

# Sonographic Findings of Common Musculoskeletal Diseases in Patients with Diabetes Mellitus

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Diabetes mellitus (DM) can accompany many musculoskeletal (MSK) diseases. It is difficult to distinguish the DM-related MSK diseases based on clinical symptoms alone. Sonography is frequently used as a first imaging study for these MSK symptoms and is helpful to differentiate the various DM-related MSK diseases. This pictorial essay focuses on sonographic findings of various MSK diseases that can occur in diabetic patients.

**Index terms:** Diabetes mellitus; Sonography; Musculoskeletal

## INTRODUCTION

Diabetes mellitus (DM) is one of the common and representative chronic endocrine diseases with continuously increasing incidence (1). Various musculoskeletal (MSK) diseases may occur during a long lifetime of diabetic patients because of immunocompromised condition, vascular insufficiency related to microcirculation disorder, and neurological problems. Contrary to most MSK diseases that can occur in non-diabetic patients, some disease entities such as muscle infarct and neuropathic joint should be considered as a differential diagnosis, especially in diabetic patients. Sonography can be used as a first diagnostic tool for diabetic patients manifesting variable

MSK symptoms because of its easy accessibility. Knowledge of various possible MSK diseases entities and their sonographic findings are helpful for accurate diagnosis.

The purpose of the current pictorial essay is to review the various DM-related MSK diseases and provide guidance for an accurate diagnosis based on the sonographic imaging manifestations.

## DM-Related Musculoskeletal Diseases

### Infectious Diseases

Hyperglycemia can influence the immune systems such as the complement system, inflammatory cytokines, leukocytes, and antibodies, and can increase the risk of infectious disease of DM due to the combination of decreased pain perception and impaired microcirculation. During the progression of the disease, diverse infections can occur, which may be the first signs of DM (2). Infection may be localized superficially in the skin or nail fold of extremities, but may also involve the deeper soft tissue, bone, and joint. The treatment options are antibiotic therapy, and abscess drainage or surgical treatment, as required.

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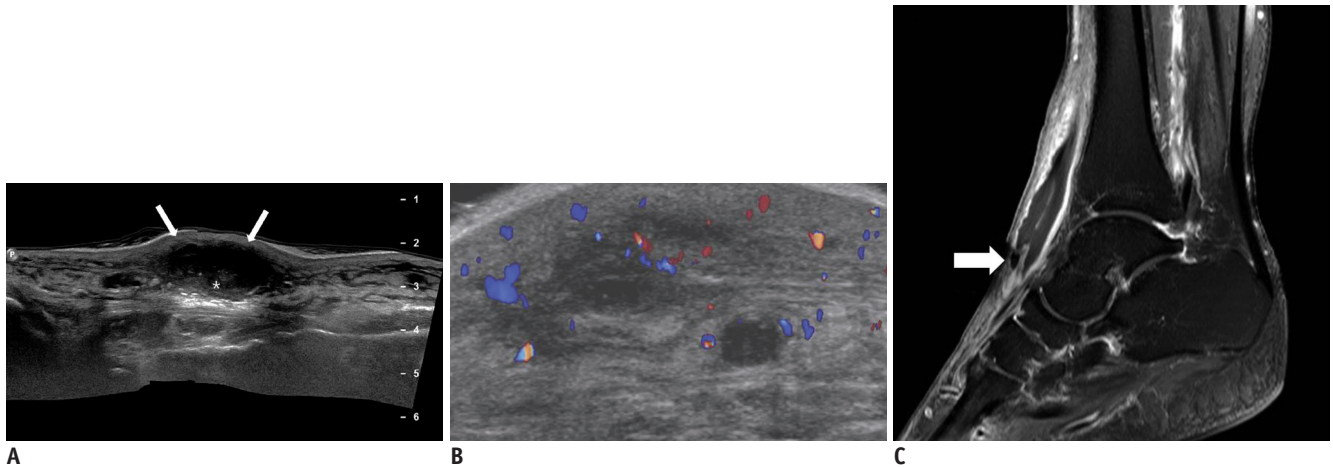
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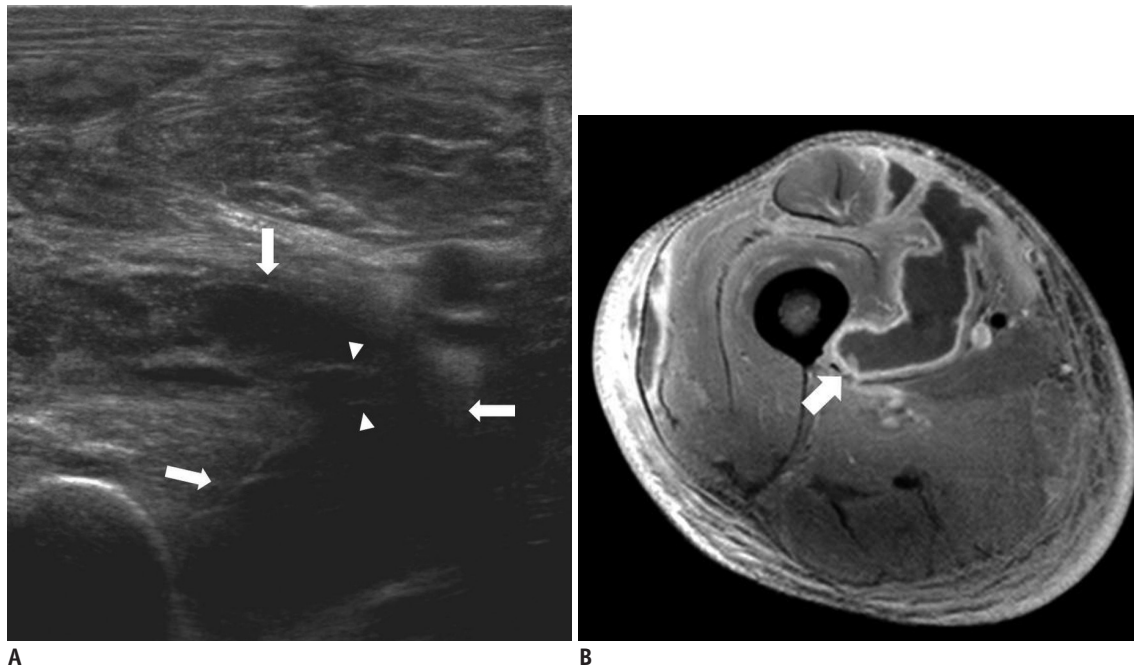
**Cellulitis**

