Hydroxyapatite Crystal Deposition Disease of the Shoulder: A Review of Cases and Literature

Reddy Ravikanth[1] Kanagasabai Kamalasekar[1] Manu Jacob Abraham[2] Ashok Alapati[2]

[1]Department of Radiology, Holy Family Hospital, Thodupuzha, India
[2]Department of Orthopedics, St. John's Medical College, Bangalore, India

Address for correspondence Reddy Ravikanth, MD, DNB, Department of Radiology, Holy Family Hospital, Thodupuzha 685605, India (e-mail: ravikanthreddy06@gmail.com).

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Abstract

Hydroxyapatite crystal deposition diseases (HADDs) are characterized by deposition of insoluble crystals within the joints and periarticular soft tissues, initiating inflammatory destructive reaction. Calcium hydroxyapatite (CHA) is the most common type of calcium in human bone and is also the most common pathologic calcification found in the body. There are three phases of the disease: silent, mechanical, and adhesive phases. The shoulder is the most common site of HADD. CHA crystals are non-birefringent in polarized light. Radiographic characteristics include homogenous, amorphous densities without trabeculations that are variable in size, ovoid, triangular, or linear. The first imaging modalities to identify calcific tendinitis (CT) were X-ray and ultrasound, as calcium deposits are readily identifiable on both. Treatment is chiefly conservative, including nonsteroidal anti-inflammatory drugs (NSAIDs), local heat application, and physiotherapy. Local corticosteroid injections may also be of benefit. When intra-articular, CHA crystals can cause joint destruction such as "Milwaukee shoulder." In the acute symptomatic phase of HADD, called acute calcific periarthritis, soft tissue and osseous edema can be present and needs to be differentiated from infection, tumor, and trauma.

Keywords
- hydroxyapatite deposition disease
- Milwaukee shoulder
- ultrasound ablation therapy
- magnetic resonance appearance

Introduction

Hydroxyapatite deposition diseases (HADDs) refer to a spectrum of abnormalities that include calcific tendinitis (CT), other periarticular hydroxyapatite deposition, and hydroxyapatite-induced arthritis.[1] Other names for HADD include calcific tendinosis, peritendinitis calcarea, calcific peritendinitis and bursitis, and hydroxyapatite rheumatism.[2] Calcium hydroxyapatite (CHA) is the most common type of calcium in human bone and is also the most common pathologic calcification found in the body.[3] CHA and other basic calcium phosphate crystals are considered the causal agents in some entities. In other situations, the basic calcium phosphates are considered secondary to underlying diseases. For example, the calcifications associated with severe renal disease, collagen vascular disease (dermatomyositis and scleroderma), chronic neurologic conditions, vitamin D overload, tumoral calcinosis, and dystrophic calcification are composed largely of CHA.

Cases

A 45-year-old woman presents with pain in both the shoulders with reduced range of motion. Axial PD (proton density MRI) fat-suppressed images of the right (►**Fig. 1A**) and left shoulders (►**Fig. 1B**) are provided demonstrating CT involving supraspinatus tendons bilaterally with no significant tendinopathy.

A 63-year-old woman presents with pain in the left shoulder with reduction in the range of motion. Coronal oblique T2-weighted fat-suppressed image (►**Fig. 2A**) and axial PD fat-suppressed image (►**Fig. 2B**) show a rounded focus of decreased signal intensity along the bursal surface of the supraspinatus tendon insertion site. Water signal is present in the subdeltoid bursa indicative of inflammation.

A 62-year-old woman presents with pain in the right shoulder with reduced range of motion. Coronal oblique T2-weighted fat-suppressed image (►**Fig. 3A**) demonstrates CT in the infraspinatus tendon and axial PD fat-suppressed image (►**Fig. 3B**) demonstrates CT in the teres minor tendon.

