SA–CME Information

Description

Hand masses: An Essential MRI review

Hand masses are commonly encountered entities that often cause clinical and diagnostic dilemmas due to their nonspecific clinical presentation and overlapping imaging findings. This article systematically reviews the most commonly encountered hand masses in clinical practice in order to help the radiologist gain a structured diagnostic approach and familiarity with typical clinical presentations. Furthermore, this review will strengthen the radiologist's ability to recognize pertinent MR imaging findings and gain knowledge of the underlying pathology on a cellular level.

Learning Objectives

After completing this activity, the participant should be able to:

- Describe the characteristics and typical clinical presentation of the most commonly encountered masses of the hand.
- Explain the underlying pathology of benign and malignant hand masses
- Identify the magnetic resonance (MR) imaging findings, patterns, size, location, and relationship of these masses to neighboring structures

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Target Audience

- Radiologists
- Related Imaging Professionals

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Hand masses: An Essential MRI review

Nicholas Hardin, DO; Shaked Laks, MD; Carola Mullins, MD; Osvaldo Padilla, MD; Lisa Kafchinski, MD; and Crysela Smith, MD

Hand masses, a common clinical entity, frequently prove to be benign; however, nonspecific clinical presentations and overlapping imaging findings often create a dilemma in clinical management. In this review, we systematically discuss and illustrate masses of the hand categorized into neuro-vascular tumors, fibrous lesions, benign primary bone/cartilage tumors, degenerative (reactive) lesions, benign primary soft tissue tumors, as well as primary malignancies, mimics, and metastases. We briefly review pertinent characteristics of each lesion, illustrate magnetic resonance (MR) imaging findings, and correlate with histological findings. The recognition of imaging patterns, size, location, and relationship to neighboring structures significantly narrows the differential diagnosis and helps to guide clinical management in a multidisciplinary approach (Table 1).

Dr. Hardin, Dr. Laks, and Dr. Smith are Radiologists; Dr. Mullins is a Researcher in Radiology; Dr. Padilla is a Pathologist, and Dr. Kafchinski is an Orthopedist, with the Texas Tech University Health Sciences Center, El Paso, TX. *The authors report no conflicts of interest; they gratefully acknowledge funding and support through the Arvin E. and Beverly Robinson scholarship for research development.*

Imaging technique

Representative MR imaging studies were performed on either a 3.0-T Siemens scanner (Siemens Corp., Washington, DC) or a 1.5-T Siemens scanner (Siemens Corp., Washington, DC). Standard pulse sequences were performed with small field-of-view (FOV) 10-12 cm, high resolution matrix (320 x 344), and dedicated coil used when possible. Standard sequences included T1-weighted turbo spin-echo (T1W), T2-weighted turbo spin echo with fat saturation (T2WFS), Short Tau Inversion Recovery (STIR), T1 weighted spin-echo without fat-saturated (T1WFS) and IV contrast administration (T1WFS C+) with the use of orthogonal planes through the mass and adjacent structures when necessary. Gadopentetate dimeglumine, 0.1 mmol/kg (Bayer, Whippany, NJ) was used for gadolinium administration.

Benign primary soft tissue tumors

Lipomatous lesions

Lipomatous lesions are exceedingly common and comprise nearly 50% of all soft tissue tumors, with the largest prevalence in the 5th-7th decades of life.[1] These lesions exist along a spectrum ranging from benign (ie, lipomas) to atypical lipomatous tumors, with the most malignant representing liposarcomas.[2] MR characteristics that help establish benignity include a well-circumscribed lesion with hyperintense signal on T1-weighted images (T1WI), hyperintense signal on T2-weighted images (T2WI), homogenous signal loss on fat-suppressed sequences, low signal on short-tau inversion recovery (STIR) or frequency selective fat suppressed images, and limited fine peripheral capsular enhancement.[1,2] MR findings which suggest an underlying malignant process include size >10 cm, thick septae, and globular or nodular soft tissue enhancement. Recent attempts at differentiating lipomas versus atypical lipomatous tumors and underlying malignancies have been developed with an atypical lipomatous tumor (ALT) scoring system to help guide clinical

DETAILS ON PAGE 11

Table 1. Hand Mass MRI Characteristics

	T1W-FS Signal	T2W FS Signal	STIR* Signal	T1W Post-Gadolinium Signal
Lipoma	Homogeneous hyperintense	Homogeneously hypointense	Hypointense, with subtle areas of increased signal	Possible fine peripheral capsular enhancement
Glomus Tumor	Homogeneously isointense to surrounding muscle	Homogeneous hyperintense	Homogeneously hyperintense	Homogeneous intense enhancement
Slow venous abnormality	Heterogenous isointense to hyperintense	Heterogeneous hyperintense signal in slow flow venous structures	Predominantly hyperintense	Vascular portions avidly enhance and may persist on delayed imaging
Hemangioma	Heterogenous isointense to hyperintense	Heterogeneous hyperintense signal in slow flow venous structures	Predominantly hyperintense	Vascular portions avidly enhance and may persist on delayed imaging
Angiomyoma	Isointense to muscle	Homogenous to heterogeneously hyperintense with hypointense capsule and linear or branching internal hyperintensities	Homogeneously hyperintense	Diffuse homogenous enhancement
Fibro-osseous pseudotumor	Heterogenous isointense to hyperintense	Heterogeneous hyperintense	Heterogeneously hyperintense	Avid enhancement
Fibroma of the tendon sheath	Heterogenous isointense to hypointense to muscle	Variable hyperintensity to hypointensity to muscle	Heterogeneously hypointense	Variable mild to avid enhancement
Fibromatosis	Heterogeneously hyperintense to isointense	Heterogenous hypointense, isointense, or hyperintense	Variable hypointense and hyperintense	Variable moderate to marked enhancement
Enchondroma	Heterogeneous hypointense to isointense	Lobulated areas of hyperintense signal	Heterogeneous hyperintense	Possible enhancing septa or mild peripheral enhancement
Intraosseous Giant Cell Tumor	Hypointense to isointense signal within the solid component	Heterogeneous hyperintense with areas of low signal intensity	Heterogeneously hyperintense	Solid components will enhance
Ganglion Cyst	Homogeneous hyperintense	Homogeneous hyperintense	Homogeneously hyperintense	Rim enhancement
Giant Cell of the Tendon Sheath	Heterogeneous hyperintense to intermediate	Heterogeneous hyperintense to intermediate	Heterogeneous hyperintense	Avid enhancement
Schwannoma	"Split-Fat" sign with thin peripheral rim of fat signal	Hyperintense to muscle with "target sign" representing a central low-signal region	Heterogeneous increased signal	Diffuse enhancement
Osteomyelitis	Confluent areas of hypointensity	Heterogeneously hyperintense regions in the bone marrow (edema)	Heterogeneously hyperintense regions in the bone marrow (edema)	Increased enhancement with possible rim (abscess)
Melanoma Metastasis	Heterogeneously isointense to muscle with subtle hyperintense regions	Variable hyperintensity to hypointensity	Variable hypointense to isointense	Avid enhancement
Soft Tissue Sarcoma	Homogeneously isointense to muscle on T1WI	Heterogeneously hyperintense	Heterogenous with possible surrounding edema	Heterogeneous enhancement