In cellulitis, there is pain, erythema, edema, and warmth due to acute infection of the skin and subcutaneous tissues (3). Sonographic findings of cellulitis include diffuse thickening and increased echogenicity of the skin and subcutaneous tissues (Fig. 1). A cobblestone appearance caused by subcutaneous edema and inflammatory exudative

in the tissue spaces can be seen. Color Doppler sonography for hyperemic changes within subcutaneous layer is helpful in differentiating from non-infective subcutaneous edema (3). Echogenic foci and dirty posterior shadowing may be observed due to collections of free air (3). The complications include abscess formation and extension of infection to the deep soft tissue (Fig. 1) (4).



**Fig. 1. Cellulitis with abscess formation of right foot in 49-year-old patient with painful swelling and fever.**  
**A.** Longitudinal sonography scan shows diffuse thickening of subcutaneous tissues with large subcutaneous fluid collection (arrows) filled with echogenic material (asterisk). **B.** Transverse color Doppler sonography scan shows increased vascularity surrounding multiloculated, hypoechoic fluid collection. *Streptococcus viridans* was cultured from fluid obtained with sonography-guided aspiration. **C.** Sagittal enhanced T1-weighted fat-suppressed image shows subcutaneous fluid collection with rim-like enhancement. Drain tube is inserted at fluid collection (arrow). Surrounding edema without involvement of deep soft tissue or bony structure is noted.



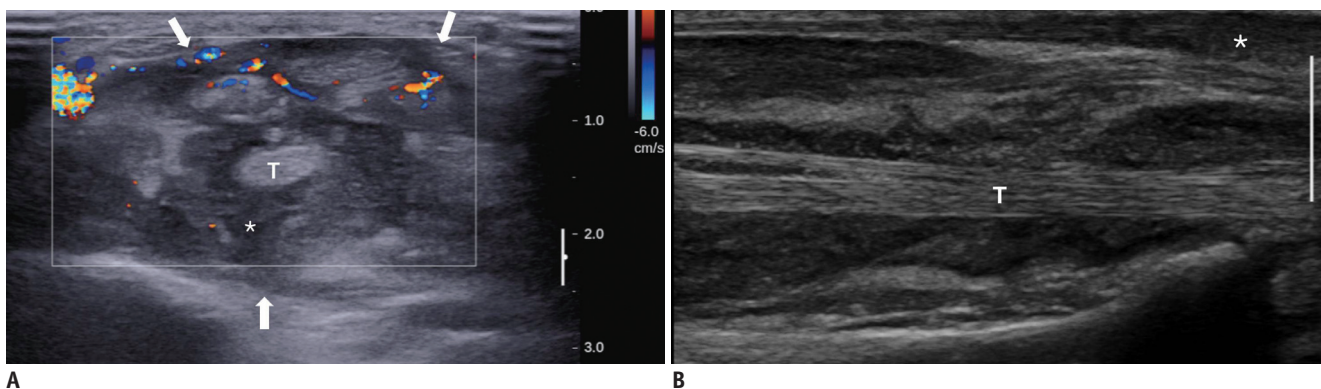
**Fig. 2. Infectious pyomyositis with intramuscular abscess due to *Staphylococcus aureus* in 36-year-old patient with right thigh pain and fever.**  
**A.** Transverse sonography scan of medial thigh shows fluid collection (arrows) with echogenic septa (arrowheads) within vastus medialis muscle. Diffuse edema of adjacent muscles and subcutaneous layer are also noted. **B.** Axial enhanced T1-weighted fat-suppressed image shows few fluid collections with rim-like enhancement within vastus medialis (arrow), vastus lateralis, and rectus femoris.

**Pyomyositis**

The bacterial infection of skeletal muscles can form an abscess by hematogenous spread. This infection can affect a single muscle or multiple muscles in the same anatomic location, or multifocal anatomic locations. DM is an important contributing factor to pyomyositis. According to a recent report, pyomyositis occurs in 31% of diabetic patients (5). In the early stage of pyomyositis, the sonographic finding is ill-defined, heterogeneously hypoechoic lesion involving one or more muscles, which corresponds to a phlegmon. An intramuscular abscess may be seen (Fig. 2) (3, 4).

