Review

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Radiological Appearences of Benign Soft-tissue Tumors of the Hand and Wrist with Special Emphasis on MRI

El-El Bileği İyi Huylu Yumuşak Doku Lezyonlarının MR Görüntüleme Bulguları

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ABSTRACT

Tumoral and pseudotumoral lesions of the hand and wrist are commonly encountered in routine clinical practice. Although most of them are benign, radiological differential diagnosis of these lesions is difficult, because of their nonspecific imaging findings, except ganglia, localized type of tenosynovial giant cell tumors and lipomas. Digital radiography, computed tomography, and ultrasound may be useful in identification of the lesions in the wrist and hand, but magnetic resonance imaging with superior contrast and spatial resolution is the most important imaging modality.

Keywords: MRI, hand, tumor, wrist, benign, lipoma, fibroma

ÖZ

El ve el bileğinin tümoral ve psödotümöral lezyonlarına rutin klinik uygulamada sıklıkla rastlanır. Çoğu iyi huylu olmasına rağmen, gangliyonlar, lokalize tenosinoviyal dev hücreli tümörler ve lipomlar dışında özgün olmayan görüntüleme bulguları nedeniyle bu lezyonların radyolojik ayırıcı tanısı zordur. El bileği ve eldeki lezyonların tanımlanmasında dijital radyografi, bilgisayarlı tomografi ve ultrason yararlı olabilir, ancak üstün kontrast ve uzaysal çözünürlüğe sahip manyetik rezonans görüntüleme en önemli görüntüleme yöntemidir.

Anahtar Sözcükler: MRG, el, tümör, el bileği, benign, lipom, fibrom

Introduction

Tumoral and pseudotumoral lesions of the hand and wrist originating from various kinds of tissues such as bone, cartilage, tendon-tendon sheath, synovium, muscle, nerve and connective tissue are commonly seen in routine clinical practice. The World Health Organization classification for soft-tissue tumors is a commonly used classification system and provides uniformity for the reporting and treatment of different tumors and tumor-like lesions (1) (Table 1). Soft-tissue lesions of the hand and wrist range from non-neoplastic-inflammatory conditions to benign and malignant tumors. Most of them are benign and usually present with painless lumps and nodules (2). Except lesions with specific imaging findings (e.g. ganglia, localized type of tenosynovial giant cell tumors and lipomas), radiological features of these tumoral lesions frequently do not allow clinicians for a definitive diagnosis (3-5). Therefore, hand surgeons often prefer excision of the lesion before reaching an exact radiological and pathological diagnosis, because of patient's cosmetic worries and functional loss. To reduce the list of the differential diagnoses, thorough clinical examination,

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taking a good anamnesis, location of the lesion, and associated systemic diseases such as rheumatologic disorders are important (6,7). X-ray and computed tomography (CT) are helpful in demonstrating calcifications within the lesion and evaluating the bony structures. Cystic nature of the lesion can be determined with a high-frequency transducer ultrasound (US). Internal vascularization of the lesion may be demonstrated with color Doppler imaging (8). Magnetic resonance imaging (MRI) with its superior contrast and spatial resolution should be the preferred imaging method in diagnosis and characterization of hand and wrist mass lesions. MRI can accurately determine the signal characteristics of the lesions that reflect the underlying pathological structure of the mass. MRI also determines the enhancement patterns of the lesion and accurate localization related to surrounding anatomical structures (2-6,9-14). In this pictorial review, the radiologic, especially MRI, findings of common and unusual hand and wrist soft-tissue lesions will be illustrated and a systematic MR-based approach for the work-up of these lesions and distinctive MRI features that help clinicians in differential diagnosis will be discussed.

Benign Soft-tissue Mass Lesions of the Hand and Wrist

Ganglion Cyst

Ganglion cysts are non-malignant cystic lesions that arise in relation with joints or ligaments. The most common palpable painless lumps located in the hand and wrist area are ganglia (15). Histopathologically, ganglion cysts consist of a thin fibrous tissue capsule with no real synovial overlaying, and include mucinous substance filled with gelatinous fluid. Previous trauma, mucosal degeneration and synovial herniation are possible reasons which result in ganglion cyst formation, although exact etiology of ganglion cyst is unclear. Characteristically, they are adjacent to the underlying joint capsule, tendon sheath or bursae. They tend to arise in young females. They mostly occur in dorsal aspect of the wrist where they generally originate from the scapholunate joint or ligament. Lesser specific regions comprise volar aspect of the wrist where they emerge from the radio-scaphoid or scaphotrapezial joint. In the fingers, the most frequent site for ganglia is third and fourth fingers where they arise from metacarpophalangeal joints and distal interphalangeal joints (2). On US and color Doppler US, ganglion cysts typically present as anechoic and avascular noncompressible cystic lesions

Table 1. WHO classification of soft-tissue tumors

Tumor type	Tumor	Patient age	Anatomic location
Adipocytic	Lipoma	Adulthood (5^{th}-7^{th} decades)	Subcutaenous; intramuscular; intermuscular
Fibroblastic/myofibroblastic	Nodular fasciitis, myositis ossificans, fibroma of tendon sheath	Young adulthood (3^{th}-5^{th} decades)	Nodular fasciitis: deep subcutaneous region or in the fascia Fibroma of tendon sheath: Tendon sheath
Fibrohistiocytic	Giant cell tumor of the tendon sheath	Adulthood (4^{th}-6^{th} decades)	Tendon sheaths
Smooth muscle	Angioleiomyoma (vascular leiomyoma)	Adulthood (4^{th}-7^{th} decades)	Subcutanous; tunica media of the veins
Skeletal muscle	Rhabdomyoma	Young adulthood (3^{th}-5^{th} decades)	Head and neck region
Pericytic (perivascular)	Glomus tumor	Adulthood (4^{th}-5^{th} decades	Tip of fingers; neuromyoarterial apparatus
Vascular	Hemangioma, epitheloid hemangioma, angiomatosis, lymphangioma	Childhood	Subcutanous; striated muscle; multicompartmental
Chondro-osseous	Juxtacortical chondromas, soft-tissue chondromas	Adolescent, young adulthood (2^{th}-4^{th} decades	Juxtacortical chondromas: Periosteum of tubular bones Soft-tissue chondromas: Origin unknown
Lesions not included in the WHO classification of soft-tissue tumors			
Lesion type	**Lesion**	**Patient age**	**Anatomic location**
Tumorlike	Ganglion cyst, hematoma, seroma, abscess, epidermal inclusion cyst, foreign body granuloma, anomalous muscle	Ganglion cyst: Young women Epidermal inclusion cyst: 4^{th}-6^{th} decades	Ganglion cyst: Adjacent to joint capsule, tendon sheath, bursae Epidermal inclusion cyst: Subcutaneous
Benign	Peripheric nerve sheath tumor (PNST): schwannoma (neurilemoma), neurofibroma, perineurioma	Adulthood (3^{th}-5^{th} decades)	Extending along nerves (superficial or deep)

(7). Floating internal echoes and internal septations may be present within the lesions. MRI displays a well-circumscribed unilocular or multilocular masses of fluid signal adjacent to a joint or tendon sheath. Although the signal of the lesions may be variable depending on the quantity of proteinaceous substance and presence of hemorrhage. On contrast-enhanced T1-weighted sequences, slight enhancement of the thin wall and septa may be observed. But there is commonly no enhancement of the interior contents of the cyst unless there is rupture (7,16) (Figure 1). The absence of pericapsular soft tissue contrast enhancement is a clue for differential diagnosis of a ruptured ganglion cyst from other solid soft-tissue lesions (7). A thin pedicle from ganglion cyst to adjacent joint or tendon sheath is often present.