* Short Tau Inversion Recovery

DETAILS ON PAGE 11

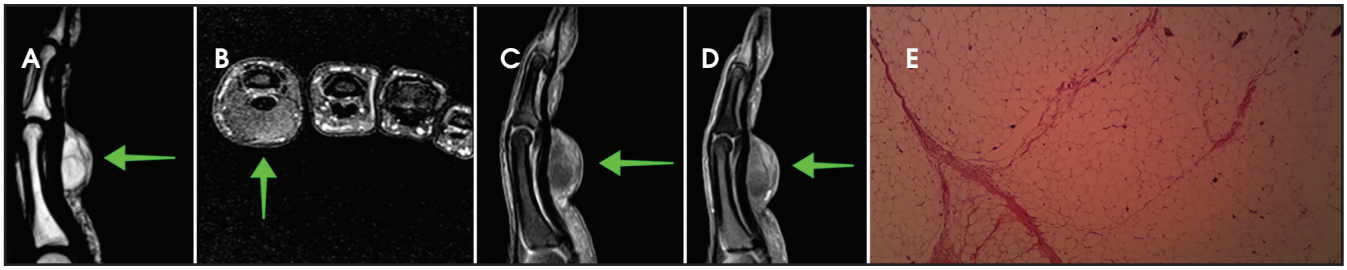

FIGURE 1. *Lipoma. 66-year-old woman with multilobulated mass extending from the mid-shaft of the proximal phalanx to proximal interphalangeal joint along the volar aspect of the 2nd flexor digitorum superficialis tendon. Lesion demonstrates hyperintense T1W signal on sagittal view (A), isointense T2W signal on axial view (B), homogeneous loss of signal on proton density fat-saturation sequences (C) as seen on sagittal view, and no significant enhancement post-gadolinium administration (D) on T1W sequences sagittally, consistent with lipoma (E).*

Table 2. Scoring for the Diagnosis of Atypical Lipomatous Tumor (ALT)

Features	Description	Points
Diameter (cm)	<10 cm	0
	>10 cm	1
Depth	Superficial	0
	Deep	1
Septa (MRI)	No	0
	Yes	2
Enhancement (MRI)	No	0
	Yes	2

management. ALT incorporates lesion diameter: 0-10 cm (0) or >10 cm (1); depth, superficial (0) or deep (1); septa: no (0) or yes (2); and enhancement: no (0) or yes (2). Lesions with total scores greater than or equal to 3 should lead to biopsy/pathologic correlation due to suspicious features (Figure 1, Table 2).[3]

Neurovascular masses

Glomus tumor

Glomus tumors are benign masses arising from the neuromyoarterial apparatus of the glomus bodies, which are responsible for thermoregulation.[4, 5] Clinically, the tumor presents as a small, reddish mass found in a typical subungual location in 25-65% of all cases and is usually seen in patients between 40 and 50 years of age. Lesions typically cause a triad of pain, sensitivity to temperature changes, and point tenderness.[4-7] Despite the fact patients seek help early, the lesion is often too small to be recognized on physical exam.[8] A subungual location in conjunction with homogeneous high signal intensity on T2WI, low or intermediate signal on T1WI, and uniform enhancement after contrast administration are characteristic (Figure 2).[6, 7]

Schwannoma

Schwannomas are benign, slow-growing tumors originating from the epineurium of peripheral nerves and usually affect adults in the third decade of their lives.[9] Tumors may grow for years prior to being diagnosed and rarely exceed three centimeters in diameter.[10] Clinically, schwannomas present as palpable solitary, painless lesions on the volar aspect of the wrist causing entrapment syndrome with paraesthesia, hypoaesthesia, and pain. Constituting approximately 0.8-2.0% of all hand tumors, schwannomas are considered rare and involve the upper twice as often as the lower extremities.[11] Neurofibromas, ganglion cysts, tumors, lipomas, and xanthomas need to be considered as possible differential diagnoses.[10] Histologically, schwannomas stain positive for S100 (marker for neuroectodermal cells), and present with an areas of spindle cells and nuclear palisading (Antoni A) next to hypocellular, myxoid regions (Antoni B).[10, 11] On MRI, schwannomas show intermediate to low signal on T1-weighted images and increased diffuse signal on T2WI. Contrast enhancement on T1WI is particularly helpful in their diagnosis, with diffuse enhancement and central areas of low signal being characteristic (target sign, Figure 3).[10]

Vascular abnormalities

Slow flow venous abnormality

Vascular abnormalities of the hand and wrist are relatively uncommon and considered non-neoplastic lesions resulting from alterations in signaling during development and vessel morphology.[4, 12] They are usually present at birth and grow proportionally with the child but may not be diagnosed until adulthood.[4, 12] Congenital vascular malformations account for 2-6% of all upper extremity tumors and are evenly distributed between genders.[12] Depending on the vascular components involved, masses can be of capillary, venous, arterial or lymphatic origin and can be classified based on their hemodynamic status as low flow (lymphatic, venous, capillary) or high flow (arteriovenous).[4, 12] Venous abnormalities are the most frequently encountered vascular malformation and clinically present as swelling with skin changes, and