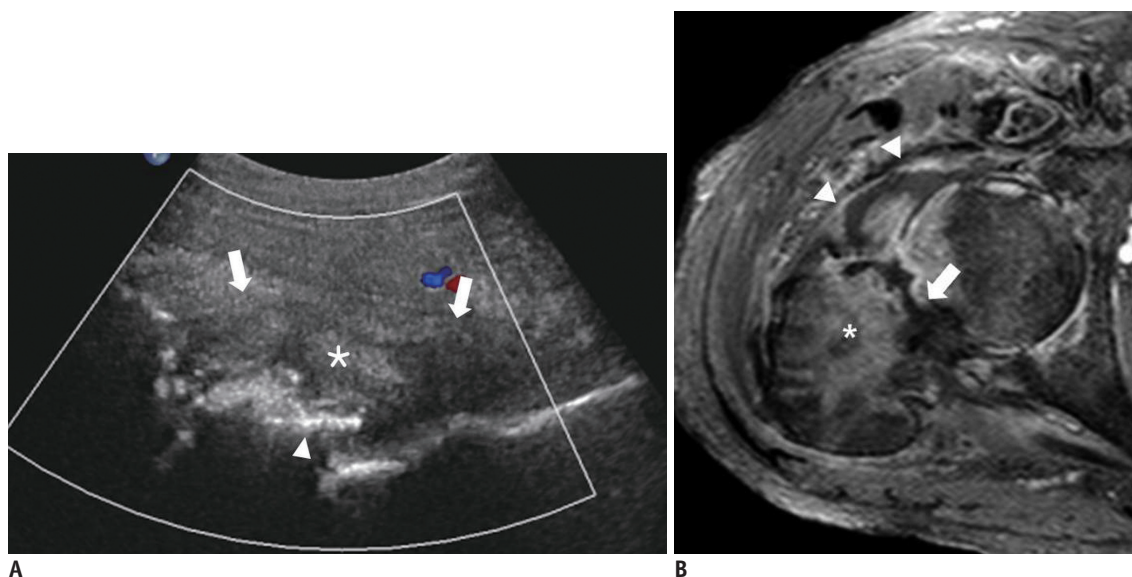
**Infectious Tenosynovitis**

Infection of tendon and its synovial sheath is caused by penetrating injury or direct extension from adjacent soft tissue infection (6). This infection is often caused by *Staphylococcus aureus*, *Streptococcus pyogenes*, mycobacterial, or fungal organisms (3, 7). On sonography, it appears as the accumulation of anechoic or hypoechoic fluid and echogenic debris within the tendon sheath. The involved tendons are enlarged, as compared with the contralateral tendons. In color Doppler sonography, hyperemic changes can be seen (Fig. 3) (3).



**Fig. 3. Infectious pyomyositis, tenosynovitis, and cellulitis with abscess due to tuberculosis in 61-year-old patient with right forearm pain and fever.**

**A.** Transverse color Doppler sonography scan at distal radioulnar joint level shows distended flexor tendon sheath (arrows) filled with echogenic debris (asterisk) and hypervascularity. Tendons are mildly thickened. **B.** Longitudinal sonography scan reveals subcutaneous extension of echogenic debris (asterisk), suggesting ruptured tendon sheath. T = tendon



**Fig. 4. Septic arthritis of right hip in 57-year-old patient with hip pain and fever.**

**A.** Longitudinal sonography scan of anterior aspect of right hip joint shows joint distension (arrows), bone destruction (arrowhead), and fluid with echogenic debris (asterisk) with adjacent soft tissue edema. **B.** Axial enhanced T1-weighted fat-suppressed image shows septic arthritis of right hip and osteomyelitis (asterisk) with pathologic fracture of femur (arrow). Joint fluid and irregular synovial enhancement (arrowheads) are seen.

**Necrotizing Fasciitis**

Necrotizing fasciitis is a relatively rare but a rapidly progressive infection that represents a life-threatening surgical emergency; mortality is approximately 40% of patients (8). On sonography, necrotizing fasciitis appears as thickened distorted intermuscular or deep fascial planes with fluid collection. Early muscle necrosis may be apparent (3). Gas entrapped in fascial layer and adjacent subcutaneous edema facilitates an easy diagnosis of necrotizing fasciitis (4).

