicopathologic report of 6 cases. *Am J Surg Pathol* 30:388–394.

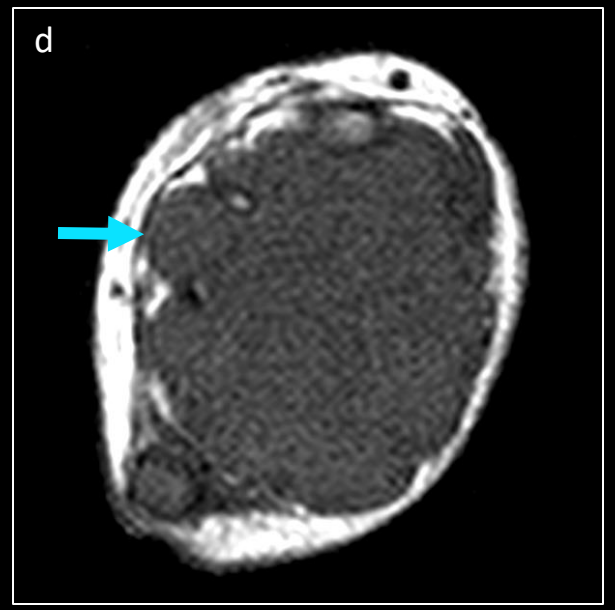
PRIMITIVE MYXOID MESENCHYMAL TUMOR OF INFANCY (PMMTI)

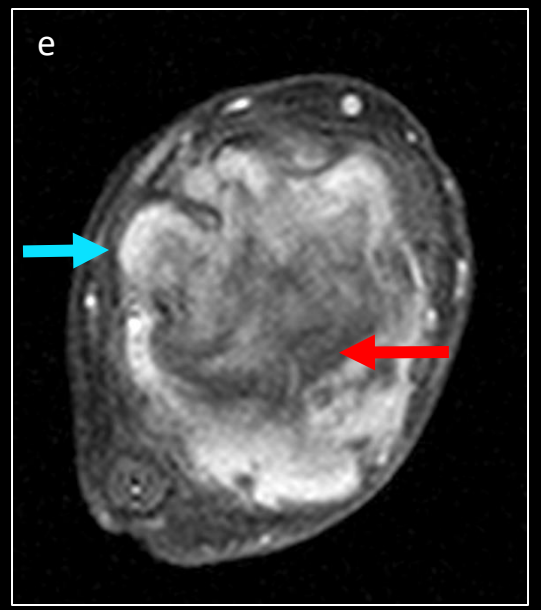


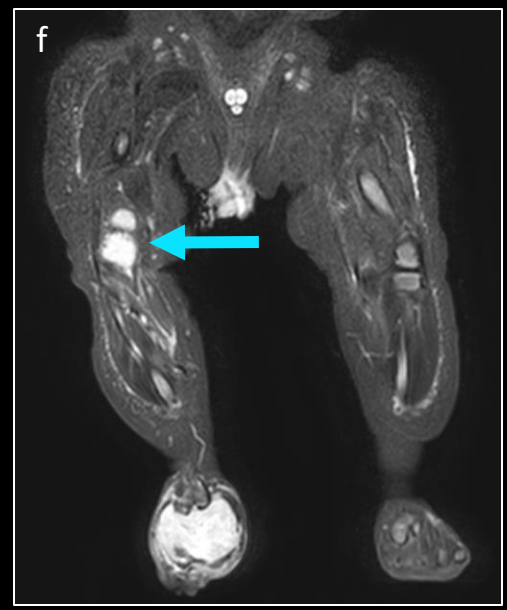


Foot PMMTI in a 3-month-old male. Well-demarcated hypoechoic solid tumor centered in the plantar aspect of the foot (a) with minimal internal vascularity (arrow in b). On MRI, the tumor shows a homogeneous hyperintense T2 signal (c), isointense to muscle on T1-WI (d), and heterogeneous enhancement with a central hypoenhancing component (red arrow in e). Note the transpatial extension in between the intermetatarsal spaces (blue arrows in d and e). Ipsilateral enlarged popliteal lymph nodes were found (arrow in f), consistent with metastasis, a finding seldom described in the few PMMTI cases reported in the literature up to this date.