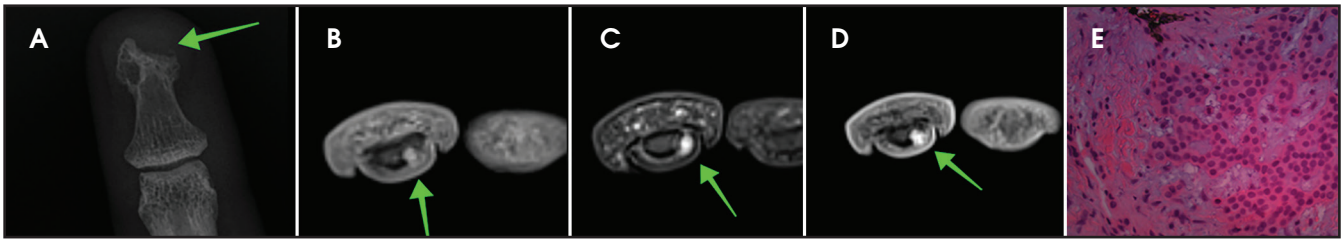

FIGURE 2. *Glomus tumor. 49-year-old man with chronic osseous deformity of the 3rd distal digit with sclerotic margins (A) on AP radiograph. Additional investigation with MR demonstrated a subungual mass centered in the ulnar aspect of the 3rd phalangeal tuft with mildly hyperintense T1W signal, hyperintense T2W fat-suppressed signal, and avid enhancement post-gadolinium administration (B, C, D) on axial views. (E) Glomus tumors (GT) are neoplasms (benign in most cases) composed of the modified smooth muscle cells seen in the normal glomus body. The figure shows the tumor cells as noted by indolent appearing cells with a centrally placed, round nuclei in a trabecular pattern. GTs may also present with variable amounts of blood vessels surrounded by nests of neoplastic glomus cells.*

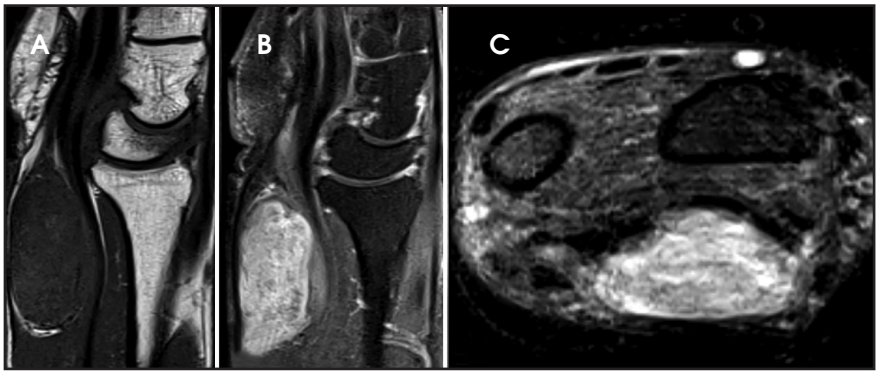

FIGURE 3. *Schwannoma. 89-year-old man with well-defined, well-circumscribed lesion in the anterior aspect of the distal forearm located superficial to the long flexor tendons and pronator quadratus in the distal forearm demonstrating (A) hypointense signal on T1W images, predominantly hyperintense (B) on T2W images with intralesional signal inhomogeneity and shows prominent enhancement (C) post-contrast administration.*

bone hypoplasia in 33% of all cases.[7] Slow flow venous abnormalities present with localized pain that can be intensified by physical activity due to thrombosis and dilatation.[12] Vessels resemble dilated vascular spaces with slow flow and septated channels, and appear as hyperintense masses on T2WI. Lesions lack high flow velocity signal voids and are isointense to muscle on T1WI.[4] Enhancement of the vascular spaces can be uniform or inhomogeneous.[4] Contrasted to arteriovenous malformations, which are more commonly encountered in the head and neck, present on MR imaging as a tangle of vessels with no prominent soft tissue component, vascular shunting, often contain thrombosis, calcification, and possible adjacent lipomatous hypertrophy (Figure 4).

Hemangioma

Hemangiomas are predominantly found in younger patients, occur more often in females, and represent the fourth most common tumor of the hand.[8] Distinctly, hemangiomas feature a period of rapid growth with endothelial cell proliferation followed by stagnation and eventually spontaneous involution, a fact that allows distinction from vascular malformations that grow proportionally with the child.[12] Superficial hemangiomas present with characteristic skin discolorations, and can therefore usually be easily diagnosed by visual inspection alone. If imaging is needed to classify the mass, hemangiomas are usually hyperintense on T2WI as a result of decreased blood flow and subsequent increased fluid content, and frequently display lobulations and septations.[6] Masses are iso- to hyperintense to muscle on T1WI, with larger lesions containing fat, smooth muscle, myxoid tissue, thrombi, hemosiderin, and fluid levels.[6] As a distinct feature, muscle atrophy in the periphery of the lesion has been described secondary to chronic ischemia due to a shunting phenomenon caused by the mass (Figure 5).[5]

Angiomyoma

Angiomyomas account for 5% of all benign tissue neoplasms, and are characteristically well-defined, grow slowly, found in the dermis, subcutaneous fat, or superficial fascia of the extremities predominantly.[9, 13] They represent proliferations of smooth muscle of the venous tunica media and are associated with pain in 58% of patients, which increases in intensity with distal locations.[9] Digital masses are more frequently located in the fingers than in the toes with a 4-3:1 ratio, and show an equal gender distribution.[9] Digital lesions appear isointense or slightly hyperintense compared to skeletal muscle on T1-weighted imaging (T1WI), hyperintense on T2-weighted imaging (T2WI), and enhance on T1WI after contrast administration.[13] A peripheral rim of low signal on T1 and T2WI resembles a fibrous pseudocapsule, and an enhancing vascular structure may accompany the mass resulting in signal heterogeneity on T2WI (Figure 6).[13]

Fibrous (reactive) lesions

Fibro-osseous pseudotumor

Fibro-osseous pseudotumors are rare, benign, but locally aggressive ossifying soft tissue lesion with approximately 100 documented cases in the literature, typically found in the digits of young adults. This entity is thought to represent a reactive process (eg, repetitive trauma) rather than a neoplasm, and considered to be a subcutaneous