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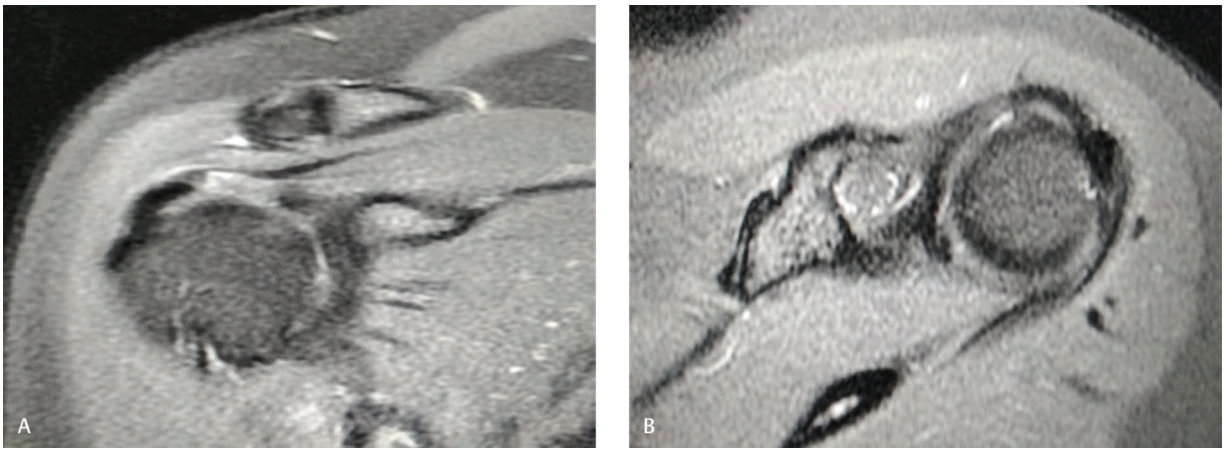

Fig. 1 **(A)** Axial PD fat-suppressed image of right shoulder and **(B)** axial PD fat-suppressed image of left shoulder demonstrating calcific tendinitis involving bilateral supraspinatus tendons.

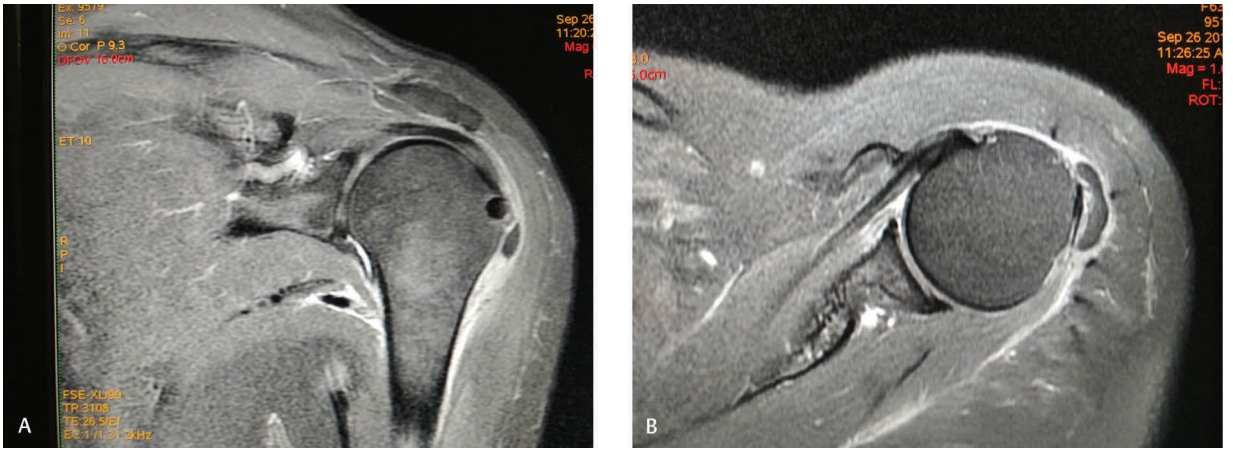

Fig. 2 **(A)** Coronal oblique T2-weighted fat-suppressed image and **(B)** axial PD-fat-suppressed image demonstrating a rounded focus of decreased signal intensity along the bursal surface of the supraspinatus tendon with features suggestive of bursitis.