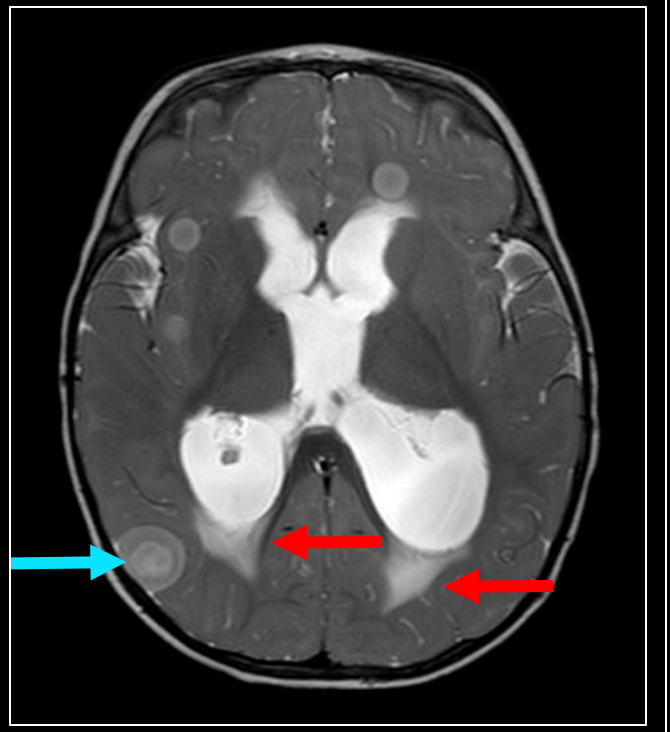




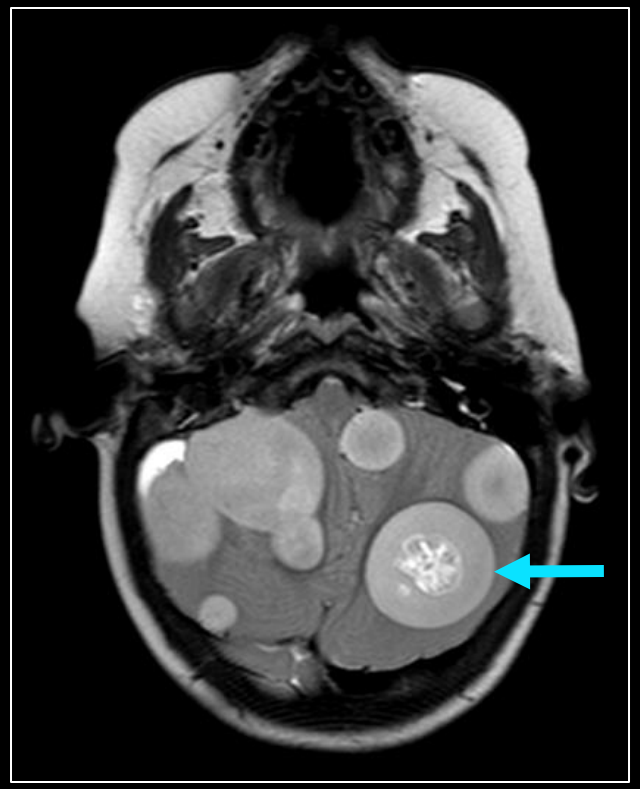
Alaggio R et al (2006) Primitive myxoid mesenchymal tumor of infancy: a clinicopathologic report of 6 cases. *Am J Surg Pathol* 30:388–394.

PRIMITIVE MYXOID MESENCHYMAL TUMOR OF INFANCY (PMMTI)

Few case reports describing this type of tumor and only two cases with documented metastases, both in the brain. This evidence has led to suggest **routine surveillance brain imaging** in patients with confirmed diagnosis of PMMTI.



Axial T2



Axial T2

3-month-old male with foot PMMTI (see previous slide). Presented 4 months after surgery with vomiting and new macrocephaly. Brain MRI reveals multiple supratentorial and infratentorial lesions , some of them with a target-like appearance (blue arrows), in keeping with disseminated brain metastases. Associated supratentorial ventricular enlargement and transependymal edema (red arrows), suggesting active hydrocephalus.

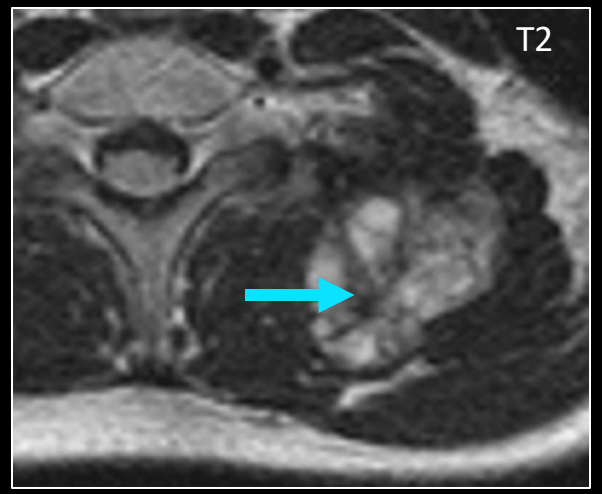
Saeed AA et al (2019) Primitive myxoid mesenchymal tumor of infancy with brain metastasis: first reported case. *Childs Nerv Syst* 35: 363–368.