DETAILS ON PAGE 11

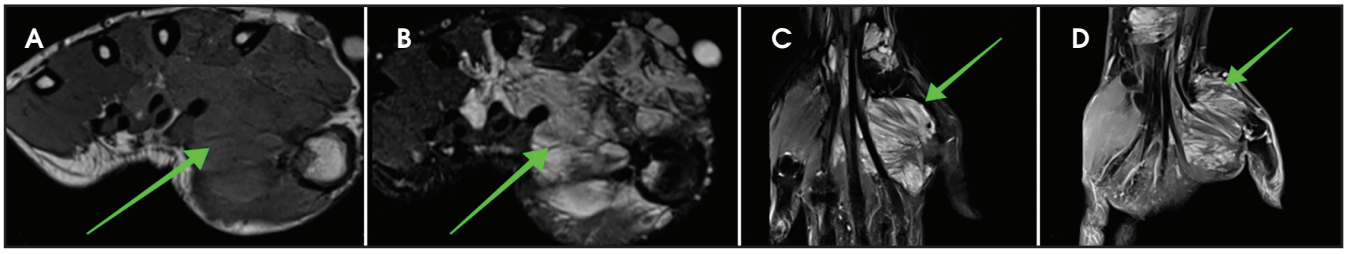

FIGURE 4. *Slow flow venous abnormality. 24-year-old man with large, diffusely infiltrative multi-compartmental mass in the distal forearm extending in the hand predominantly along the volar radial aspect of the thenar muscles, long flexor tendons of the index and middle fingers, and infiltrating the lumbricals. Mass demonstrates isointense T1W signal, hyperintense short T1 inversion recovery, and persistent enhancement on delayed 3-minute images post-gadolinium administration (A, B, C, D), axial and coronal views, respectively.*

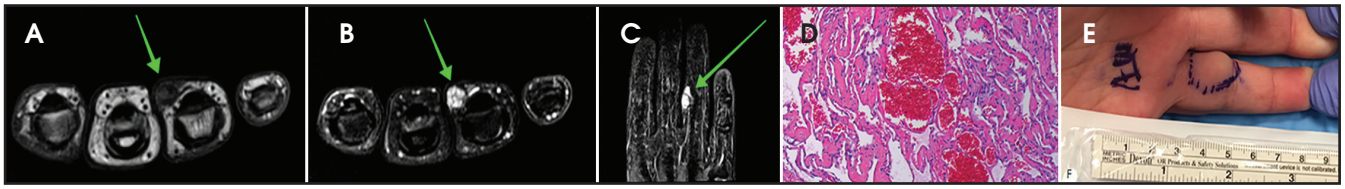

FIGURE 5. *Hemangioma. 30-year-old woman with lobulated mass centered in the subdermal and superficial subcutaneous soft tissues along the volar radial aspect of the fourth digit at the level of the proximal interphalangeal joint. Mass demonstrates T1W isointense signal, heterogeneously hyperintense T2W fat-saturated signal, and hyperintense short T1 inversion recovery signal (A-C). Pathologically proven to be a hemangioma. Clinically the mass was tender to palpation and increased in size with prolonged use of the hand. Histologic examination of the surgically resected lesion demonstrated hemangioma. (D) Hemangiomas are benign lesions presenting with a proliferation of blood vessels. The figure shows thin-walled blood vessels, which is more compatible with a cavernous type of hemangioma. (E) Photograph prior to surgical resection demonstrates a large soft tissue mass in the proximal 4th digit.*

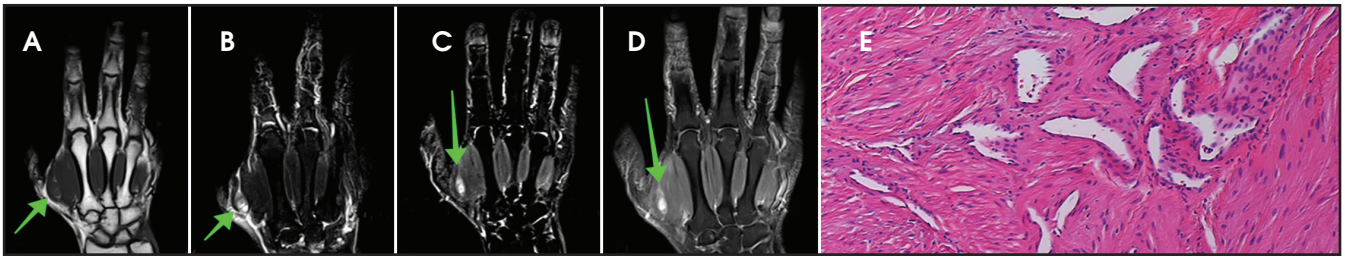

FIGURE 6. *Angiomyoma. 52-year-old man with fusiform mass in the first dorsal interosseous muscle demonstrating heterogenous T1W signal intensity, hyperintense T2W fat-saturated signal, and hyperintense signal on short T1 inversion recovery (A, B, C) on coronal views, and intense enhancement post-gadolinium administration on T1W coronal views (D). (E) The figure shows a proliferation of vascular channels in a background of spindled cells, which represent smooth muscle. No mitosis, necrosis, or pleomorphic cells are identified.*

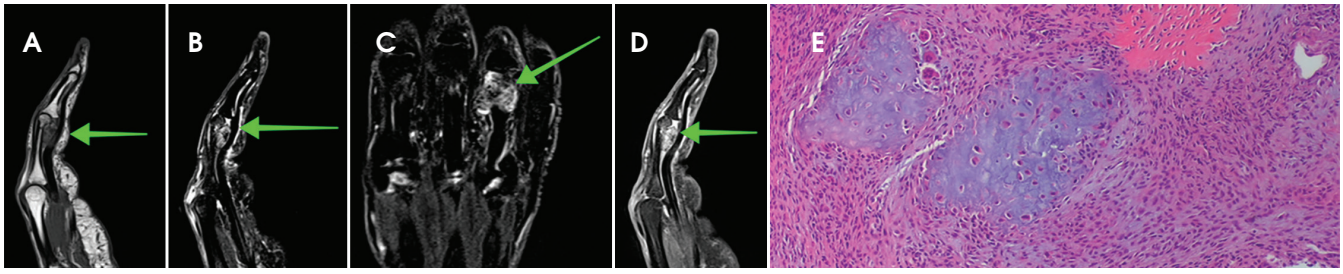

FIGURE 7. *Fibro-osseous pseudotumor. 62-year-old woman with lobulated mass interposed between the 4th flexor digitorum profundus tendon and the proximal phalanx. Mass demonstrates isointensity on T1W, heterogeneous signal on T2W fat-saturated sequences, and hyperintensity with short T1 inversion recovery (A, B, C) on sagittal and coronal views, respectively. Mass demonstrates avid enhancement post-gadolinium administration on T1 sequences (D) on sagittal reformations. (E) Fibro-osseous pseudotumor of the digit (FOPD) is an unusual, ossifying, soft tissue lesion that microscopically resembles myositis ossificans (MO) consisting of fibroblasts and bone forming elements (mature bone, giant cell osteoclasts, and sometimes cartilage). However, unlike MO, FOPD has no zonal proliferation of these elements, and these components are randomly distributed throughout the lesion.*

soft tissue variant of myositis ossificans.[11,14-16] Lesions are confined to the dermis and subcutis and may cause a periosteal reaction. Clinical diagnosis is difficult and lesions are often misdiagnosed as malignant with subsequent radical excision or amputation.[11] Symptoms occur over weeks or months and are associated with pain, redness, and affect functionality.[11] Patients in the 4th decade of their lives are more frequently affected with a slightly higher