Epidermal Inclusion Cyst

Epidermal inclusion cysts (EICs) are the most encountered type of cutaneous lesions representing with well-encapsulated mobile painless nodules. Congenital misplacement of residual ectodermal tissues, obstruction of the pilosebaceous unit by adjacent inflammation or tumor, human papilloma virus infection, and traumatic or surgical implantation of epithelial components into the dermis are proposed mechanisms for epidermal inclusion cyst formation (17). There is a mild male predominance, and middle -aged adult population is affected mostly. Because hands are particular body regions with increased risk of penetrating injuries, EICs commonly occur in the hands (11). There are imaging features of EICs related to the cyst maturation and cyst content composed of keratin and cholesterol. US and color Doppler US show well-circumscribed heterogenous mildly echogenic avascular mass lesions. On MRI, EICs appear hyperintense on both T1-weighted and T2-weighted images secondary to high lipid concentration (Figure 2) (12). Small low-signal foci on T2-weighted sequences may be present secondary to existence of internal keratin debris and microcalcifications. Peripheral thin rim enhancement can be observed on post-contrast T1-weighted images. Absence of central enhancement on postcontrast T1-weighted images is the characteristic MRI finding of non-complicated EICs (12). Ruptured EICs may simulate inflammatory or neoplastic lesions with thick and irregular peripheral rim enhancement and surrounding soft-tissue edema (18).

Giant Cell Tumor of the Tendon Sheath

Giant cell tumors of tendon sheath (GCTTS) or localized type tenosynovial giant cell tumors are benign and slow-growing masses of unknown etiology arising from tendon sheaths. They are the most common solid lesion arising from soft-tissues in the hand (10). They frequently present between 4th and 6th decades with a slight female dominance. The volar aspects of first three fingers are frequently affected and much less commonly the wrist is affected. Flexor tendons are affected twice as often as extensors (13). On plain radiography, osseous abnormalities accompany the lesion approximately in 20% of patients. The most common osseous abnormality is extrinsic cortical erosion with scalloping. Calcifications and periosteal reaction are rarely seen (19). GCTTSs present as multilobulated hypoechoic solid masses on US examination. During dynamic US examination, they do not move with the adjacent tendon when the affected digit is flexed or extended (20). On color Doppler US, increased blood flow is commonly seen (21). MRI is more reliable and GCTTS characteristically present as well-defined lesions adjacent to or surrounding

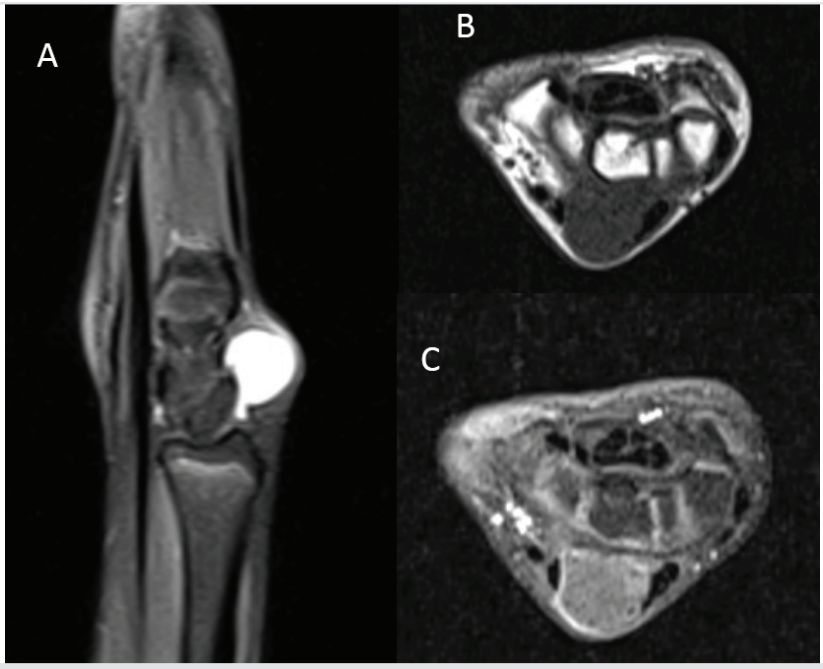

Figure 1. Ganglion cyst in a 12-year-old female presenting with slowly growing painless hand lump. (a) Sagittal fat saturated PDW sequence demonstrates a smooth, well circumscribed lesion with homogeneous low signal adjacent to lunate bone. (b) The lesion is hypointense on axial T1w sequence. (c) After contrast administration, faint rim enhancement is seen with no internal enhancement

a tendon. On T1-weighted sequences, the mass is generally hypointense, and nearly isointense compared to skeletal muscle. Hemosiderin deposition caused by chronic hemorrhage results in prominent hypointensity on T2-weighted sequences (2). On gradient echo sequences blooming artifacts may be present. The pathognomonic finding of GCTTSs on MRI is marked low signal intensity on T2-weighted images and blooming artifact caused by hemosiderin deposition. GCTTSs commonly show hyperintensity on STIR images (10). Existence of abundant proliferative capillaries within the collagenous stroma is the cause of vivid enhancement in GCTTSs (Figure 3) (11).

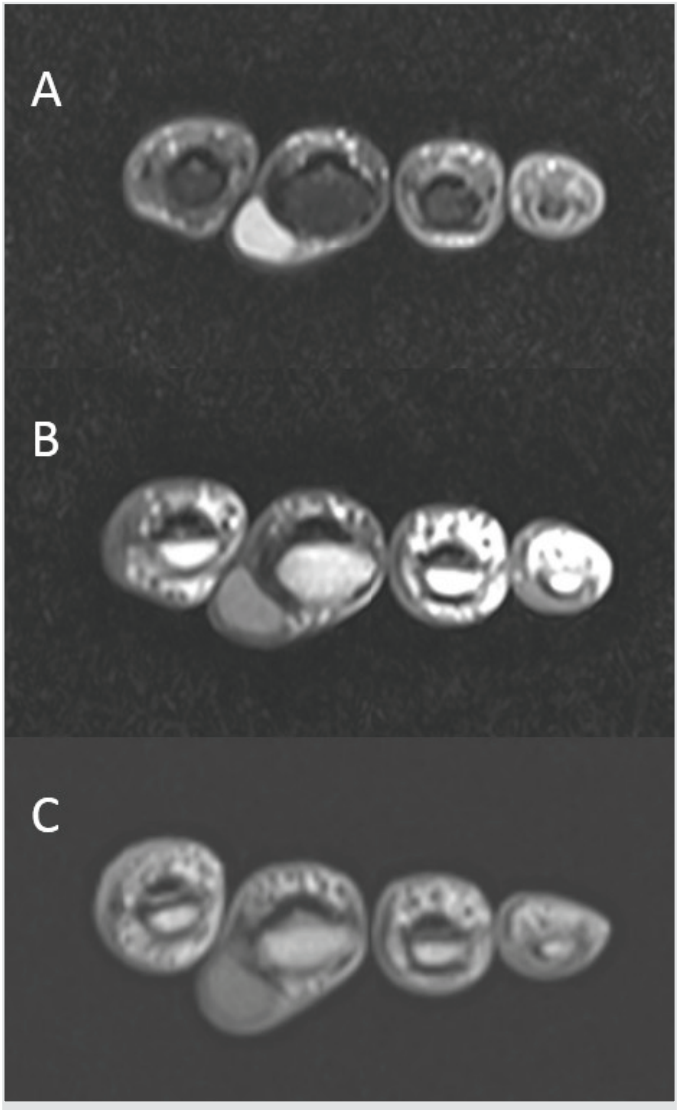

Figure 2. a-c. Epidermal inclusion cyst in a 45-year-old male presenting with a lump over the third proximal interphalangeal joint. Axial PD-weighted fat-saturated (a) MR image demonstrates a smooth, well-demarcated subcutaneous hyperintense lesion. Axial precontrast (b) and postcontrast (c) T1-weighted MR images demonstrate a mildly hyperintense mass lesion due to high lipid content with no contrast enhancement