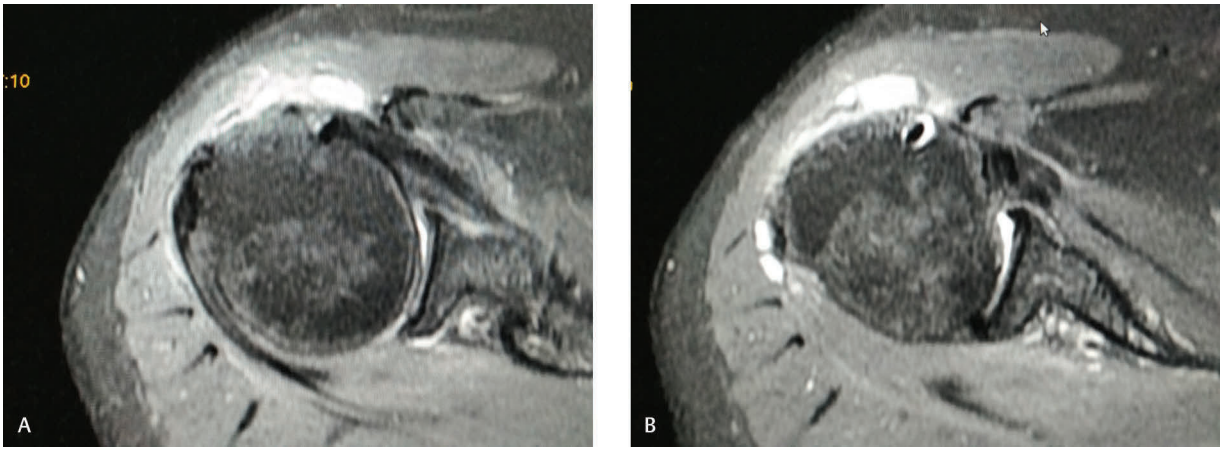

Fig. 3 **(A)** Axial T2-weighted fat-suppressed image demonstrating calcific tendinitis in the infraspinatus tendon and **(B)** axial PD-fat-suppressed image demonstrates calcific tendinitis in the teres minor tendon.

A 56-year-old woman presents with pain in the left shoulder with reduced range of motion. Coronal oblique (►**Fig. 4A**) and axial PD fat-suppressed images (►**Fig. 4B**) of the left shoulder are provided demonstrating CT involving supraspinatus tendons with tendinopathy, respectively.

Discussion

Clinical Presentation

There are three phases of the disease: (1). Silent phase: the initial phase in which calcium is completely contained in the tendon or tissue and appears sharply defined and