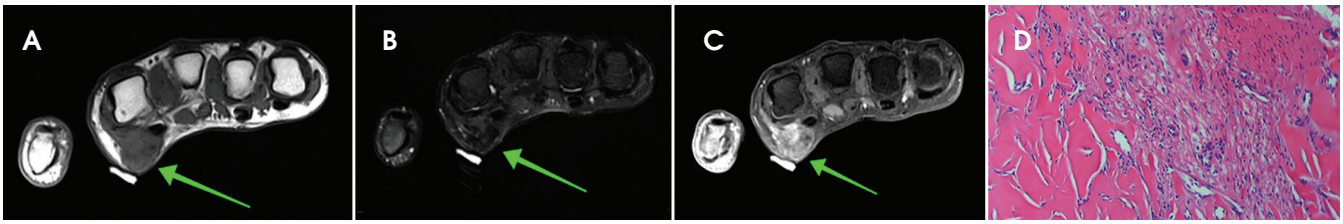

FIGURE 8. *Fibroma of the tendon sheath (FTS). 34-year-old man with lobulated mass centered within the volar and radial aspect of the 2nd flexor digitorum profundus tendon resulting in mass effect. Mass demonstrates hypointense T1W signal, isointense T2W fat-saturated signal, and avid enhancement post-gadolinium administration on T1W sequences (A, B ,C). (D) The figure shows a FTS with bland, spindled fibrocytes and elongated ("slit-like") vascularity, which is then surrounded by a dense collagenous matrix.*

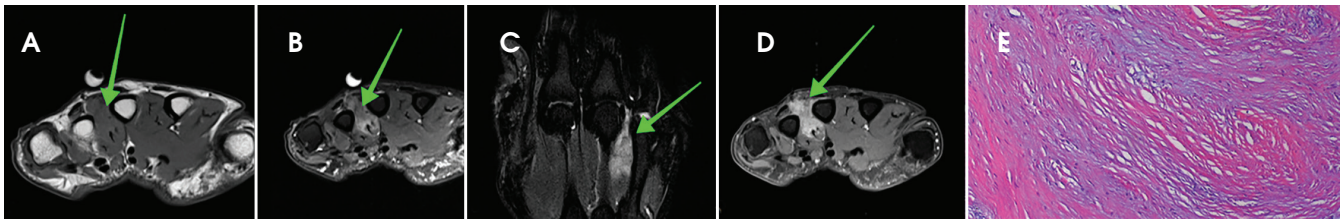

FIGURE 9. *Fibromatosis. 44-year-old woman with ill-defined mass interposed between the 3rd and 4th interosseous muscles with isointense T1W signal, heterogeneous T2W fat-saturated signal, and hyperintense short T1 inversion recovery signal (A, B, C) on axial and coronal views, respectively. Avid increased enhancement was demonstrated on post-gadolinium T1W images on axial view (D). (E) Spindled fibroblasts with dense, stromal collagenization.*

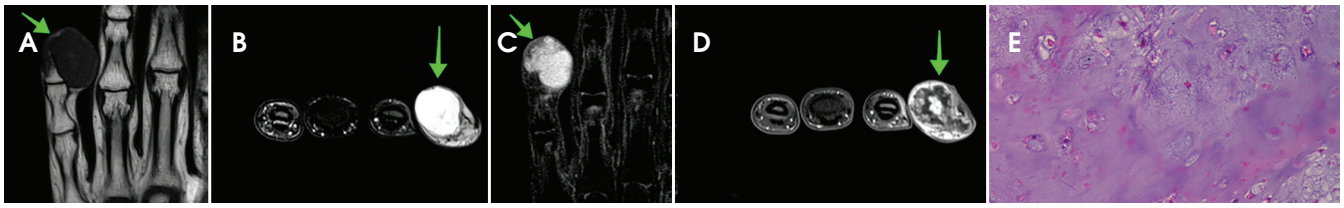

FIGURE 10. *Enchondroma. 32-year-old woman with ovoid mass centered in the distal fifth phalanx, eroding the radial surface. Mass is homogeneously isointense on T1W and hyperintense on T2W sequences (A, B) on coronal and axial views, respectively. Mass also demonstrates hyperintense short T1 inversion recovery signal and heterogeneous enhancement post-gadolinium administration on T1W sequences (C, D) coronal and axial views, respectively. (E) The figure shows a hypocellular, avascular tumor with an abundant hyaline cartilage matrix. The malignant features of chondrosarcoma, such as nuclear pleomorphism, hyperchromasia, increased mitosis, or invasion of surrounding tissue, are not present.*

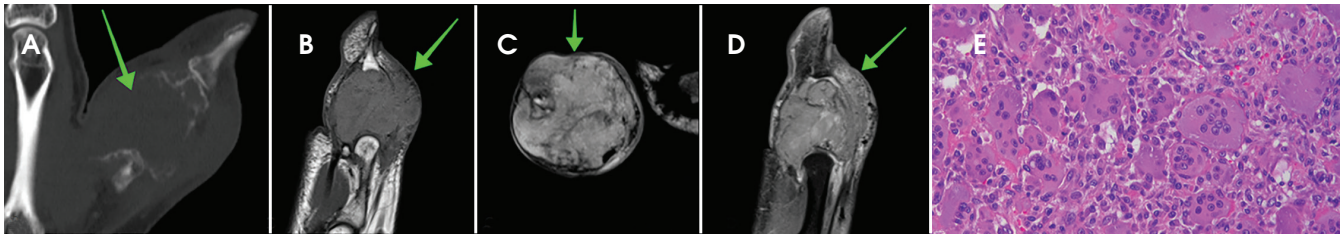

FIGURE 11. *Giant cell tumor. 22-year-old man with soft tissue mass approximated near the radial aspect of the distal phalanx of the 4th digit without apparent osseous involvement on AP radiograph (A). Additional investigation with MR demonstrated a well-circumscribed oval mass within the subcutaneous soft tissues of the distal fourth digit with homogenous hypointense signal on T1W sequences, mildly hyperintense T2W signal, and heterogeneous enhancement post-gadolinium administration (B, C, D) sagittal, axial, and sagittal views, respectively. (E) This figure shows the typical admixture of the different cellular components, involving "foamy" histiocytes, mononuclear histiocytes, multinucleated giant cells, siderophages, and fibrous stroma. Amounts of each of these components may vary.*

female prevalence.[11] Radiologic findings often include a radiolucent band between the mass and cortex as well as a focal soft tissue swelling with associated calcification and may be differentiated from myositis ossificans by a lack of well-defined zoning pattern.[14] MR findings are generally of T1W/T2W hyperintensity with mild heterogeneous enhancement. Occasionally, in its earliest phase, the lesion may present with aggressive-appearing features, including periosteal thickening and local cortical erosion, which may favor inclusion of juxtacortical osteosarcoma in the differential diagnosis.[14-16] Clinical history, close interval follow-up, and if necessary pathologic

