Imaging of calcific tendinitis of the shoulder: a multimodality approach

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Learning objectives

- To expose the etiology and pathology of calcific tendinitis.
- To depict the types of calcific tendinitis.
- To review the imaging findings of calcific tendinitis of the shoulder on Radiographs, Ultrasound (US), Computed Tomography (CT) and Magnetic Resonance Imaging (MRI).
- To identify imaging pitfalls and differential diagnosis on varied imaging modalities.

Background

Introduction:

Calcific tendinitis is caused by deposition of calcium hydroxyapatite crystals in the substance of the tendons. The most common sites are the rotator cuff, Achilles, and patellar tendons. The nomenclature of this condition is vast; terms such as calcific periarthritis, periarticular apatite deposition, calcifying tendinitis, calcareous tendinitis and calcific tendinopathy have been used.

Prevalence in Caucasian populations ranges from 2.7% to 20%, with a slight predominance of women, mostly between 30 and 50 years. Associations include diabetes mellitus and thyroid disorders, and these patients usually have a worse clinical course.

Clinical Presentation:

Although asymptomatic in 50% of patients, clinical manifestations include activity-related pain, tenderness, localized edema and decreased range of motion, resulting in disability. The clinical course is variable, with a tendency towards spontaneous reabsorption. During the resorptive phase patients may experience acute symptoms, for about two weeks, but persistent pain and decrease in range of motion can occur.

Etiology

Several etiological hypotheses were speculated, including tendon degeneration with intracellular calcium accumulation, secondary to vascular ischemia, repetitive trauma, or necrosis of tenocytes; reactive calcification due to an active cell mediated process; or endochondral ossification of fibrocartilage at the enthesis of the tendon. Recent work suggests that chondral metaplasia with erroneous differentiation of tendon-derived stem cells into osteogenic cells plays a role.
Pathology: Calcification Process

Pathologically, a favorable environment permits an active process of cell-mediated calcification, usually followed by a phagocytic reabsorption. Three stages in the calcifying process are described:

- **Precalcific Stage:** Fibrocartilaginous metaplasia within the tendon.

- **Calcific Stage:** Calcific deposits are formed. This stage is subdivided into three phases:
  
  - Formative Phase: Calcium crystals deposited in matrix vesicles that coalesce to form foci of calcification.
  - Resting Phase: Fibrocollagenous tissue borders the foci of calcification. Termination of deposition.
  - Resorptive Phase: Vascular channels appear at the periphery of the deposit. Macrophages and multinucleated giant cells phagocytose debris. The deposit exhibits a thick, creamy, or toothpaste-like material.

- **Post Calcific Stage:** An attempt by the tendon to heal.

<table>
<thead>
<tr>
<th>Stages</th>
<th>Precalcific</th>
<th>Calcific</th>
<th>Postcalcific</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Active cell mediation</strong></td>
<td>Cellular Change</td>
<td>Formative Phase</td>
<td>Resting Phase</td>
</tr>
<tr>
<td><strong>Cellular Response</strong></td>
<td>Chondrocyte → Ficrocartilage</td>
<td>Mineralization</td>
<td>Enlargement/Liquefaction</td>
</tr>
<tr>
<td><strong>Clinical Symptoms</strong></td>
<td>+/- Pain</td>
<td>+/- Pain</td>
<td>+/- Pain</td>
</tr>
</tbody>
</table>

Table 1: Progressive Calcification and Clinical Symptoms of Calcific Tendinitis.  
**References:** Adapted from Chiou HJ et al. (2010) Correlations among mineral components, progressive calcification process and clinical symptoms of calcific tendonitis. Rheumatology 49:548-555

Findings and procedure details

Calcific Tendinitis of the Shoulder

The commonest site of hydroxyapatite deposition is the rotator cuff, especially in the supraspinatus tendon, followed by the infraspinatus and subscapularis. The typical calcification site in the supraspinatus is approximately 1cm from its insertion on the
greater tubercle of the humerus, an area of relative avascularity. Other tendons of the shoulder girdle, particularly the biceps, can be affected.

**Imaging Findings:**

The first line imaging modalities are x-ray and ultrasound, as calcium deposits are readily identifiable on both.