MR: Magnetic resonance, PD: Proton-density

Fibroma of the Tendon Sheath

Fibromas of the tendon sheaths (FTS) are rare lesions of the tendon sheath and consist of fibroblasts within a dense fibrous stroma. They generally manifest as firm, painless, slow- growing masses, and preferentially located in the hand and wrist area (22). They frequently present in 3rd-5th decades and are seen three times more common in males (23). FTS are usually well-defined lesions and have low signal on all MRI sequences secondary to presence of abundant fibrous tissue (2). Due to fibrous component, they may demonstrate no contrast enhancement or demonstrate minimal contrast enhancement (Figure 4). However, signal intensity on T2w sequence and contrast enhancement may be variable, most probably due to different ratio of fibrous and cellular tissue. If a fibroma of the tendon sheath presents as hypointense signal on all MR sequences, it can be confused with GCTTS. On GRE sequence, GCTTSs usually demonstrate "blooming artefact" of accentuated low signal intensity, which is not an expected finding in FTS (2,3).

Leiomyoma

Leiomyomas are solitary, benign, slowly growing tumors that originate from nonstriated muscle. Leiomyomas are commonly found in genitourinary system, and gastrointestinal tract. Locations other than these regions including hand and wrist region are rare. Soft-tissue leiomyomas can be classified into three main groups. The most encountered subtype, the cutaneous leiomyoma, is quite small; therefore it is seldomly interpreted radiologically. The second form, deep soft tissue leiomyoma, is located in deep soft tissues of extremities or the retroperitoneum. The third form, angioleiomyoma, is a rare benign tumor arising from smooth muscle of the veins (3). They present as painful subcutaneous nodules in fingers and they are histopathologically characterized by multiple thick-walled blood vessels with thickened non-striated muscle coating (24). On T1- weighted sequences, angioleiomyomas present as well-demarcated subcutaneous mass lesions hypointense compared to fat and isointense compared to muscle with homogenous strong enhancement after intravenous application of contrast medium. On postcontrast T1-weighted images, a vessel leading up to the lesion can be observed. On T2-weighted sequences, they present as heterogenous high signal masses (3) (Figure 5).

Peripheral Nerve Sheath Tumors

Peripheral nerve sheath tumors (PNSTs) are tumors that originate from nerve sheaths. They can be benign or malignant. The benign forms are classically classified as schwannomas and neurofibromas. Schwannomas are fusiform shaped masses originate from the schwann cells which envelope the peripheral nerves and contain cellular and myxoid components. Schwannomas are encapsulated and localized eccentrically to the parent nerve, and surgical resection can mostly be performed. In contrast, neurofibromas are non-encapsulated tumors consisted of schwann cells and fibroblasts (25). Neurofibromas are fusiform shaped masses located centrally within the involved nerve and tend to separate nerve fibers; therefore surgical excision of the parent nerve with the tumor is required because neurofibromas

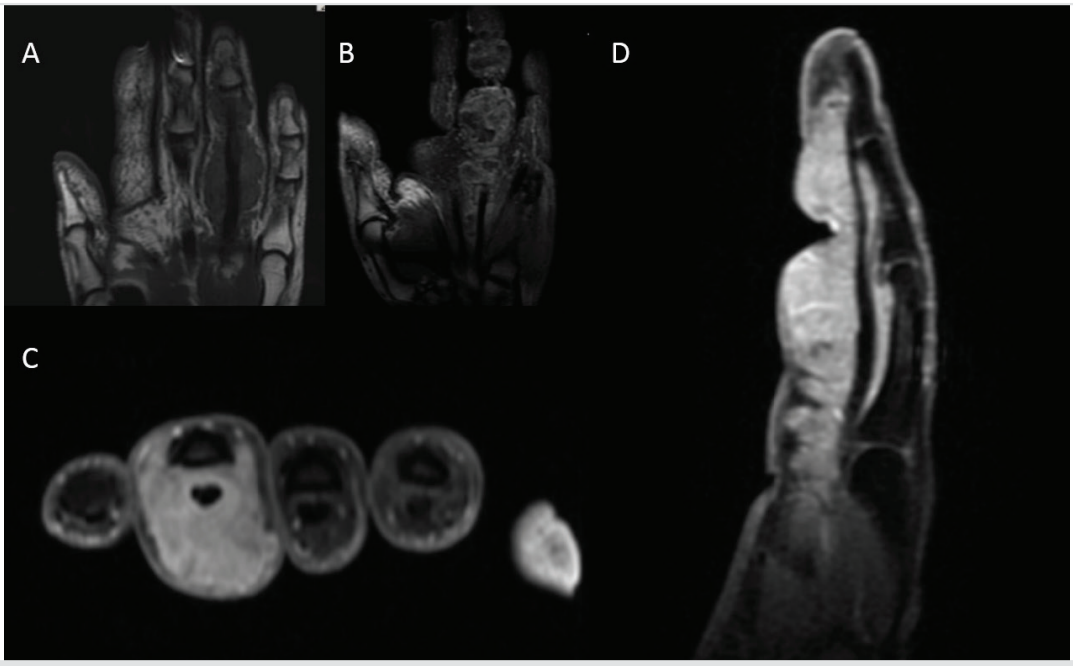

Figure 3. GCCTS of flexor tendon sheath in a 59-year-old-male presenting with a soft-tissue mass in the fourth finger. A lobulated hypointense mass is seen enveloping the flexor tendons of the fourth finger on coronal T1-weighted MR image (a). The mass has heterogenous signal intensity with low signal areas on coronal PD-weighted fat-saturated MR image (b). A significant homogenous contrast enhancement of the mass is observed on the axial and sagittal fat-saturated T1-weighted MR image (c,d)