DETAILS ON PAGE 11

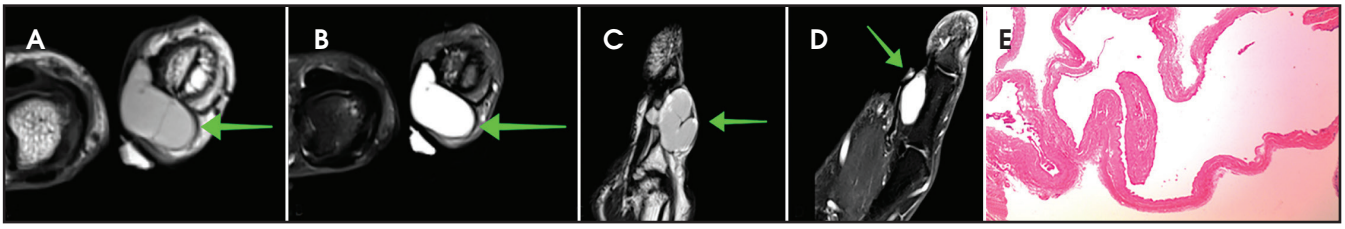

FIGURE 12. *Ganglion cyst. 59-year-old woman with multilobulated soft tissue mass along the volar aspect of the first proximal phalanx, abutting the flexor pollicis longus tendon without apparent joint involvement or osseous abnormalities. Mass demonstrates homogeneous intermediate T1W hyperintense signal and hyperintense T2W fat-saturated signal best viewed on axial reformations (A, B), no significant loss of signal on fat suppressed proton density images on sagittal view (C) and no significant enhancement post-gadolinium administration (D) sagittally. (E) This lesion is filled with mucinous material, which may rupture and permeate surrounding fibrous connective tissue.*

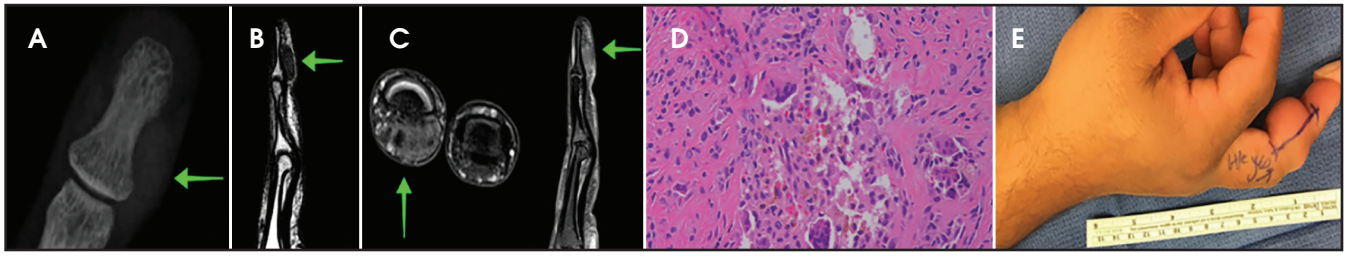

FIGURE 13. *Intraosseous giant cell tumor. 34-year-old woman with expansile mass centered in the first proximal phalanx causing medullary expansion with severe remodeling and areas of cortical destruction on non-enhanced CT coronal reformation (A). MR evaluation of the mass demonstrated a large, expansile mass with homogeneous hypointense T1W signal, heterogeneous T2W fat-suppressed signal, and heterogeneous enhancement post-gadolinium administration T1W sequences (B, C, D) on sagittal, axial, and sagittal views, respectively. (E) Giant cell tumors (GCT) involving bone are locally aggressive neoplasms, often with infiltrative margins. The figure shows the classical features seen in GCTs composed of sheets of neoplastic mononuclear cells, interspersed with uniformly distributed osteoclastic-like giant cells.*

tissue correlation may be required to establish benignity (Figure 7).

Fibroma of the tendon sheath

Fibromas of the tendon sheath are rare, benign tumors directly involving the tendon sheath thought to be secondary to local reactive processes rather than a neoplastic pathology. Lesions occur most commonly in the hand and wrist in 82% of all cases, and are more frequently found in men (3:1) in the 4th decade of life.[2, 8] Fibromas may directly involve the neurovascular bundle, can locally recur after resection, and have no malignant potential. Fibromas of the tendon sheath are often challenging to diagnosis as the lesion typically shares nonspecific imaging characteristics with other tumors of the tendon sheath (mostly giant cell tumors) and soft tissue sarcomas.[6,8] MR imaging features include mixed T1W and T2W appearance based on variability in composition (low T1W signal in fibrous regions and heterogeneous T2W signal in cellular/stromal regions), and typically a lack of enhancement. Distinguishing MR features include a lack of blooming artifact on gradient recalled echo (GRE) sequences and no evidence of bony scalloping, both of which are more commonly seen in giant cell tumors of the tendon sheath (GCTTS, Figure 8).[2]

Fibromatosis (pathologic origin)

Fibromatosis is a benign, occasionally locally aggressive and infiltrative lesion without metastatic potential, representing a proliferative disorder of mature fibroblasts.[15, 17, 18] Lesions are thought to be multifactorial in pathogenesis (genetic, endocrine, traumatic, and/or microvascular injury) and are categorized as superficial or deep. Superficial locations include palmar and plantar fibromatosis. Palmar fibromatosis (referred to as Dupuytren disease) occurs more commonly in men (3:1) over the age of 65 and plantar fibromatosis (referred to as Ledderhose disease) occurs mostly in men (2:1) aged 30-50 years. Contributing factors include diabetes, alcoholism, and chronic liver disease. Deep fibromatoses occur most frequently in women in the 2nd and 4th decades of life, and tend to be more locally aggressive.[17, 19] MR imaging typically demonstrates T1W intermediate to hypointense signal, T2W hyperintense signal with hypointense bands, and avid enhancement in T2 hyperintense regions (Figure 9).