Raved D (2023) Primitive myxoid mesenchymal tumor of infancy with brain metastasis case report and literature review. *J Pediatr Hematol Oncol* 45: e980–e983.

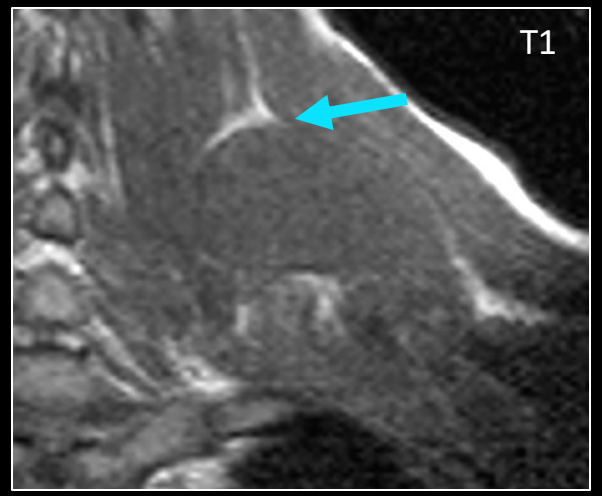
LOW-GRADE MYXOID FIBROSARCOMA

- Rare soft-tissue sarcoma reported in children and adolescents, most commonly located in the extremities
- Characterized by the interposition of fibrous bundles in a background of myxoid matrix
- Indolent behavior with tendency to local recurrence

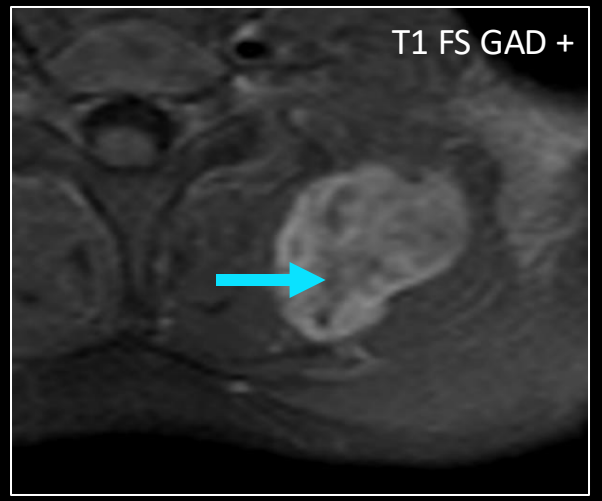
Intermuscular paravertebral myxoid fibrosarcoma in a 13-year-old male.



Characteristic **T2 hypointense bundles** representing the fibrous component of these lesions (arrow)



On T1WI images, some of these lesions show a typical **T1 hyperintense rim** surrounding the lesion (arrow) consistent with fat (split fat sign). This sign can also be seen in peripheral nerve sheath tumors

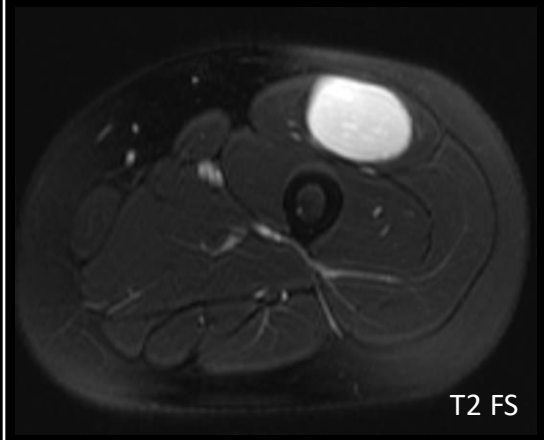


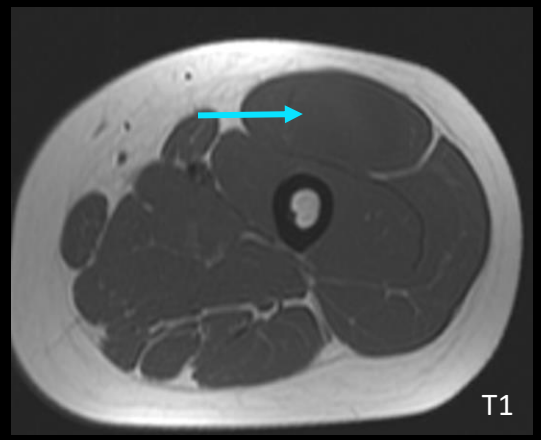
Heterogeneous post-contrast enhancement. Note the absence of enhancement of the fibrous component (arrow)