MR: Magnetic resonance, GCCTS: Giant cell tumors of tendon sheath

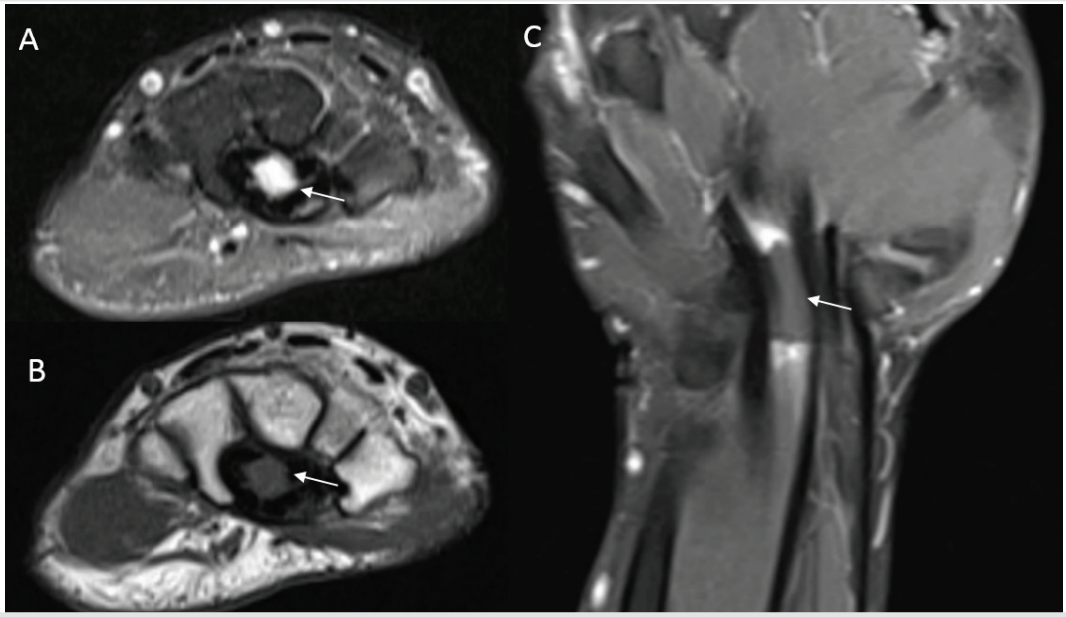

Figure 4. Fibroma of the tendon sheath in a 49-year-old male presenting with a 8-month history of a lump in the left hand on the radial part of the first carpal bone. Axial PD fat-saturated MR image (a) shows a hyperintense mass between the superficial and deep flexor digital tendons. Axial (b) T1-weighted sequence shows a hypointense mass, which is slightly hyperintense compared to muscle. Fat-saturated, contrast-enhanced, coronal T1-weighted sequence (c) reveals foci of contrast enhancement at the anterior and posterior part of the lesion

MR: Magnetic resonance, PD: Proton-density

can not be separated from the nerve fibers. PNSTs are among the common lesions of the wrist and hand. In the hand and wrist region, schwannomas originate from deeper and thicker nerves (especially the ulnar nerve), so they generally arise along the flexor aspect, while neurofibromas tend to involve smaller cutaneous nerves (11). PNSTs usually present as slow growing, painless, solitary small mass lesions (<5 cm). Neurofibromas usually occur in 3rd and 4th decades and schwannomas generally occur in 4th and 6th decades. PSNTs are rarely associated with neurofibromatosis. On MRI, signal pattern of PNSTs is nonspecific. They are isointense or mildly hyperintense compared to muscle on T1-weighted sequences and prominently hyperintense on T2-weighted sequences. PNSTs usually demonstrate significant enhancement following intravenous gadolinium (Figure 6). Sometimes, especially neurofibromas may show no enhancement (26). Heterogenous enhancement may be seen in malignant PNSTs and in the presence of cystic degeneration. "Target sign" with peripheral hyperintense rim surrounding a hypointense center on T2-weighted sequences secondary to central fibromatosis surrounded by myxomatous tissue is more usually observed in neurofibromas, however can also be occasionally observed in schwannomas (25). Other MRI findings especially present in larger tumors include; a fusiform lesion in the characteristic location of the nerve, "string sign" representing the parent nerve entering and exiting the lesion, "plit fat sign" due to the rim of fat that encircles the tumor, and "fascicular sign" secondary to small ring-like components on T2-weighted sequences corresponding to fascicular fibers inside the

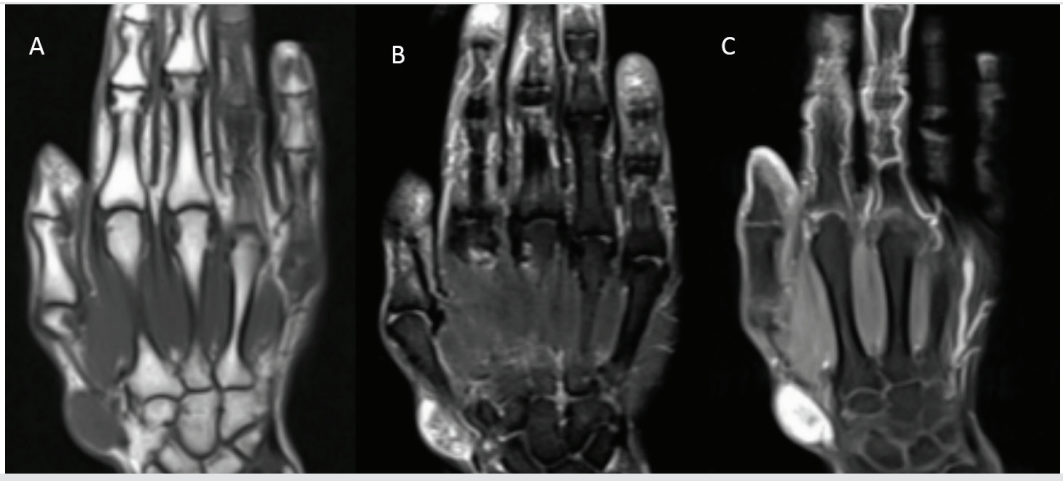

Figure 5. a-c. Angioleiomyoma in a 64-year-old man presenting with a painful mass in the radial aspect of the first carpometacarpal joint. Coronal T1-weighted image (a) shows a well demarcated hypointense mass which is isointense compared to muscle. The mass is heterogenous hyperintense on coronal PD fat-saturated image (b). Coronal, contrast-enhanced, fat-saturated T1-weighted MR image (c) demonstrates strong contrast enhancement

MR: Magnetic resonance

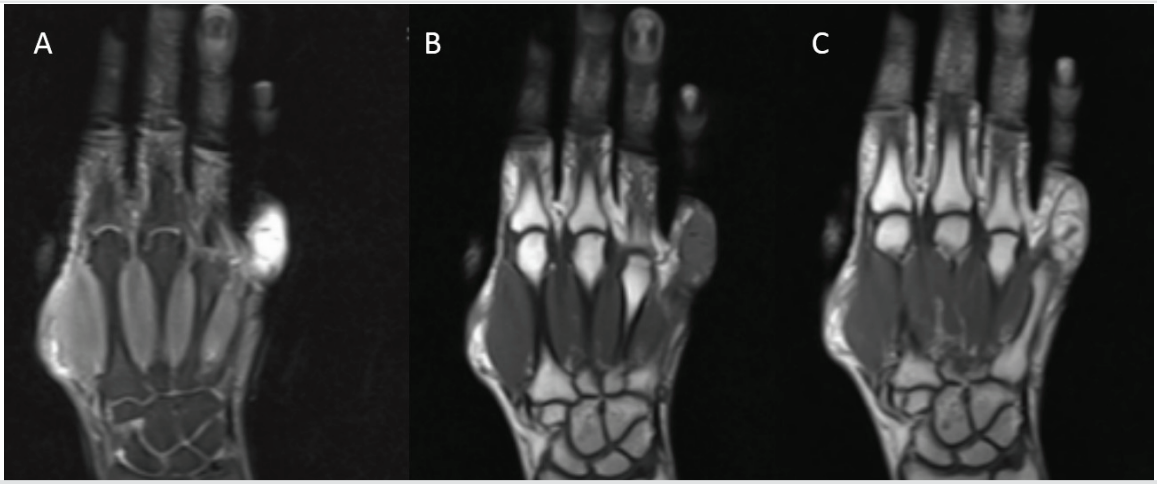

Figure 6. a-c. Schwannoma in a 55-year-old man with a painless mass in the dorsal part of the proximal phalanx of the 5th finger. Coronal fat-saturated PD-weighted MR image (a) shows a subcutaneous, well demarcated fusiform hyperintense lesion. The lesion is hypointense on T1-weighted MR image (b). Coronal contrast-enhanced T1-weighted MR image (c) shows strong contrast enhancement

MR: Magnetic resonance

tumor (27). Malignant change is very rare in PNSTs. Features such as large tumor size (>5 cm), the presence of peritumoral edema, infiltrative margins, marked heterogeneity and fast growth should raise the suspicion of malignancy (26,28).