Benign primary bone/cartilage tumors

Enchondroma

Enchondromas are the most common primary bone tumors and account for 12 - 24 % of all benign bone tumors and almost 3 % of all bone tumors overall.[10,20] Approximately 35% of all enchondromas can be found in the hand, accounting for almost 90% of all primary hand bone tumors.[21] They are considered a proliferation of hyaline cartilage in the metaphyseal-diaphyseal region of bones with endochondral ossification.[20] Enchondromas are slow growing, develop in patients between 30 and 40 years of age, and commonly affect the ulnar sided tubular bones with the proximal phalanges most frequently involved.[10] They are

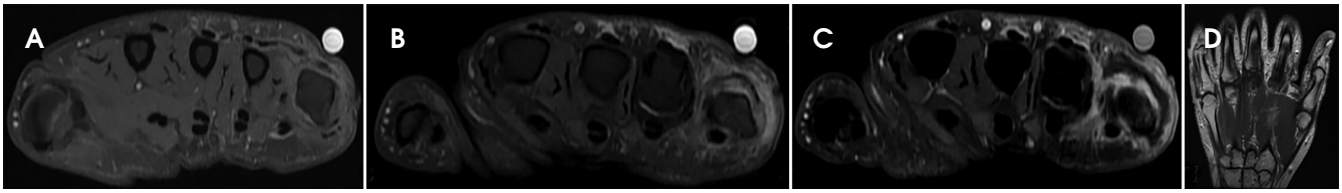

FIGURE 14. *Epitheloid sarcoma. 30-year-old woman with ill-defined mass surrounding the 5th digit with abnormal increased signal on proton density sequences and heterogeneous enhancement post-gadolinium. Representative images including the T1W fat sat (A), axial PD-fat sat (B), axial T1 post-gadolinium (C) and coronal T1 post-gadolinium (D). Pathology confirmed epithelioid sarcoma.*

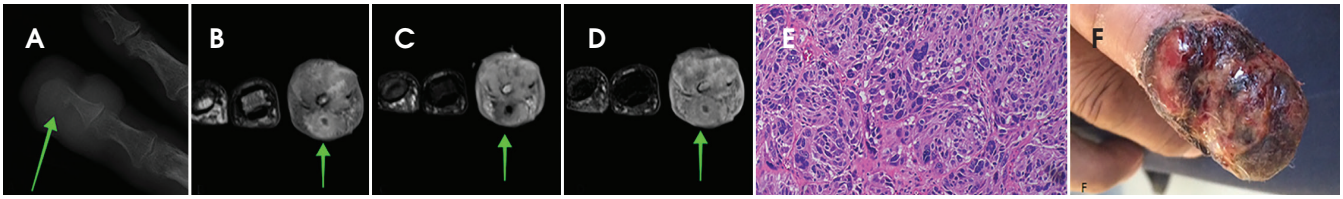

FIGURE 15. *Melanoma mets. 62-year-old man with nodular soft tissue mass of the distal 2nd digit with ungal elevation (A). MR evaluation presented multifocal nodular subcutaneous lesions within the dorsal soft tissues of the distal 2nd digit at the level of the phalangeal tuft with heterogeneous T1W signal, heterogeneous T2W fat-suppressed signal, and heterogeneous enhancement post-gadolinium administration on T1W sequences (B, C, D) on axial views. (E) The tumor cells have a nested or lobular architectural pattern with nuclear pleomorphism, hyperchromasia, and increased nuclear to cytoplasmic ratio. (F) Clinical photograph of a bleeding, fungating lesion of the 2nd digit.*

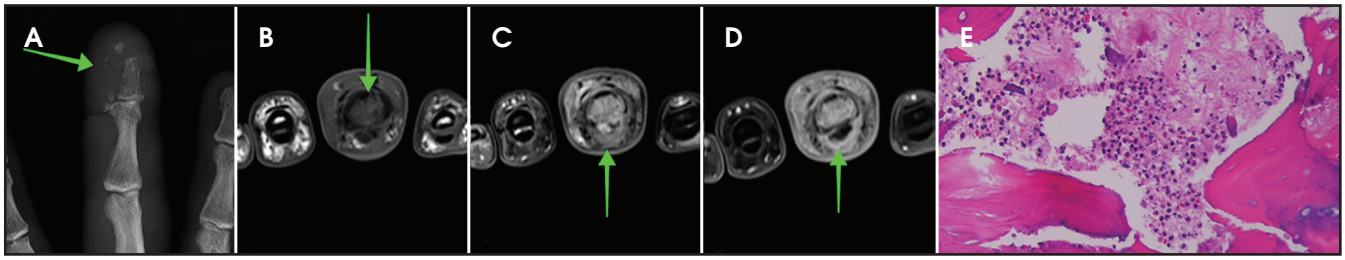

FIGURE 16. *Osteomyelitis. 46-year-old man with osseous erosion of the distal phalanx of the 3rd digit and fragmentation of the tuft (A) on oblique hand radiograph. MR demonstrates cutaneous irregularity of the distal tip of the 3rd digit with small adjacent fluid collection. Homogeneous hypointense T1W signal, hyperintense T2W signal, and heterogeneous enhancement post-gadolinium administration was demonstrated within the middle and distal phalanges of the 3rd digit (B, C, D), on axial images consistent with osteomyelitis. (E) Acute osteomyelitis often shows marrow necrotic debris, trabecular bone necrosis, and an abundant of granulocytes (mostly neutrophils). Subacute and chronic osteomyelitis (not shown) will demonstrate regenerative bone (woven bone), myelofibrosis, and chronic inflammatory cells (lymphocytes, histiocytes, and plasma cells).*

usually incidental findings associated with pathological fractures in 40-60% of all cases on initial presentation.[10,20] On MRI, enchondromas appear as well demarcated masses with intermediate to low signal on T1 WI, high signal on T2WI with decreased signal due to calcifications, and variable enhancement after contrast administration (Figure 10).[20]