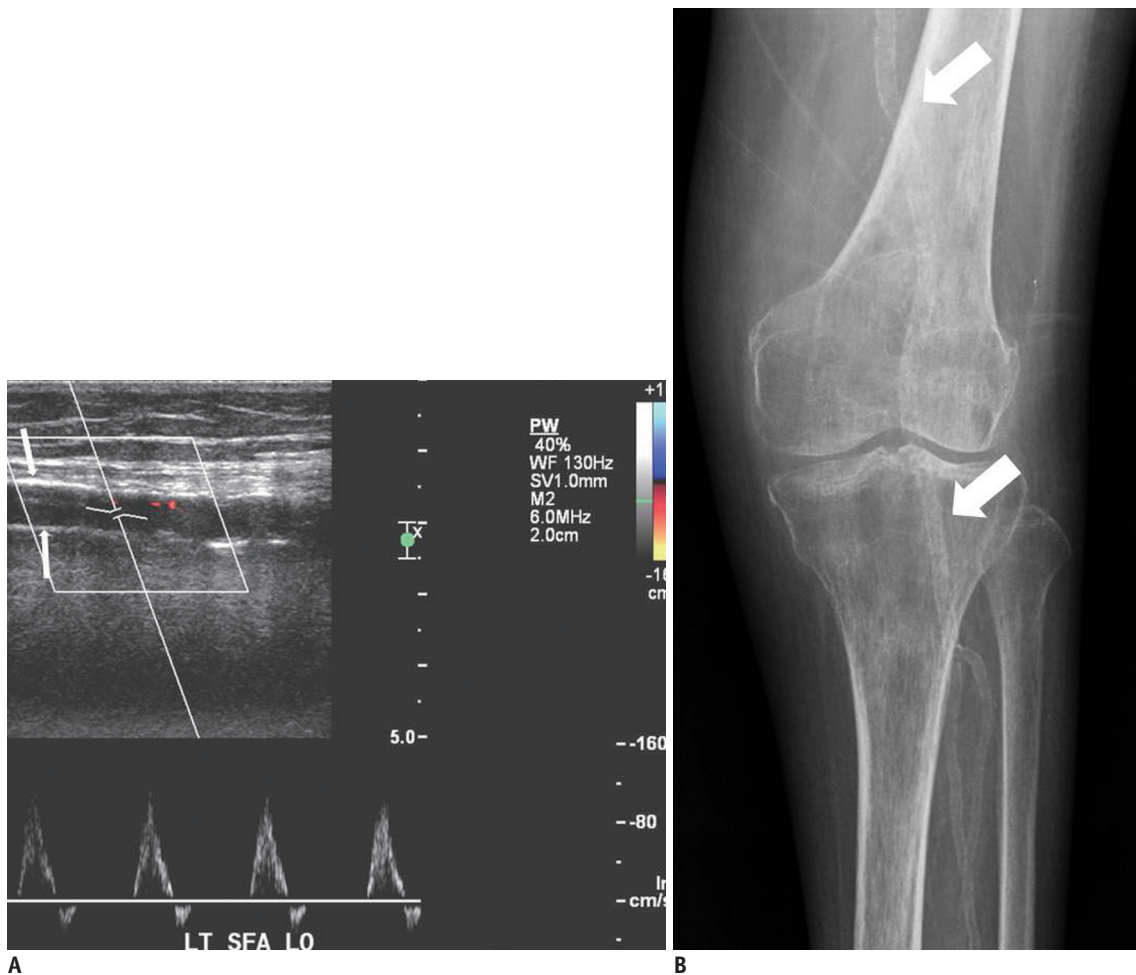
**Septic Arthritis**

Without appropriate treatment, septic arthritis can cause joint destruction and irreversible loss of joint function (3). Sonographic findings of septic arthritis are joint effusion, hyperechoic fluid, synovial hypertrophy, and thickening of joint capsule with adjacent soft tissue swelling. Bone

erosion or destruction can be observed (Fig. 4) (9). A small amount of joint effusion may be masked by transducer compression. Usually, joint fluid analysis is needed because of the difficulty in differentiating this condition from non-infected joint effusion (3, 9).

**Vascular Disorders**

Uncontrolled DM accompanies many vascular disorders including peripheral arterial disease (PAD), coronary artery disease, and carotid artery stenosis, which is followed by vascular insufficiency. DM increases the risk of atherosclerosis (10). Vascular disease causes susceptibility to lower-extremity complications in diabetic patients. The risk of PAD is increased 2- to 4-fold in diabetic patients (11). Diabetic PAD occurs at a younger age as compared to nondiabetic PAD, and tends to be advanced and diffuse with poor collateral circulation (12). Vascular evaluation is



**Fig. 5. Medial arteriosclerosis showing stiff Doppler flow pattern in lower extremity in 60-year-old patient.**  
**A.** Longitudinal sonography scan of superficial femoral artery shows continuous echogenic lines (arrows) in vessel wall without luminal narrowing. Doppler flow pattern shows decreased 2nd reversal flow in early diastole and loss of 3rd wave. These findings are suggestive of decreased resistance of distal arteries and arterial stiffness. **B.** Plain radiography of left knee shows continuous circumferential fine calcification along superficial femoral artery and popliteal tributaries (arrows).