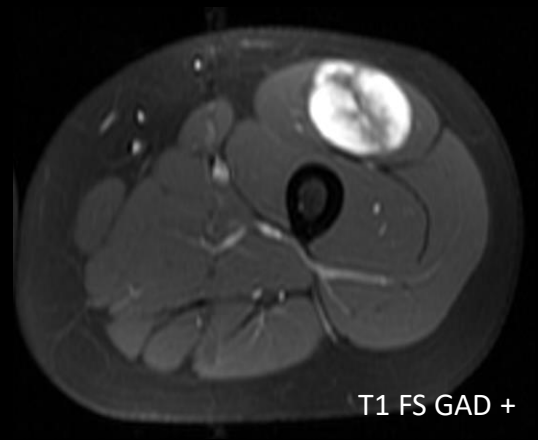
Another MRI finding described on fluid sensitive images in this type of tumor is the **gyriform pattern** with multiple folded layers of predominantly low signal intensity within the mass, mimicking brain gyri

Hwang S et al (2012) Imaging features of low-grade fibromyxoid sarcoma (Evans tumor). *Skeletal Radiol* 41:1263–1272.

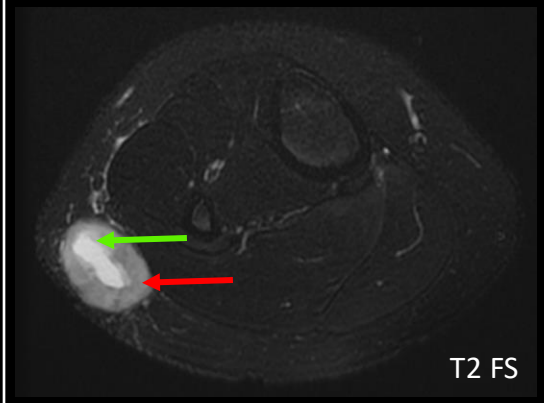
LOW-GRADE MYXOID FIBROSARCOMA

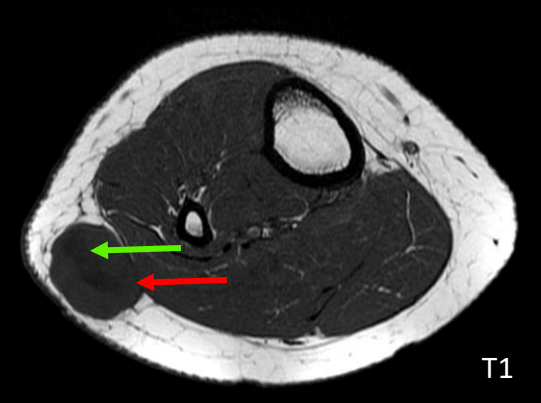


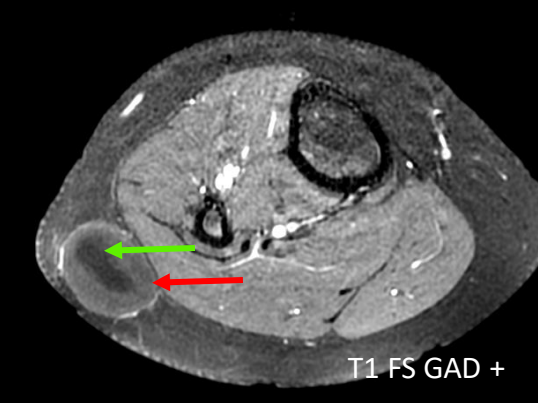




Intramuscular low-grade myxoid fibrosarcoma in the rectus femoris of a 12-year-old female. Similar appearance as the previously mentioned cases of myxoid liposarcoma, with bright T2 signal, isointense to muscle on T1 (arrow) and heterogeneous enhancement







Subcutaneous low-grade myxoid fibrosarcoma in the leg of an 8-year-old male. Peripheral T2 intermediate intensity (red arrow) and T1 isointensity to muscle (red arrow) with central T2 hyperintensity (green arrow) and T1 hypointensity (green arrow). On postcontrast MRI, there is faint peripheral enhancement (red arrow) and central absent enhancement (green arrow)