Intraosseous giant cell tumor

Giant cell tumors (GCT) are benign but locally aggressive neoplasms typically found in the epiphysis of long skeletal bones in patients 20 to 40 years of age.[22] Only 2% of all GCT are located in the hand, and present with progressive pain, swelling and pathological fracture due to the lytic nature of the lesion, without calcifications, sclerosis, or periosteal reaction.[22] GCTs can be classified as *Grade 1* (corresponds to a latent, cystic lesion with sclerosed margins), an active *Grade 2* (the most common type, characterized by a thin cortex but no extension into the surrounding tissue), and *Grade 3* (identifiable by a perforated cortex and invasion of the neighboring tissue).[22] The three stages described correlate to aggressiveness and risk of recurrence.[22] Intraosseous giant cell tumors typically present with hypointense to isointense signal within the solid component on T1WI, heterogenous T2W signal, and enhancement of the solid components after gadolinium administration on T1WI (Figure 11).[23]

Degenerative (reactive) lesions

Ganglion cyst

Ganglion cysts make up a large percentage (60-70%) of frequently diagnosed masses of the hand and wrist, are mostly seen in young women in the second to fourth decades of their lives, and resemble degenerated connective tissue as a consequence of chronic irritation or as a result of repetitive microtrauma.[4,6,7,24] Clinically, these mucin-filled synovial cysts present as painful lesions that may compress the median or ulnar nerve and are usually between 1-3 cm in size.[7,24] Masses appear uni-or multilocular and predominantly involve the dorsum of the wrist (60%), where they often arise from the scapholunate joint.[4,6] Volar masses

DETAILS ON PAGE 11

(20%) usually originate from the radioscaphoid, scapho-trapezial, or metacarpotrapezial joint.[4] Involvement of the flexor tendon sheath (10%) and distal interphalangeal joint (10%) occur less commonly.[4] Low signal on T1WI and high signal on T2WI are typical imaging findings. Signal may be altered to iso- or hyperintensity on T1 WI due to proteinaceous or hemorrhagic content, and mild enhancement of the capsule and septae can be visualized after gadolinium administration (Figure 12).[4,5]

Giant cell tumor of the tendon sheath

Giant cell tumors of the tendon sheath (GCTTS) are the second-most common hand masses and appear as benign, painless, well-defined masses involving the tendon sheath in the volar aspect of the hand, slightly favoring women 30-50 years of age.[4,6,7] GCTTS are thought of as reactive lesions associated with degenerative processes rather than a neoplasm, but expansive growth may result in pressure changes of adjacent structures and affect hand function.[6,7] Recurrence rates after surgical excision of up to 44 % have been reported.[7] Hypointensity on T1WI and T2WI are characteristic imaging findings and may be accompanied by areas of low and high signal intensities on T2WI due to hemosiderin deposits and fluid accumulation.[4,6] Susceptibility artifacts on GRE sequences and strong enhancement due to capillary proliferation are typical and can aid in the diagnosis (Figure 13).[6]

Malignancies, metastases, and mimics

Epithelioid sarcoma

Epithelioid sarcomas are the most common primary soft tissue sarcoma of the hand and are usually diagnosed in young men 20-30 years of age as a firm, nontender tumor of the distal upper extremity.[22,25] Epithelioid sarcomas usually have a benign presentation with slow progression, often misdiagnosed as chronic inflammation, necrotizing granulomas, or fibrohistiocytic tumors.[25] Lesions are initially solitary but may become multiple with disease spreading along tendons, fascia, and aponeurosis. As the tumor progresses, necrosis, hemorrhage, ulceration, and periosteal bone invasion become characteristic, as well as involvement of regional lymph nodes and metastases.[25] Metastatic rates of up to 50% can be seen and predominantly involve the lung.[25] Local recurrences within 1-2 years after treatment are common and are usually associated with a worse clinical outcome.[25] Histologically, epithelioid sarcomas can be classified as epithelioid, spindled, or mixed and stain positive for vimentin, epithelial membrane antigen, and cytokeratin.[25] MRI with contrast demonstrates the hypervascularity of the lesion, the extent of necrosis and involvement of neighboring structures. Epithelioid sarcomas are isointense to muscle on T1WI and hyperintense on T2WI with superficial lesions appearing homogenous with heterogenous deep lesions (Figure 14).[22]

Malignant masses (primary and metastatic melanoma)

Malignant lesions of the hand are rare and often carry a poor prognosis. Examples include sarcomas, malignant nerve sheath tumors, and metastatic lesions with primary tumors predominantly located in the lung, breast, or kidney.[2,8,19,26] Malignant tumors characteristically present as destructive lytic lesions, have poorly defined margins, are edematous, lobulated, and show signs of hemorrhage and necrosis.[8] Melanomas of the hand account for 3% of all hand tumors.[7] Demonstrated in this specific case series, examples of primary and metastatic melanoma have a unique MR imaging appearance. Primary melanoma can be differentiated from metastatic melanoma since primary lesions are contiguous with the skin. Several studies have shown the degree of increased T1W signal often correlates directly with melanin content.[26,27] although it has been theorized that bound biologic paramagnetic substances to the melanin may be the causative agent rather than melanin itself.[27] T2W signal is often heterogeneous, which may be secondary to hemorrhagic products. Melanoma lesions typically enhance avidly after gadolinium administration (Figure 15).

Osteomyelitis

Osteomyelitis is most commonly caused by *S. aureus* and *Streptococcus* organisms, resulting in pain, swelling, and erythema.[28] Soft tissue and osseous infections of the hand are common and can often mimic soft tissue masses. Infection in the hand and wrist are mostly caused by direct inoculation of pathogens after trauma or surgery, but may also result from local or hematogenous spread.[29] Spread of the pathogen along the anatomical planes (usually traumatized bone) subsequently results in osseous necrosis.[29] Common risk factors for hand infections include immunocompromise, drug and alcohol abuse, inflammatory arthropathy, peripheral vascular disease, and renal failure.[30] Careful attention to clinical history and anatomic detail is paramount in investigating a potential hand infection or soft tissue mass. Radiographic findings include identification of soft tissue swelling or ulceration with possible local periosteal reaction or erosions. Osteolysis is present in 70% of all cases, followed by osteopenia (10%), osteosclerosis (10%), and periosteal reactions (10%).[28] Identification of osteomyelitis on MR includes confluent regions of low signal intensity on T1W images, increased signal on fluid-sensitive sequences, and avid contrast enhancement (Figure 16).[19,30,31]

Conclusion

Soft tissue masses of the hand and wrist are common in clinical practice, and while most masses are benign, MR plays a vital role in deciphering the preoperative diagnosis and guiding clinical management. While overlapping MR findings may necessitate the need for clarification with clinical history, follow-up imaging, or additional pathologic correlation, the radiologist

DETAILS ON PAGE 11

should be familiar with various benign, malignant, and potential tumor mimics to develop and narrow the differential diagnosis.

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