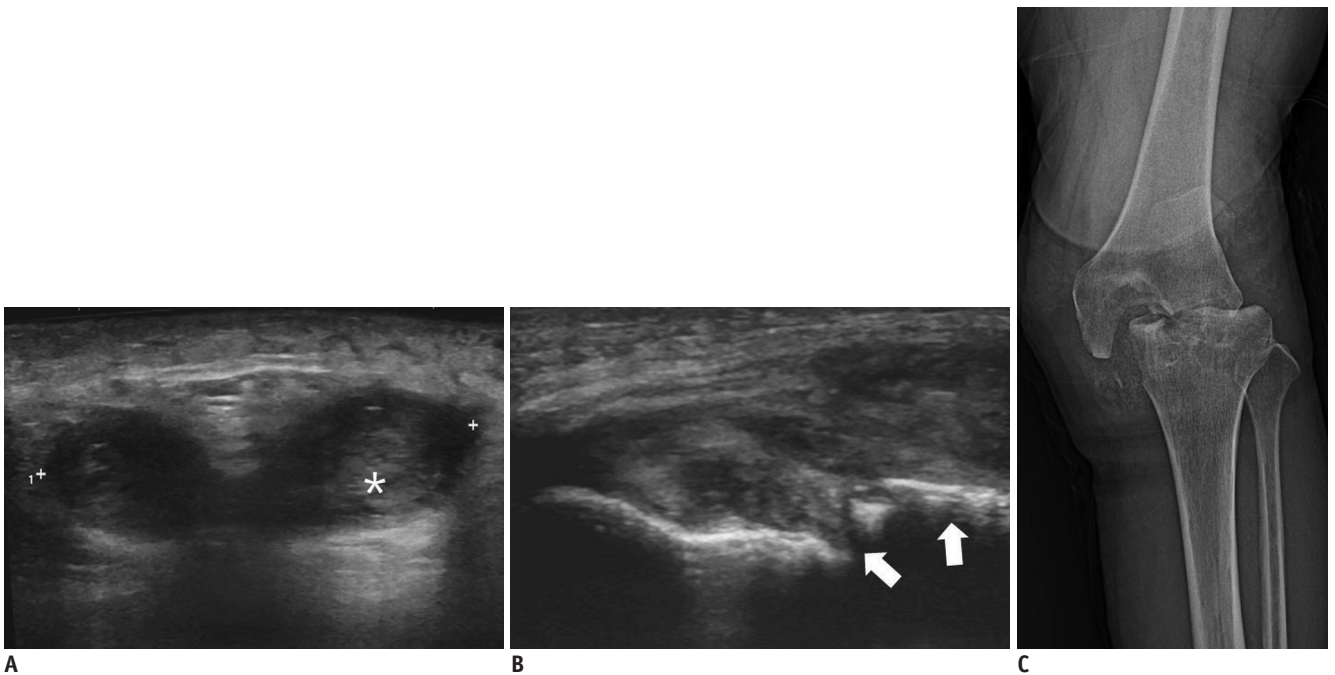


important for assessment of healing potential of diabetic foot. So, vascular Doppler sonography of extremities is a commonly used and feasible diagnostic tool for evaluating general vascular conditions (anatomy, physiology) in diabetic patients with nonspecific peripheral symptoms (13).

**Medial Arteriolosclerosis**

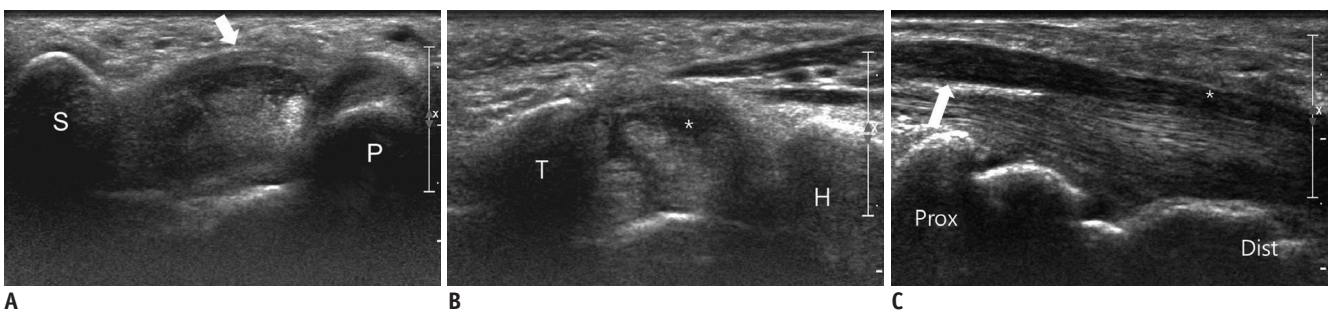
Medial arteriolosclerosis, so-called Mönckeberg's arteriosclerosis, is characterized by calcific deposits within the media of medium and small-sized arteries that do not cause luminal narrowing. It results in

increased arterial stiffness and decreased resistance index (Fig. 5A) (14). This disease is associated with DM and chronic kidney disease (15). In diabetic patients, medial arteriolosclerosis is associated with diabetic nephropathy, neuropathy, retinopathy, lower limb amputation, and other macrovascular complications (16, 17). The sonographic manifestation includes typically diffuse and circumferential calcification along the vessels without luminal narrowing (Fig. 5) (18).



**Fig. 6. Neuropathic osteoarthropathy with combined infection (*Pseudomonas aeruginosa*) of left knee in 61-year-old patient with knee swelling.**

**A.** Transverse sonography scan of suprapatellar bursa shows large amount of joint effusion filled with echogenic material (asterisk) and diffuse thickening of subcutaneous tissues. **B.** Longitudinal sonography scan of medial aspect of left knee shows cortical destruction of tibia (arrows) and joint effusion with echogenic materials. **C.** Plain radiography of left knee shows severe bone destruction with discrete margin, fragmentations, joint subluxation, and soft tissue edema. Serial radiographs (not shown) demonstrate rapid progression of bone destruction.



**Fig. 7. Carpal tunnel syndrome of left wrist in 58-year-old patient with complaint of tingling sensation of both hands.**

**A.** Transverse sonography of left wrist scan shows palmar bowing of flexor retinaculum at proximal carpal tunnel level delimited by scaphoid (S) and pisiform (P). Diffuse thickening of flexor retinaculum is noted (arrow). **B.** Transverse sonography scan shows median nerve flattening (asterisk) at distal carpal tunnel level delimited by hamate (H) and trapezium (T). **C.** Longitudinal sonography scan shows median nerve flattening (asterisk) at distal (dist) carpal tunnel level and median nerve swelling (arrow) at distal radius level (prox). Surgical release of carpal tunnel was performed because of non-responsiveness to conservative management.

### Diabetic Neuropathy

Diabetes is the most common cause of neuropathy. The risk factor for the development of diabetic neuropathy is long-standing and poorly controlled DM. Diabetic neuropathy could be caused by metabolic factors and nerve ischemia related to microangiopathy. The most common form of diabetic neuropathy is distal symmetric polyneuropathy, which initially affects the distal lower extremities (19, 20). Inappropriate management of diabetic neuropathy can lead to some complications, such as foot ulceration and neuropathic osteoarthropathy.