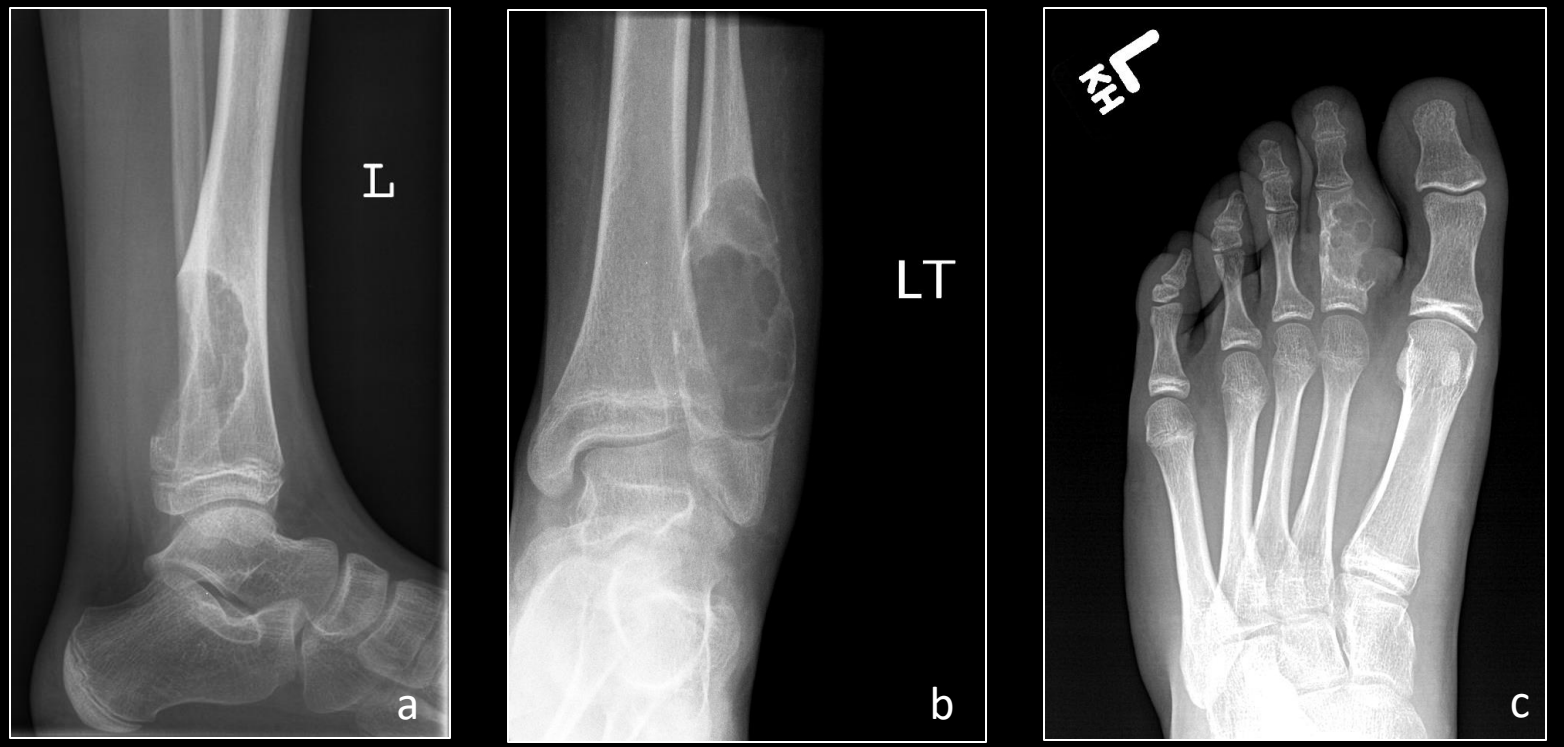
Although specific MRI findings have been described, these lesions can resemble other types of myxoid-containing tumors or benign-looking lesions, therefore, the final diagnosis is based on histology

Hwang S et al (2012) Imaging features of low-grade fibromyxoid sarcoma (Evans tumor). *Skeletal Radiol* 41:1263–1272.

CHONDROMYXOID FIBROMA

- Rare bone tumor representing less than 1% of bone neoplasms with benign clinical course
- Contains varying amounts of chondroid, fibrous, and myxoid tissues
- Most frequently in the second decade of life, arising particularly in the metaphysis of the long bones