Hemangiomas and Vascular Malformations

Hemangiomas and vascular malformations are among the commonest soft-tissue lesions throughout the body. Vascular malformations are common in the hand. They are located deeply in the hand, but they are usually located subcutaneously in the fingers (11). Most lesions represent as isolated lesions, while some lesions represent as ill-defined infiltrating lesions involving several anatomic structures. International Society for the Study Vascular Anomalies (ISSVA) classifies vascular anomalies into two major groups according to cellular turnover and histopathological characteristics: benign vascular tumors (hemangiomas) and vascular malformations. Vascular malformations are not true neoplastic lesions; in fact, they are errors of vascular morphogenesis with a normal rate of endothelial turnover. Vascular malformations are subdivided into low-flow (venous, lymphatic, capillary, and mixed) and high-flow types (fistula and arteriovenous malformations) dependent on predominant histologic component and hemodynamic features (29-31).

On USG, hemangiomas appear as iso/hyperechoic well-defined solid mass lesions. However, they can show hyperechoic areas consistent with fatty component. Anechoic vascular channels can also be present on USG. Phleboliths may be seen as bright echogenic foci with posterior acoustic shadowing inside the lesion. On color Doppler US, hypervascularity may be detected in hemangiomas (8,29). On MRI, hemangiomas are typically iso to hypointense compared to muscle on T1-weighted sequences and have high signal intensity on T2-weighted sequences due to increased fluid content secondary to slow blood flow in vessels (Figure 7) (32). Larger lesions (>2 cm) appear more heterogenous on all sequences, because they contain nonvascular components such as fat, smooth muscle, fibrous tissue, myxoid stroma, hemosiderin, and thrombus. Fluid-fluid levels may also be observed in larger masses. Serpentine vascular flow void areas are sometimes present. A feeding vessel or early draining vessel may also accompany the lesion. Enhancement on post-contrast series is variable from mild to heterogeneous, but usually there is strong enhancement following intravenous gadolinium (33).

Capillary malformation, also called port wine stain, is the most common form of vascular malformation. A clinical diagnosis is sufficient in most of the patients; so imaging is rarely needed. Imaging reveals asymmetric skin thickening with no associated mass lesion and apparent vascular channels. Slow flow vascular malformations (lymphatic and venous) are usually multiseptated and display iso to low signal intensity on T1-weighted sequences and high signal intensity on T2-weighted sequences. Venous malformations are composed of enlarged slow-flowing vascular channels with no solid tissue content. Venous malformations show delayed enhancement. They are characterized by phleboliths which results in signal void foci on all pulse sequences. In lymphatic malformations, multiple lymphatic fluid included areas with intervening septa are seen histopathologically. They tend to be more infiltrative than the venous form. On MRI, lesions with micro or macrocsyts are present. Microcystic form of lymphatic malformations show no enhancement but macrocystic form show septated enhancement after intravenous contrast material is injected (29). Arteriovenous malformations (AVMs) are vascular lesions with abnormal linkage between arteries and veins. Central nidus is present in AVMs whereas there is no central nidus in arteriovenous fistulae. On MRI, they present as dilated vascular channels without a soft tissue component. High flow vascular malformations are characterized by arterial feeders, draining veins, and arterial or early venous enhancement (29). Phleboliths may also be present in high flow vascular malformations (34). Doppler US or MR angiography may be applied to demonstrate the high flow and evaluate arterial supply and venous drainage pattern in high flow vascular malformations.

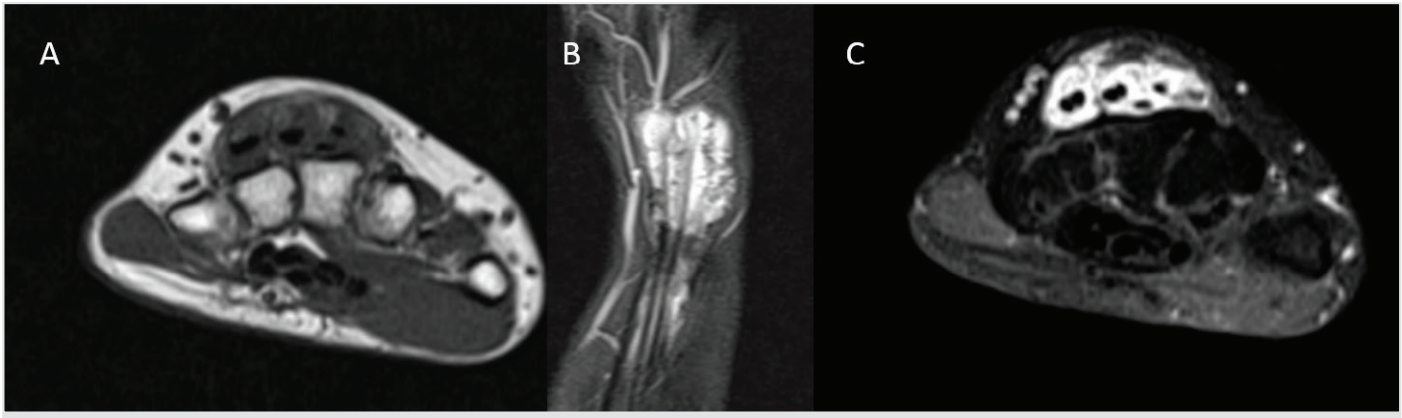

Figure 7. a-c. Hemangioma in a 35-year-old female with a swelling history on the volar part of the hand over the carpal bones and the carpometacarpal joints. Axial T1-weighted MR image (a) shows a hypointense lesion surrounding the extensor tendons of the hand. This lesion is hyperintense on coronal fat-saturated T2-weighted MR image (b). Axial, contrast-enhanced, fat-saturated T1-weighted MR image (c) shows avid and near homogenous contrast enhancement

MR: Magnetic resonance

Glomus Tumor

Glomus tumors are small hamartomas originating from the neuromyoarterial apparatus inside the glomus bodies which are responsible for thermoregulation. Thus, glomus tumors are mostly present at the finger tip, either in the pulp or under the fingernail. They account up to 5% of soft tissue tumors of the hand and characteristically occur in the fourth or fifth decade of life, equally in both sexes (35). Typical clinical presentation is finger pain and tenderness exacerbated by temperature changes and mild trauma. Large lesions located in the nail beds may be seen as red-blue spots. X-rays demonstrate smooth extrinsic erosions of dorsal aspect of the fingers if the lesions are large enough. On MRI, they present as small, smooth-contoured masses with low or intermediate signal on T1-weighted images and with homogenously high signal intensity on T2-weighted images, and show uniform strong enhancement following intravenous contrast material injection (Figure 8) (10). The imaging properties of glomus tumors resemble to vascular tumors, but typical distal location and relatively small size may help clinicians in differential diagnosis.