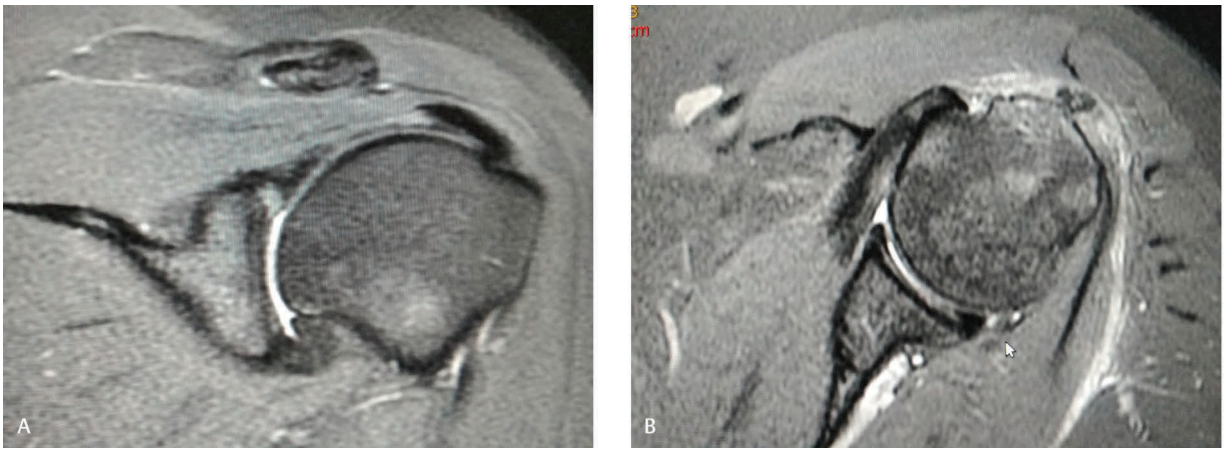

Fig. 4 **(A)** Coronal oblique PD fat-suppressed image and **(B)** axial PD fat-suppressed image of left shoulder demonstrating calcific tendinitis involving supraspinatus tendons with high signal intensity suggesting tendinopathy.

circumscribed. Patients generally have minimal or no symptoms in this phase. (2) Mechanical phase: it is characterized by enlargement of the deposit. Liquefaction of the deposit occurs leading to increased pressure and impingement, bursitis, or inflammatory-like symptoms. The radiographic appearance of the deposit may be less well defined. Recurrent attacks may lead to rupture of the deposit. Evacuation of the calcium may occur completely or incompletely. Later stage is characterized by acute painful attacks. Disappearance of the calcium may occur and may or may not correspond with the clinical course. (3) Adhesive phase: it is the late stage of general debility, pain, and limited motion. This stage is characterized by variable-sized calcium deposits and local tissue destruction.

Anatomic Sites of Involvement

The shoulder is the most common site of HADD. In one study that examined the prevalence of CT in the general population, 2.7% of study participants had calcified deposits (presumed CHA deposits) in the rotator cuff complex. Of these patients, only 34 to 45% had problems that could be associated with the CHA deposits. In this study, women were more often symptomatic than men and disease occurred most commonly between the ages of 31 and 40. The shoulder is said to account for 60% of cases of acute calcific periarthritis.[4] HADD can involve any of the components of the rotator cuff complex, and the supraspinatus tendon is most commonly involved. HADD can also involve adjacent tendon structures, including the long and short heads of the biceps tendon, coracobrachialis tendon, triceps tendon, and pectoralis tendon. Subacromial and subdeltoid bursal calcifications appear as a teardrop-shaped radiodense areas below the acromion and deltoid muscle.

Laboratory Findings

Laboratory tests are usually negative in HADD patients. CHA crystals are 75 to 250 nm and are not visible with light microscopy, except when the crystals form aggregates.[5] The CHA crystals are non-birefringent in polarized light.

Radiographic Characteristics

Radiographic characteristics include homogenous, amorphous densities without trabeculations that are variable in size, ovoid, triangular, or linear. Margins are usually smooth though they may be ill defined and tendinous deposits usually occur close to insertion site. Well-defined oval calcifications are most likely in the deep trochanteric bursa.