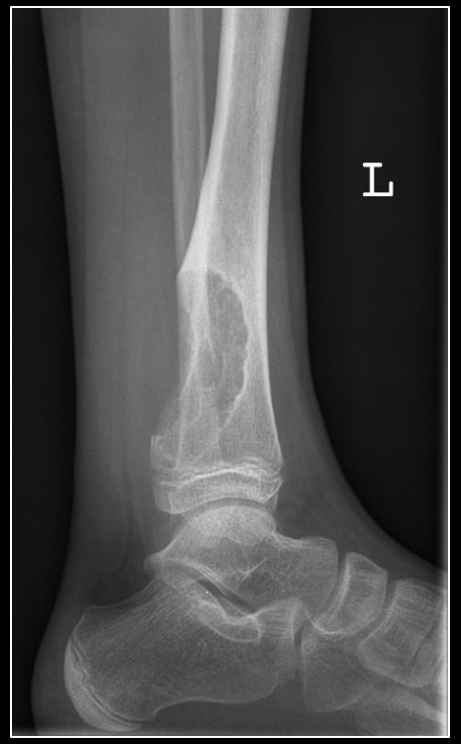
This type of tumor poses challenges to its diagnosis due to its rarity and overlapping imaging features with other solid tumors. The differential diagnosis includes aneurysmal bone cyst, giant-cell tumor, chondrosarcoma, chondroblastoma, enchondroma and non-ossifying fibroma



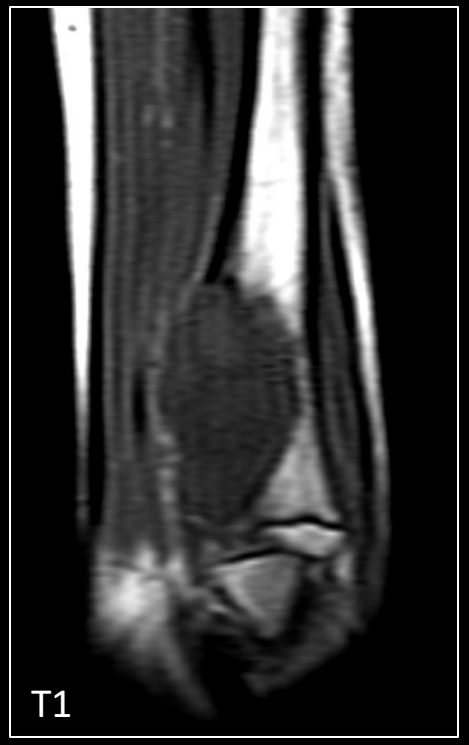
Three different examples of chondromyxoid fibromas involving the distal tibial metaphysis (a), distal fibular metaphysis (b) and proximal phalanx of the second digit (c). In all cases an expansile radiolucent lesion is demonstrated, with well delineated and sclerotic margins and multiple internal septations. Findings suggest a non-aggressive nature.

CHONDROMYXOID FIBROMA

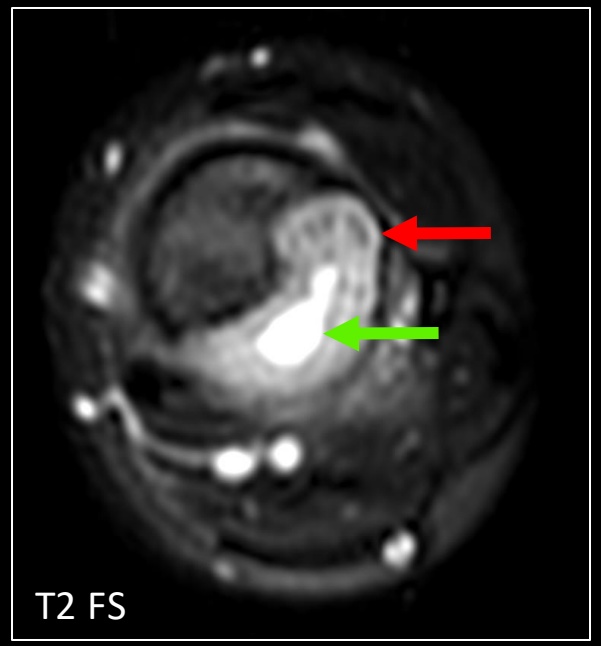
Distal tibial metaphysis chondromyxoid fibroma in a 10-year-old female.



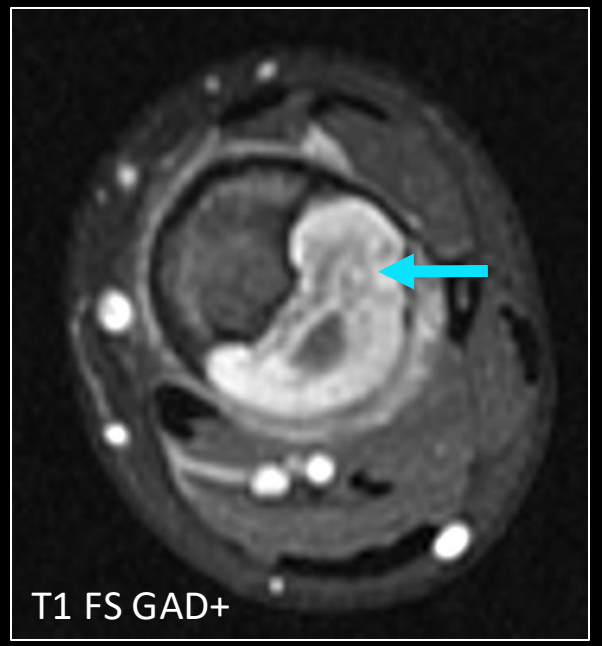
Well-marginated radiolucent lesion with sclerotic outline in the distal tibial metaphysis