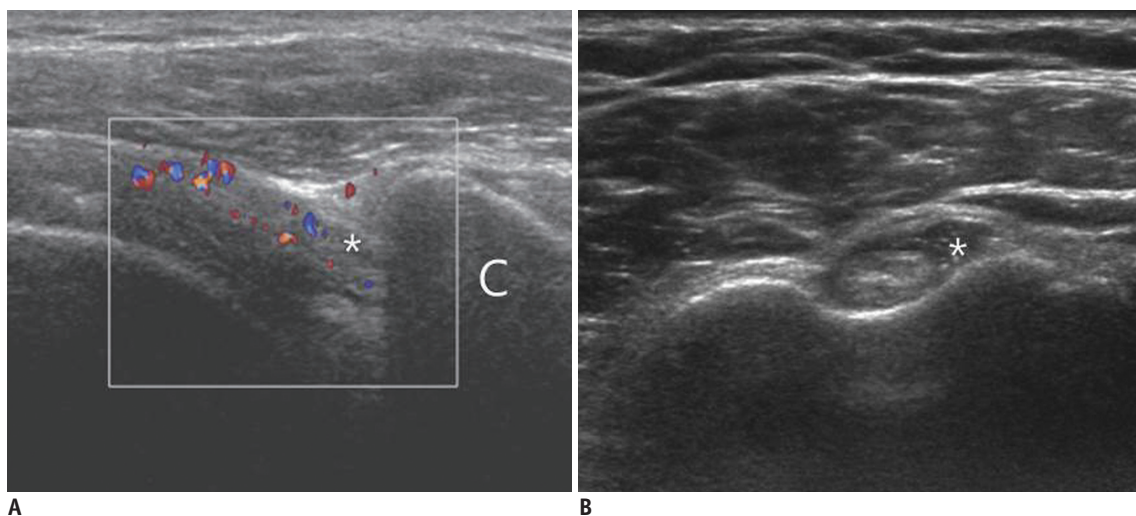
### Neuropathic Osteoarthropathy

Diabetes mellitus is one of the common causes of neuropathic osteoarthropathy (21). One of the suggested theories is that abnormal neuronal function renders the bone and joint susceptible to a sequence of pathologic alterations. Repetitive trauma to insensate joints and autonomic dysfunction of the blood flow eventually result in bone destruction, joint subluxation and dislocation, and foot deformity (22). Neuropathic osteoarthropathy usually occurs in the midfoot or the Lisfranc joint. Vascular calcification accompanied by Lisfranc fracture or displacement is highly suggestive of DM (20). On sonography, neuropathic osteoarthropathy appears as irregularities and discontinuity of the cortex and hyperemic changes in the soft tissue (Fig. 6) (23). But, it is difficult to differentiate from neuropathic osteoarthropathy with other diseases, such as osteomyelitis and uninfected bone

destruction. Sonography alone is insufficient to discriminate osteomyelitis. According to the American College of Radiology Appropriateness Criteria, plain radiography can be used as a screening examination. In addition, plain radiography and MRI are complementary imaging tools (24). Imaging findings that include the presence of ulcer, sinus tract, cellulitis, or abscess with an adjacent bone lesion, are more diagnostic of osteomyelitis than neuropathic osteoarthropathy (22). Although sonography is an inadequate diagnostic tool for neuropathic osteoarthropathy, sonography-guided fluid aspiration can be helpful to obtain specimen for fluid analysis and culture (3).

### Carpal Tunnel Syndrome

Carpal tunnel syndrome (CTS) is caused by entrapment of the median nerve within the carpal tunnel at the volar aspect of the wrist. Accompanying CTS occurs in 11–21% of diabetic patients (25). The pathophysiology of CTS is multifactorial. In DM, ischemic changes related to microvascular disease is a possible cause of CTS (26). The outcomes of carpal tunnel release are worse in diabetic patients due to increased inflammation or delayed wound healing (27). On sonography, the normal median nerve within the carpal tunnel is identified as a rounded hypoechoic structure with hyperechoic dots within. In CTS patients, sonography demonstrates nerve flattening in the distal tunnel, nerve swelling in the distal radius region, and palmar bowing of the flexor retinaculum (Fig. 7) (28).



**Fig. 8. Adhesive capsulitis of right shoulder in 49-year-old patient with bilateral shoulder pain.**

**A.** Transverse color Doppler sonography scan shows thickening of cuff interval structures with increased vascularity (asterisk). Dynamic sonography scan of right shoulder shows marked limitation of sliding movement of supraspinatus tendon beneath acromion during lateral passive elevation of arm (not visualized in this figure). **B.** Transverse sonography scan shows distension of biceps long head tendon sheath (asterisk) with joint fluid collection. C = coracoid process

**Other Diseases**

**Adhesive Capsulitis**

Adhesive capsulitis is also called frozen shoulder. The main features of this disease are thickening of the joint capsule and synovium. DM increases the risk of adhesive capsulitis. Its prevalence is about 10 to 20% (29). The sonographic manifestation demonstrates restriction of sliding movement of the supraspinatus tendon beneath the acromion during lateral passive elevation of the arm (30). The other sonographic findings are hyperechoic, thickened synovium along the cuff interval and fluid collection around the biceps tendon at the bicipital groove level (Fig. 8) (31).