Diagnostic Imaging

The first imaging modalities to identify CT were X-ray and ultrasound, as calcium deposits are readily identifiable on both. Radiographs should be performed in anterior-posterior (AP)—neutral, internal rotation, and external rotation—axillary and outlet view. On radiographs, calcific deposits appear homogeneous, amorphous densities without trabeculation, which allows a differentiation from heterotopic ossification or accessory ossicles. Most calcifications are ovoid, and the margins may be smooth or ill defined.[6] Ultrasound (US) is advantageous in the diagnosis of CT as it helps detect other associated conditions as well such as rotator cuff tears and long head of the biceps (LHB) pathologies; moreover, it also characterizes deposit consistency, their tendon location, and can be helpful to assist injections and bursal lavage. According to the morphology of the calcium deposit, US has been used to classify different types of CT due to its ability to discriminate between well-defined calcifications with strong shadowing and those with faint or absent shadowing. Chiou et al[7] classified calcific depositions into four shapes: an arc shape (echogenic arc with clear shadowing), a fragmented or punctate shape (at least two separate echogenic spots or plaques, with or without shadowing), a nodular shape (echogenic nodule without shadowing), and a cystic shape (a bold echogenic wall with an anechoic area, weak internal echoes, or layering content). Conditions associated with non–arc-shaped calcifications include hypervascularity, widening of subacromial-subdeltoid bursa, and large size of calcifications. High-resolution US in combination with color Doppler can differentiate between formative or resorptive status. In

the resorptive phase, the deposits are nearly liquid and can be successfully aspirated. US has been also used successfully in overhead athletes to identify CT showing a prevalence greater than that reported in the general population and that the presence of calcific tendinopathy correlates positively with age. Computed tomographic scan and magnetic resonance imaging (MRI) should be reserved for doubtful cases. Computed tomography has an excellent resolution to detect calcium deposit as high-density foci of solid stippled or amorphous character, but the cost and exposure to radiation limit its use. MRI should not be used as a first-line imaging modality, because deposits appear as vague regions of low signal on T1 and T2 and can be missed.[8] Some enhancement around the deposit can be seen after contrast, and surrounding areas of hyperintensity on T2 due to peripheral edema or subacromial-subdeltoid bursal fluid are possible. Loew et al[9] proposed the first magnetic resonance classification based on the morphologic appearance of the CT: type A—compact and homogeneous one-part structure, clearly defined outline; type B—subdivided homogeneous structure, clearly defined outline; and type C—diffuse area of low-signal intensity, no defined outline in the tendon.

Treatment and Prognosis

Treatment is chiefly conservative, including nonsteroidal anti-inflammatory drugs (NSAIDs), local heat application, and physiotherapy. Local corticosteroid injections may also be of benefit. Surgical removal of calcifications may be appropriate for cases refractory to other attempts of conservative treatment. US ablation may prove to be of short-term benefit in particular cases.[10] However, its long-term benefit has not yet been demonstrated.

Complications

When intra-articular, CHA crystals can cause joint destruction. Any joint can be involved; the shoulder is most commonly affected, resulting in "Milwaukee shoulder."[11] "Milwaukee shoulder" refers to a destructive shoulder arthropathy due to deposition of hydroxyapatite crystals, and identification of these crystals in synovial fluid is the cornerstone of diagnosis.

Differential Diagnosis

The differential diagnosis of joint pain with calcification is extensive and occurs in many conditions such as calcium pyrophosphate dihydrate deposition disease (CPPD), dystrophic calcification, renal osteodystrophy, hyperparathyroidism, hypoparathyroidism, tumoral calcinosis, collagen vascular disease, sarcoidosis, ochronosis, milk-alkali syndrome, and hypervitaminosis D.[12]

Conclusion

HADD is a common disorder characterized by periarticular deposition of CHA crystals and an accompanying inflammatory process. Although any joint can be involved, the shoulder is the most commonly affected site. In this review article, we have highlighted the magnetic resonance appearances of HADD involving the shoulder joint. On MRI, CHA deposits present as small, oval foci of decreased signal intensity on T1W or T2W images. Adjacent marrow signal intensity may be altered because of intraosseous edema due to crystal deposition. A decrease in the size of the edematous, inflamed tissue and its high signal intensity on MRI correlates with clinical improvement. In the acute symptomatic phase of HADD, called acute calcific periarthritis, soft tissue and osseous edema can be present and needs to be differentiated from infection, tumor, and trauma.

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Conflict of Interest
None.

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