Same lesion appears hypointense on T1WI, showing extraosseous extension



Characteristic peripheral T2 intermediate intensity and central T2 hyperintensity

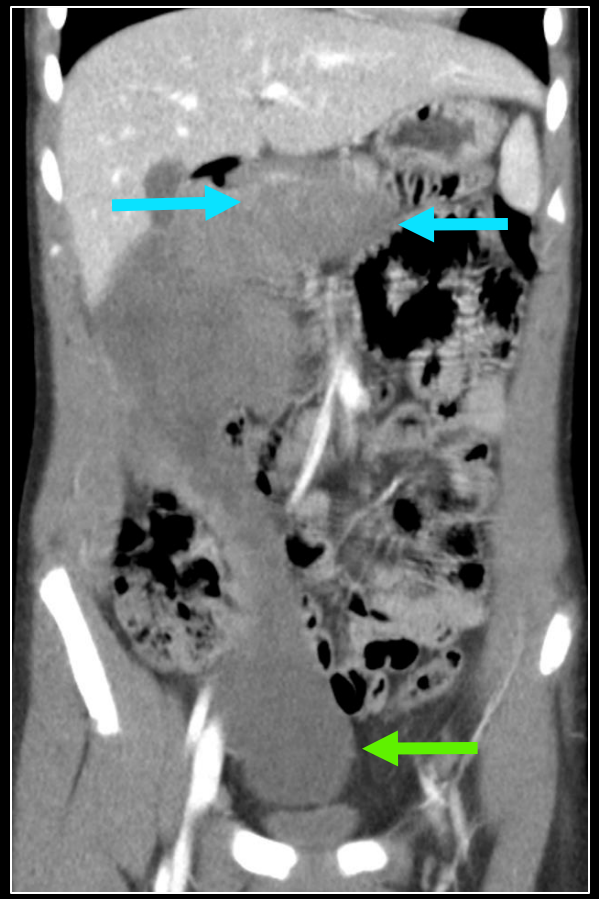


On postcontrast fat-sat T1WI, there is enhancement of the peripheral component

Kim HS et al (2011) MRI of chondromyxoid fibroma. *Acta Radiol* 52:875–880.

PLEXIFORM FIBROMYXOMA

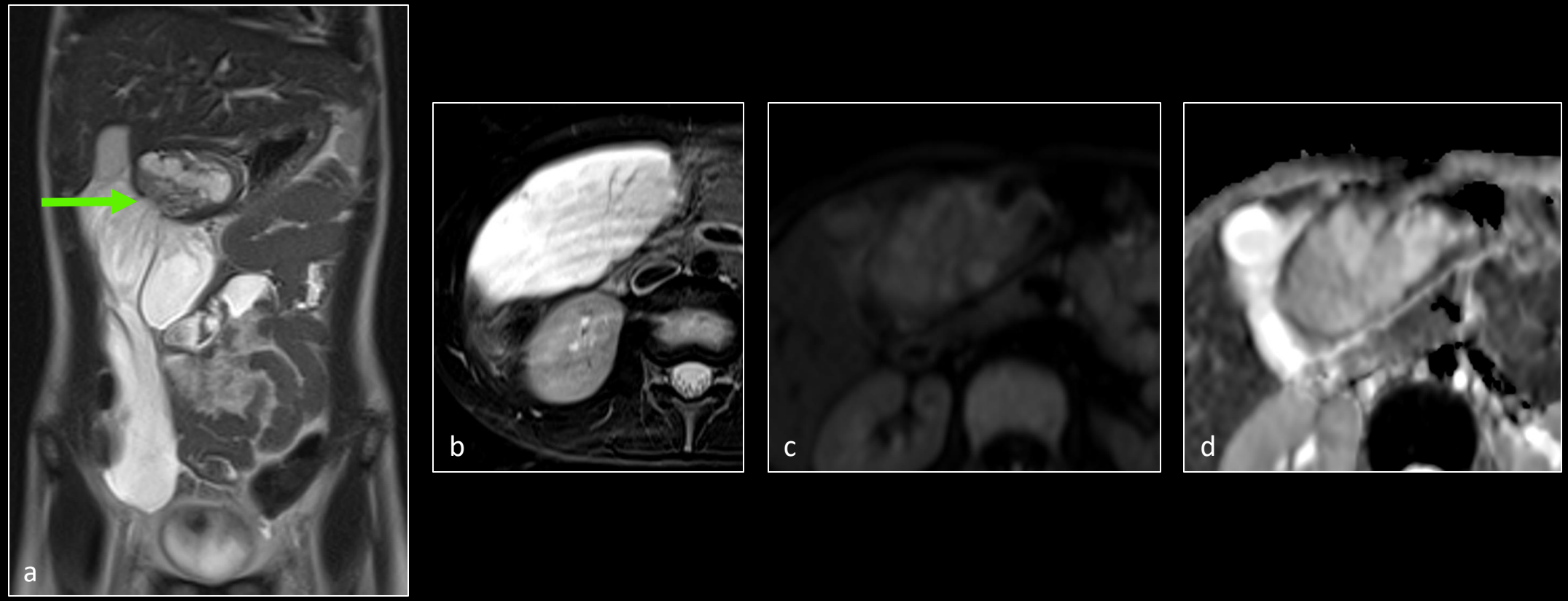
- Rare benign mesenchymal neoplasm that was first described in 2007 and was officially recognized by the World Health Organization (WHO) in 2010
- Characterized by a plexiform growth of bland spindle to ovoid cells embedded in a myxoid stroma
- Typically found in the stomach antrum
- Mean age presentation is 40-50 years but recently described in pediatric patients
- No metastasis or malignant transformation has been reported
- Main differential diagnosis is gastrointestinal stromal tumor (GIST)
- Surgical removal is the current mainstay of treatment