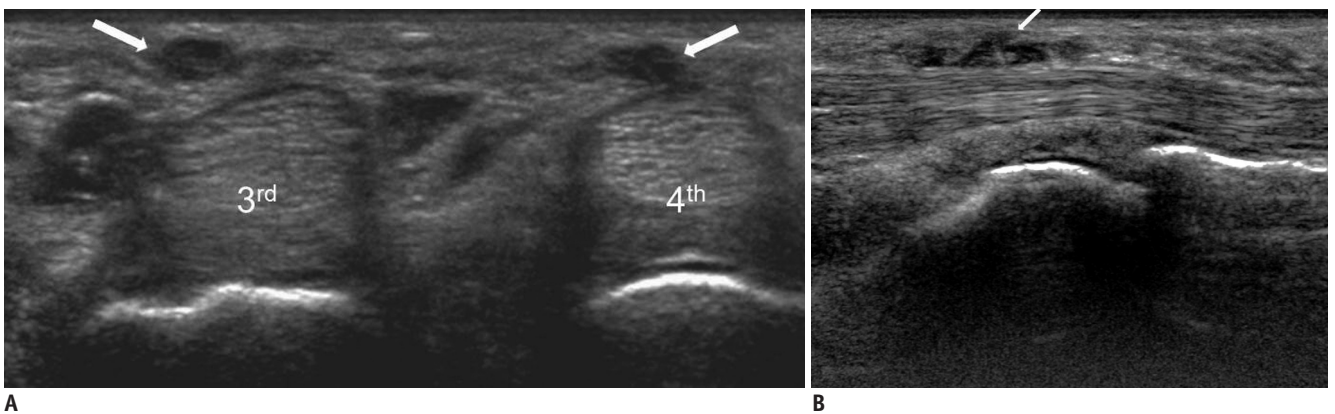
**Dupuytren's Contracture**

Dupuytren's contracture is a fibroproliferative disease affecting the palmar fascia of the hand. Formation of painless, subcutaneous nodule occurs in early stage of this disease. Nodules may progress slowly to fibrous cords

or bands that attach to flexor tendons (32). The fibrotic lesions with shortening and thickening of the palmar fascia lead to flexion contracture of the flexor tendon of finger. Fourth and fifth fingers are the most commonly affected fingers (25). This disease frequently affects males aged above 30 years and occurs bilaterally. It is related to DM, alcoholism, smoking, HIV infection, and hyperlipidemia (33). On sonography, Dupuytren's contracture appears as subcutaneous nodules and cords in palmar subcutaneous tissue, superficial to flexor tendons (Fig. 9) (32). The nodule varies from a mixed echogenic nodule to a hypoechoic nodule. According to Créteur et al. (34), the early nodule is hypoechoic with hypervascular Doppler signal. The older nodules are iso to hyperechoic without hypervascular Doppler signal. The cord is located superficially and parallel to the adjacent flexor tendon.

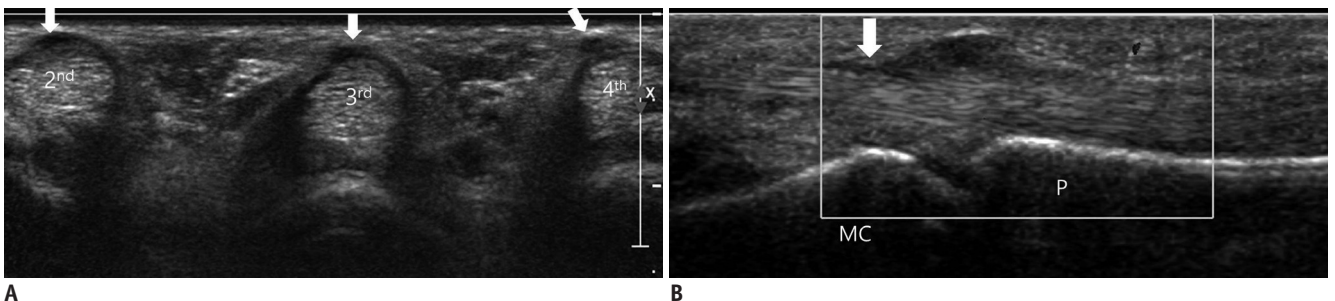
**Stenosing Flexor Tenosynovitis**

Stenosing flexor tenosynovitis is also called trigger. A



**Fig. 9. Dupuytren's contracture of right hand in 48-year-old patient complaint of contracture of right 4th finger and palpable nodules on palm.**

**A.** Transverse sonography scans shows hypoechoic nodular lesions (arrows) in subcutaneous fat layer of right palm at 3rd and 4th metacarpal head level, suggesting nodular thickening of palmar fascia. **B.** On longitudinal sonography scan, subcutaneous cord (arrow) at distal crease level is contiguous with thickened tendon sheath of 4th flexor digitorum tendon. 3rd = 3rd metacarpal head, 4th = 4th metacarpal head