Nodular Fasciitis

Nodular fasciitis is a rapidly growing benign reactive fibroblastic mass thought to be related with trauma. It is commonly located on volar aspect of hand (36). It usually occurs in young adults. It is composed of various amount of myxoid, cellular, or fibrous tissues which result in variable MRI appearance of the lesion (22). Lesions with high cellularity or myxoid component appear hypointense or nearly isointense compared to skeletal muscle on T1-weighted sequences and high signal on T2-weighted sequences. On the contrary, those with high fibrous component are hypointense on all MRI sequences. Contrast enhancement is frequently uniform, but it may also be peripheral in lesions with an extensive extracellular myxoid matrix and central cystic degeneration (22). Fascial tail sign is an important diagnostic feature of nodular fasciitis which is characterized by linear extension of the lesion along the adjacent fascia on MRI (13). Due to rapid growth pattern and nonspecific MRI findings, nodular fasciitis may mimic a malignant soft tissue lesion. Differential diagnoses should include soft tissue sarcoma, fibrous histiocytoma, peripheral nerve sheath tumor and early stage of myositis ossificans.

Extraosseous Chondroma

Extraosseous chondromas consist of articular chondromas, juxtacortical chondromas (also known as periosteal or parosteal chondroma) and soft tissue chondromas. Nearly all juxtacortical and soft tissue chondromas occur in the hands and feet. They are usually located in fingers. Soft tissue chondromas and juxtacortical chondromas only differ in their anatomical location (3). Young and middle-aged adults are most frequently affected. X-rays demonstrate an ovoid or lobulated soft-tissue mass with sharply demarcated borders. Calcifications occur up to in 50% of chondromas which may be central or peripherally located. A surrounding shell of continuous or discontinuous bone may also be present on plain films or CT (37). MRI appearance of chondromas depends on tumor contents and the grade of matrix calcification. On T1-weighted images these tumors are isointense to hypointense compared to skeletal muscle. On T2-weighted sequences they appear typically hyperintense due to high fluid content of chondroid matrix. If calcification is present, hypointense foci can be seen on both sequences. After intravenous gadolinium administration, septal or peripheral enhancement is seen similar to enchondromas (Figure 9) (38).

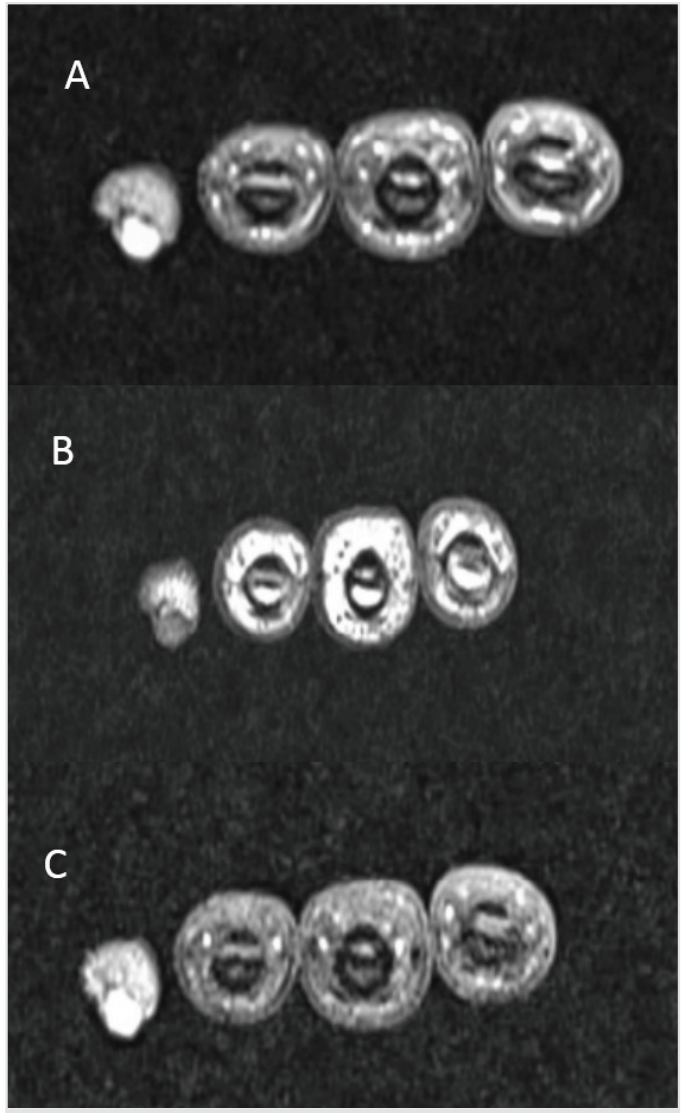

Figure 8. Glomus tumor in a 35-year- old female with a painful lump on the tip of the right 5th finger. Axial, PD-weighted fat-saturated sequence (a) shows a smooth-well circumscribed subcutaneous lesion of extremely high signal intensity. Axial T1-weighted sequence (b) shows intermediate signal intensity lesion. After contrast administration, intense and homogenous enhancement is present on axial contrast-enhanced fat-saturated T1-weighted MR image (c)

MR: Magnetic resonance, PD: Proton-density

Lipoma

Lipomas are consisted of benign mature adipocytes. In spite of the fact that lipomas are the most common soft tissue tumors in the body, they are relatively uncommon in the hand and wrist region (39,40). When they are located in upper extremity, they are frequently located in subcutaneous region, however, may also be located in muscles, bones, and tendons. In hand and wrist, they typically present as slow-growing painless masses at the thenar or hypothenar eminence. On US, they appear usually as homogeneous solid mass lesions with or without a capsule and are predominantly hyperechoic or isoechoic compared to surrounding fat tissue. On Doppler US, they show no vascularity or show minimal vascularity (8). On MRI, lipomas have the similar MRI signal pattern as the subcutaneous fat tissue. So, they are seen as encapsulated masses that are hyperintense on both T1-weighted and T2-weighted sequences (3). They show homogenous signal loss on the STIR or fat-saturation sequences. Lipomas usually show no contrast enhancement after intravenous contrast material administration. Thin (less than 2 mm) septae and nonfatty components with low signal intensity on both T1- and T2-weighted sequences can be seen inside the lesions. Minimal contrast enhancement of septa may be present. It can be hard to differentiate benign lipomas from atypical lipomatous tumor (synonymous with well-differentiated liposarcoma in the extremities) or liposarcomas. Thick enhancing septations (>2 mm) or nodules and persistent areas of high signal on STIR or fat-saturated sequences should raise the suspicion of liposarcoma (41).

Lesions Associated with Rheumatic Diseases and Metabolic Disorders

Rheumatoid nodules (RN) are typically encountered in subjects with severe long-standing rheumatoid arthritis (RA), although, infrequently, they may be also observed in other autoimmune disorders including systemic lupus erythematosus, ankylosing spondylitis, and rheumatic fever. Infrequently, RNs precede the articular findings of rheumatic disorders. Histopathologically, RNs are composed of chronic inflammatory cells and palisading fibroblasts with or without central necrosis. They frequently arise on the dorsal aspect of the hand and fingers inside the subcutaneous tissue (particularly at sites of compression, traction, and repetitive microtrauma), however the bursae, joints, tendons, and ligaments can also be included (12). RNs are observed approximately in 20% of subjects with RA. MRI features of RNs are non-specific. On MRI, RNs present as ill-defined masses inside the subcutaneous tissue demonstratingalow to intermediate signal intensity on T1-weighted sequences. The signal intensity of the nodules on T2-weighted images is variable. Solid nodules appear hypointense, while cystic lesions appear hyperintense on T2-weighted sequences (7). Contrast enhancement is also variable. Solid nodules show intense and homogenous contrast enhancement. Nodules with cystic components show weak or peripheral contrast enhancement (Figure 10) (12).