Antral plexiform fibromyxoma in a 9-year-old male. Coronal enhanced CT scan of the abdomen and pelvis shows a hypodense lobulated lesion arising from the stomach (blue arrows) and its extragastric extension reaching the pelvis (green arrow).
Courtesy of Dr. M. Gonzalo from Vall d'Hebron Hospital, Barcelona, Spain.

Arslan ME et al (2021) Plexiform fibromyxoma: Review of rare mesenchymal gastric neoplasm and its differential diagnosis. *World J Gastrointest Oncol* 13:409-423.

PLEXIFORM FIBROMYXOMA



On coronal T2-weighted images (a) , the lesion centered in the stomach antrum shows hyperintense signal and a lobulated appearance. Note the margin discontinuity/tumoral rupture (arrow) which leads to an extragastric extension, a finding described once in the literature in a 26-year-old patient. On axial fat-saturated T2-weighted images (b), the intrinsic high T2 signal is better appreciated, related to its myxoid stroma.

On axial DWI sequences (c), the tumor shows minimally increased signal but similar to adjacent organs, with high ADC signal (d), in keeping with facilitated diffusion.

Zhang R et al (2022) Huge gastric plexiform fibromyxoma presenting as pyemia by rupture of tumor: A case report. *World J Clin Cases* 10:2253–2260.

SUMMARY OF TUMOR TYPES

	Myxoid Liposarcoma	PMMTI	Low-grade myxoid fibrosarcoma	Chondromyxoid fibroma	Plexiform fibromyxoma
Location	Lower extremities	Neck, trunk or extremities	Extremities	Metaphysis of long bones	Stomach antrum
Age presentation	Second – fourth decades	First year of life (congenital tumor)	Adolescents and young adults	Second – third decades	Fourth-fifth decades (reported cases in children)
Prognosis	Good	Poor	Good	Good	Good
Imaging considerations	High T2 signal on MR with facilitated diffusion (''pseudocystic'' appearance)	No specific MR features (similar to sarcomas)	T2 hypointense bundles of fibrous tissue	Expansile lucent lesion with sclerotic margins on radiographs	Lesion of variable appearance arising from the bowel wall
	Little or absent macroscopic fat		T1 hyperintense surrounding rim (split fat sign)	Peripheral T2 intermediate intensity with increased enhancement and central T2 hyperintensity with no enhancement	Given its myxoid component, it can have areas of high T2 signal and facilitated diffusion
			Gyriform pattern on fluid sensitive sequences		

TEACHING POINTS

1. Myxoid-containing tumors are rare in children and adolescents

2. They can present in different parts of the body with several imaging presentations and overlap with other non-myxoid tumors as sarcomas

3. Ultrasound and MRI are the main diagnostic modalities for imaging work-up

4. The myxoid matrix has a high content of water, which gives a characteristic high T2 signal and facilitated diffusion on MRI

5. Given its non-specific imaging characteristics and potential aggressivity, tissue sampling is ultimately required in most instances

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