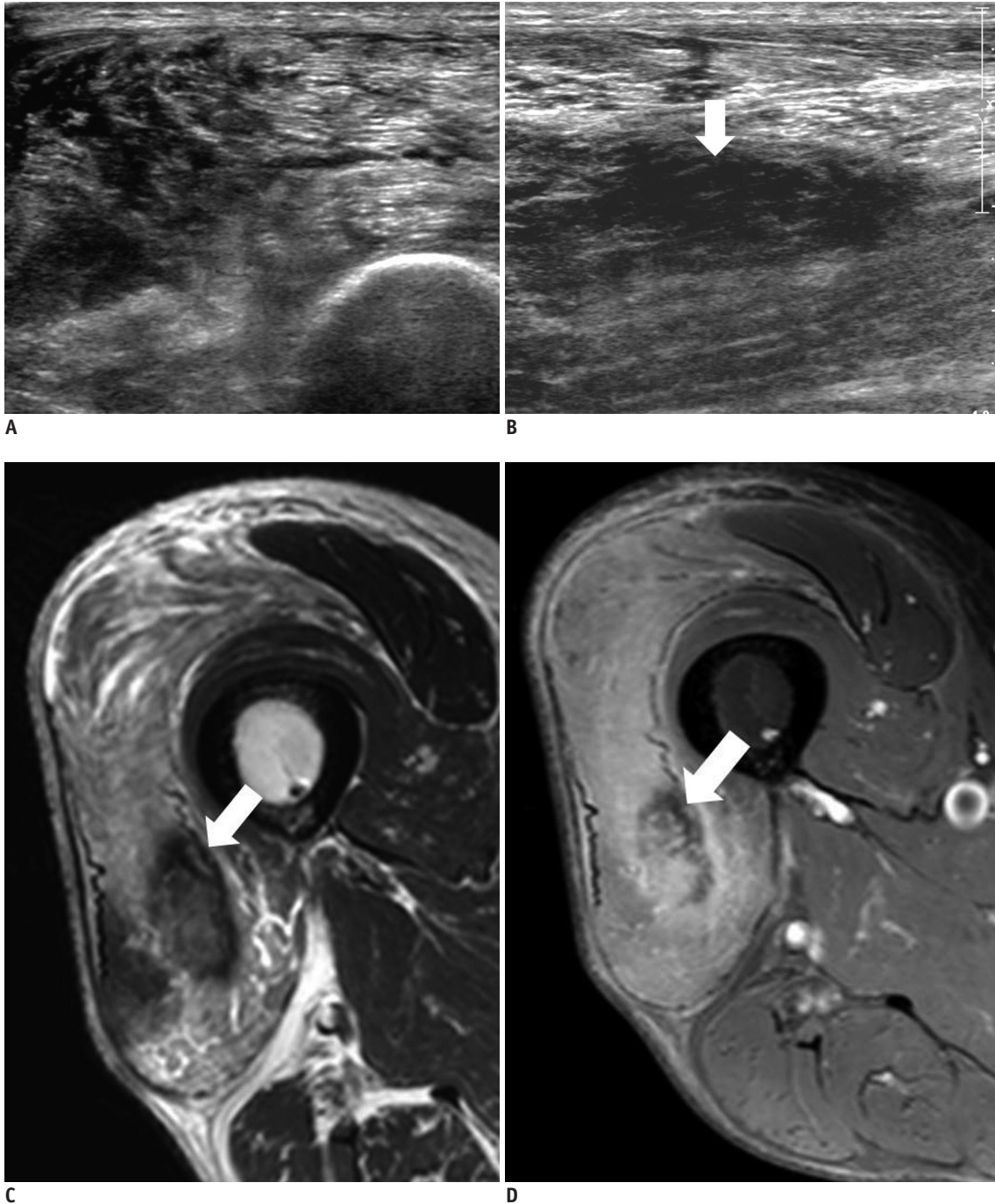
**Fig. 10. Trigger finger affecting right 2nd-4th fingers in 38-year-old patient with difficulty in extension of right 2nd-4th fingers.**

**A.** Transverse sonography scan shows hypoechoic nodular thickening of first annular pulleys (arrows) at metacarpophalangeal joint level. **B.** Longitudinal sonography scan shows blurred margin of 2nd flexor digitorum tendon (arrow). 2nd = 2nd flexor digitorum tendon, 3rd = 3rd flexor digitorum tendon, 4th = 4th flexor digitorum tendon, MC = 2nd metacarpal bone, P = 2nd proximal phalanx



previous report shows that approximately 20% of the diabetic population have stenosing flexor tenosynovitis (25). This disease involves the flexor tendons and the surrounding retinacular pulley system, most commonly at the level of the first annular (A1) pulley. It results in thickening of the sheath

with local inflammatory changes and fibrocartilaginous metaplasia (35). The sonographic finding is diffuse or nodular thickening of the A1 pulley (Fig. 10). Also, the flexor digitorum tendons show various abnormal sonographic findings, such as loss of normal fibrillar echogenic pattern,



**Fig. 11. Diabetic muscle infarction affecting right thigh in 55-year-old patient with leg pain.**

**A, B.** Transverse (**A**) and longitudinal (**B**) sonography scans show heterogeneous echogenicity of right vastus lateralis muscle. On longitudinal scan (**B**), hypoechoic portion with preservation of echogenic fibrillar pattern of muscle fibers (arrow) is noted. Significant fluid collection is absent. **C.** Axial T2-weighted MR image shows diffuse edema of right vastus lateralis muscle. Note focal T2 low signal intensity lesion (arrow). **D.** On axial enhanced T1-weighted fat-suppressed MR image, focal T2 low signal lesion corresponds to lesion with decreased enhancement and surrounding enhancement (arrow).



irregularity or blurring of the tendon margin, and fluid collection in the tendon sheath (36).

### **Diabetic Muscle Infarction**

Diabetic muscle infarction is also called diabetic muscle ischemia or diabetic myonecrosis. It is common in patients with long-standing, poorly controlled diabetes or end-organ complications such as retinopathy, nephropathy, and neuropathy (37). Diabetic muscle infarction occurs predominantly in type 1 diabetic patients (38). The pathogenesis of this disease is not well understood, but may involve microangiopathy (39). Typical clinical features of diabetic muscle infarction are abrupt severe pain and swelling of the thigh or calf and accompanying development of a palpable mass, over days or weeks, in the absence of systemic signs of infection (39). On sonography, diabetic muscle infarction appears as a well-marginated, hypoechoic, intramuscular lesion with internal linear structures compatible with muscle fibers coursing through the lesion. Lack of a predominantly anechoic region and absence of motion or swirling of fluid with transducer pressure are also important sonographic findings (Fig. 11) (37). Infectious myositis and inflammatory myositis are important differential diagnostic considerations. Clinical and radiologic features favoring the diagnosis of infectious myositis are systemic signs of infection and abscess formation within involved muscle. In inflammatory myositis, gradually progressive proximal muscle weakness and bilateral symmetric edema in involved muscles are key features for the differential diagnosis (22).

### **CONCLUSION**

Many MSK diseases, such as infectious disease, vascular disorder, diabetic neuropathy, and other diseases, can occur in diabetic patients. Sonography is a useful imaging modality for detection of the various MSK diseases of DM, although limited for osseous lesions. Recognition of possible MSK diseases in the diabetic patient and typical sonographic findings of each disease entity can be helpful in making an accurate diagnosis.

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