Crystal deposit diseases including gout and pseudogout (hydroxyapatite and calcium pyrophosphate dehydrate deposition disease) may rarely present as focal periarticular soft-tissue mass at the hand and wrist region (7). Clinical and imaging findings of gout and pseudogout are usually specific. Soft-tissue masses with or without calcifications causing juxtacortical erosions with overhanging edges may be seen on hand X-rays. On T1-weighted sequences, gouty tophi and pseudogout tend to be hypo to isointense. On T2-weighted MR sequences, related to degree of inflammation and presence of calcification, they demonstrate heterogenous hypo or hyperintense signal intensity (3,7). Gouty tophi can show diffuse or peripheral contrast enhancement.

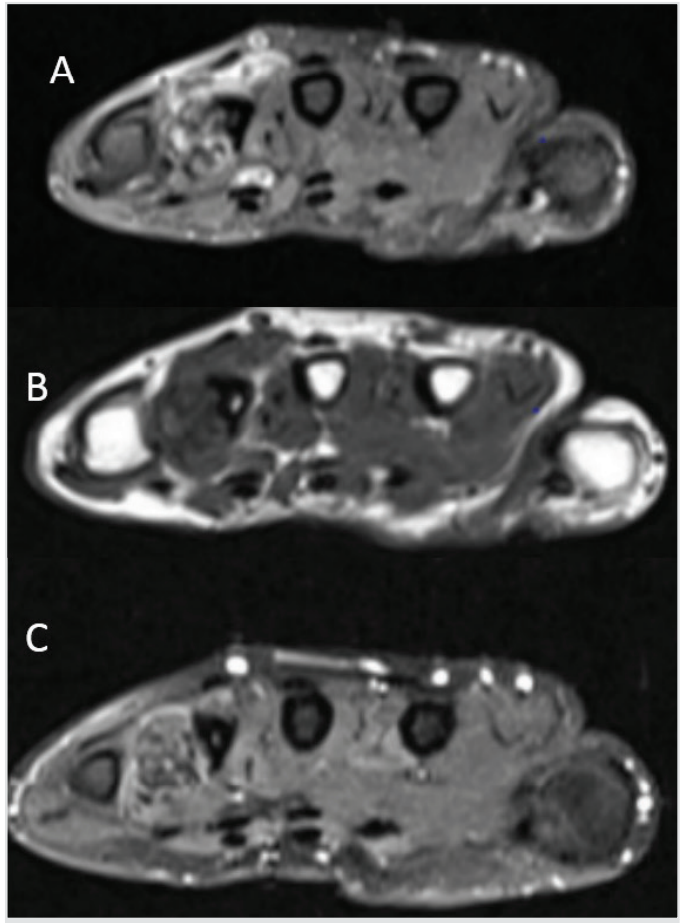

Figure 9. Juxtacortical chondroma in a 37-year-old female presenting with a painless mass lesion on the distal part of the 4th metacarpal bone, who has described slow growth over the previous 1 year. Lesion appears hyperintense due to high fluid content of chondroid matrix and includes hypointense foci consistent with calcifications on axial PD-weighted fat-saturated sequence (a). Axial T1-weighted image (b) shows a hypointense lobulated heterogenous mass. After contrast administration, heterogenous enhancement is observed on axial contrast-enhanced fat-saturated T1-weighted MR image (c)

MR: Magnetic resonance, PD: Proton-density

Table 1. WHO classification of soft-tissue tumors

Tumor type	Tumor	Patient age	Anatomic location
Adipocytic	Lipoma	Adulthood (5^{th}-7^{th} decades)	Subcutaenous; intramuscular; intermuscular
Fibroblastic/myofibroblastic	Nodular fasciitis, myositis ossificans, fibroma of tendon sheath	Young adulthood (3^{th}-5^{th} decades)	Nodular fasciitis: deep subcutaneous region or in the fascia Fibroma of tendon sheath: Tendon sheath
Fibrohistiocytic	Giant cell tumor of the tendon sheath	Adulthood (4^{th}-6^{th} decades)	Tendon sheaths
Smooth muscle	Angioleiomyoma (Vascular leiomyoma)	Adulthood (4^{th}-7^{th} decades)	Subcutanous; tunica media of the veins
Skeletal muscle	Rhabdomyoma	Young adulthood (3^{th}-5^{th} decades)	Head and neck region
Pericytic (perivascular)	Glomus tumor	Adulthood (4^{th}-5^{th} decades	Tip of fingers; neuromyoarterial apparatus
Vascular	Hemangioma, epitheloid hemangioma, angiomatosis, lymphangioma	Childhood	Subcutanous; striated muscle; multicompartmental
Chondro-osseous	Juxtacortical chondromas, Soft-tissue chondromas	Adolescent, young adulthood (2^{th}-4^{th} decades	Juxtacortical chondromas: Periosteum of tubular bones Soft-tissue chondromas: Origin unknown
Lesions not included in the WHO classification of soft-tissue tumors			
Lesion type	**Lesion**	**Patient age**	**Anatomic location**
Tumorlike	Ganglion cyst, hematoma, seroma, abscess, epidermal inclusion cyst, foreign body granuloma, anomalous muscle	Ganglion cyst: Young women Epidermal inclusion cyst: 4^{th}-6^{th} decades	Ganglion cyst: Adjacent to joint capsule, tendon sheath, bursae Epidermal inclusion cyst: Subcutaneous
Benign	Peripheric nerve sheath tumor (PNST): schwannoma (neurilemoma), neurofibroma, perineurioma	Adulthood (3^{th}-5^{th} decades)	Extending along nerves (superficial or deep)

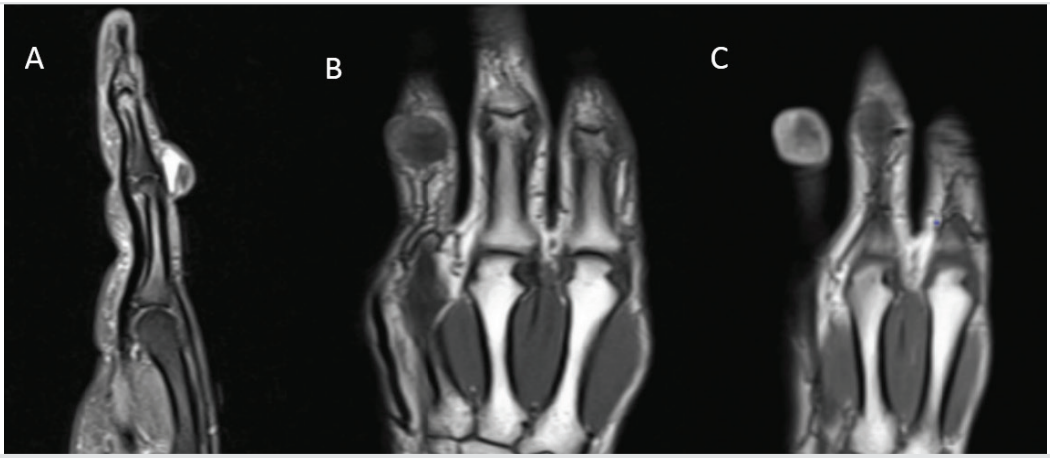

Figure 10. a-c. Rheumatoid nodule in a 40-year-old male, with a 5-year history of known rheumatoid arthritis. Sagittal PD-weighted fat-saturated sequence (a) reveals a well-demarcated subcutaneous lesion composed of solid and cystic components. The solid component is mildly hyperintense and the cystic component is hypointense on coronal T1-weighted sequence (b). After contrast administration, solid component shows mild to moderate contrast enhancement on coronal contrast-enhanced fat-saturated T1-weighted MR image (c)

MR: Magnetic resonance

Table 2. Characteristic MRI findings that may help identify benign soft-tissue tumors and tumor-like lesions of hand and wrist region

Lesion type	Speficic finding (If present)	T1 signal intensity	T2 signal intensity	Contrast enhancement pattern
Ganglion cyst	A thin pedicle extending to adjacent joint space	A well-circumscribed unilocular or multilocular mass with similar to fluid (low signal)	A well-circumscribed unilocular or multilocular mass with similar to fluid (very high signal)	Slight enhancement of the thin wall
Epidermal inclusion cyst	Volar subcutanous location	Moderate high signal	High signal	No central enhancement Thin peripheral enhancement or Absent peripheral enhancement
Giant cell tumor of the tendon sheath	Well-defined lesions surrounding a tendon	Hypointense	Marked low signal intensity "Blooming artefact" on gradient-echo sequences	Moderate to significant enhancement
Fibroma of the tendon sheath	Well-defined lesions adjacent to a tendon	Hypointense	Hypointense "Blooming artefact" absent	No or mininimal contrast enhancement Moderate to marked diffuse enhancement
Angioleiomyoma	Subcutanous nodules A vessel leading up to the lesion on postcontrast T1-weighted images	Hypointense to fat and isointense to muscle	Heterogenous high signal	Strong enhancement
Peripheral nerve sheath tumor	"String sign" "Split fat sign" "Fascicular sign" "Target sign"	Isointense or slightly hyperintense to muscle	Hyperintense; hyperintense rim and central area of a low signal in target sign lesions	Variable (generally intense; central in target sign lesions
Hemangioma	Lobulated, septated, multicompartmental; Well-circumscribed or poorly defined margins	Iso to hypointense to muscle Hyperintense regions in fat containing lesions or lesions with hemorrhage Fat within and at the periphery of the lesion is diagnostic Phleboliths seen as low-signal intensity foci	High signal intensity Typically high T2 signal intensity in areas of slow flow Serpentine vascular flow void areas in high flow lesions Fluid-fluid levels in larger lesions Phleboliths seen as low-signal intensity foci	Variable from mild to heterogeneous; usually strong enhancement
Venous malformation	Slow-flowing vascular channels with no solid tissue component Multiseptated lesion	Iso to hypointense to muscle In the presence of phlebolits; signal void foci	High signal intensity No evidence of high flow velocity signal voids In the presence of phlebolits; signal void foci	Delayed enhancement.
Lymphatic malformation	Multiseptated lesion Infiltrative Lesions with multiple micro or macrocsyts	Iso to hypointense to muscle	High signal intensity Fluid-fluid levels	Microcystic form of lymphatic malformations show no enhancement. Macrocystic form show septal enhancement

Table 2. Characteristic MRI findings that may help identify benign soft-tissue tumors and tumor-like lesions of hand and wrist region

Lesion type	Speficic finding (If present)	T1 signal intensity	T2 signal intensity	Contrast enhancement pattern
Arteriovenous malformation	Dilated vascular channels without a soft tissue component and with an intervening central nidus	Dilated hypointense vascular channels	Dilated hypointense vascular channels	Intense enhancement of arterial feeders and draining veins. Early venous enhancement
Glomus tumor	Small, smooth-contoured mass at the finger tips	Hypo or intermediate signal	Homogenously high signal	Uniform strong enhancement
Nodular fasciitis	Fascial tail sign	Variable (Nearly isointense to muscle, or hypointense)	Variable (hyper or hypointense)	Uniform; rarely peripheral
Extraosseous chondroma	Solitary ovoid or lobulated soft-tissue mass with sharply demarcated borders adjacent to phalanx	Isointense to hypointense to skeletal muscle Hypointense foci in the presence of calcifications	Typically hyperintense due to high fluid content of chondroid matrix Hypointense foci in the presence of calcifications	Septal or peripheral enhancement
Lipoma	Subcutaneous mass lesion located at the thenar or hypothenar eminence Homogenous signal loss on the STIR or fat-saturation sequences Infiltrating or insinuating margins tend to suggest benign lipoma rather than liposarcoma	Similar signal to subcutaneous fat tissue; hyperintense	Similar signal to subcutaneous fat tissue; hyperintense	No contrast enhancement
Rheumatoid nodule	Ill-defined masses in the subcutaneous tissue	Iso to hypointense to muscle	Variable. Solid nodules are hypointense, cystic lesions are hyperintense	Variable. Solid nodules demonstrate intense and homogenous contrast enhancement. Cystic nodules demonstrate weak or peripheral contrast enhancement
Gout-pseudogout	Nodular masses in the subcutaneous tissue	Hypo to isointense to muscle	Heterogenous hypo or hyperintense signal intensity	Diffuse or peripheral contrast

Table 3. MRI features which indicate malignancy

Diameter >5 cm
Lobulation
Peritumoral edema
Bone and neurovascular bundle involvement
Fascial edema; extension through the fascia
Skin thickening
Skin contact
Hemorrhage
Necrosis
Contrast enhancement: Type 2 curve pattern
Thick rim enhancement
Solid internal enhcencement
Presence of thickened septae (>2 mm)
MRI: Magnetic resonance imaging

Lesion Characterization Based on MRI and Specific Features that are Useful in Differential Diagnosis of Benign Lesions from Malignant Counterparts

The MRI with its high contrast and spatial resolution is the most important imaging modality in radiological examination of hand and wrist mass lesions. Characteristic MRI findings that may help identify benign soft-tissue tumors and tumor-like lesions of hand and wrist region are demonstrated in Table 2. By noting the signal characteristics and determining the lesion location, a confident diagnosis can often be made in certain lesions such as lipomas, ganglion cysts, GCSTs, and PNSTs. Beyond mentioned certain lesions, the exclusion of malignancy should be the first and most important step for the treatment algorithm. In literature, various MRI features of hand and wrist soft-tissue lesions that may allow differentiation between benign and malignant lesions were reported (Table 3) (4-6,13-14,42). Knowing these various MRI features, rendering biopsy of these lesions that may lead to unnecessary mortality and morbidity redundant. Histologic examination should be the definite and

final method to establish the diagnosis especially in lesions which demonstrate indeterminate MRI characteristics.

Conclusion

Wrist and hand may be involved by different types of soft-tissue lesions. Most of these lesions are benign. Patients' history, clinical evaluation and diagnostic imaging, especially the MRI with its high soft-tissue contrast would play an important role in appropriate management of these lesions. By noting the signal features and defining the lesion localization, an exact diagnosis can often be made in particular lesions such as lipomas, ganglion cyts, GCSTs, enchondromas, and PNSTs.

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