On plain film, more than one view is required, including anteroposterior (AP) - neutral, internal rotation and external rotation - and outlet view. The radiographic appearance of calcific tendinitis are homogeneous, amorphous densities without trabeculation, which allows for differentiation from heterotopic ossification or accessory ossicles. Most calcifications are ovoid, and margins may be smooth or ill-defined.

**Fig. 1:** Frequent sites of crystal deposition in external (left) and internal (right) rotation. Colors indicate specific tendons: red - supraspinatus; blue - infraspinatus; yellow - teres minor; orange - subscapularis; green-biceps. The humeral head overlaps the infraspinatus and teres minor calcifications in external rotation.

**References:** Serviço de Imagiologia, Centro Hospitalar de Vila Nova de Gaia/Espinho - Vila Nova de Gaia/PT
Ultrasound has some advantages. It detects other common sources of shoulder pain, such as rotator cuff tears, characterizes consistency of the deposits, depicts their location in the tendon, and guides interventional techniques.

Various classifications were proposed for the calcific plaques based on their morphology on ultrasound. The ability to discriminate between well defined calcifications with strong shadowing, and those with faint or absent shadowing is emphasized in all of them.

Chiou et al. classifies 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).
Fig. 3: Ultrasound classification of calcific deposits. a) arc-shape calcification in the infraspinatus: echogenic arc with clear shadowing; b) fragmented shape calcification in the infraspinatus: three echogenic plaques are identified, in this case showing strong shadowing; c) nodular shape in the supraspinatus: echogenic nodule without shadowing; patient presented to the emergency department with intense pain and movement limitation; d) cystic shape: echogenic wall with weak internal echoes.

References: Serviço de Imagiologia, Centro Hospitalar de Vila Nova de Gaia/Espinho - Vila Nova de Gaia/PT

There is a correlation between the morphology of the calcified deposit, the clinical symptoms and the three phases of the calcific stage (Table 2).

<table>
<thead>
<tr>
<th>Morphology</th>
<th>Pain</th>
<th>Calcific Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arc</td>
<td>+</td>
<td>Formative Phase</td>
</tr>
<tr>
<td>Fragmented/Punctuate</td>
<td>++</td>
<td>Formative Phase</td>
</tr>
<tr>
<td>Nodular</td>
<td>+++</td>
<td>Resting Phase</td>
</tr>
<tr>
<td>Cystic</td>
<td>+++++</td>
<td>Resorptive Phase</td>
</tr>
</tbody>
</table>
Table 2: Correlation between shape of calcified deposits, symptoms and calcification stages.

**References:** Adapted from Chiou HJ et al. (2010) Correlations among mineral components, progressive calcification process and clinical symptoms of calcific tendonitis. Rheumatology 49:548-555

Besides, there is an association with Color Doppler ultrasonography of the rotator cuff and the calcific stage/clinical symptoms. The non-arc shape calcific plaques are more hypervascular, especially the nodular type, suggesting resting or resorptive stage.

![Large nodular calcification showing hypervascularity and bursal extrusion, complicated with bursitis](image)

**Fig. 4:** Large nodular calcification showing hypervascularity and bursal extrusion, complicated with bursitis (notice fluid in the bursa and parietal thickening).

**References:** Serviço de Imagiologia, Centro Hospitalar de Vila Nova de Gaia/Espinho - Vila Nova de Gaia/PT

Severe symptoms are associated with non arc-shape calcifications, hypervascularity, widening of subacromial-subdeltoid bursa and the presence or large calcifications. The combination of high resolution ultrasonography and color Doppler predicts more
accurately formative or resorptive status. Identifying the resorptive phase is important for management as these deposits are nearly liquid and can be successfully aspirated.

CT and MRI usually are reserved for doubtful cases. CT also readily demonstrates calcification, as high density foci of solid stippled or amorphous character, but cost and radiation limit its use.

**Fig. 5**: A well defined calcification is seen near the pectoralis major insertion. On plain film calcifications can be seen in the pectoralis major and infraspinatus.

**References**: Serviço de Imagiologia, Centro Hospitalar de Vila Nova de Gaia/Espinho - Vila Nova de Gaia/PT

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. 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. MRI is advisable, however, when the calcification is large enough to cause a strong shadow on ultrasound, and there is a strong suspicion of coexisting rotator cuff tear.
Fig. 6: MRI appearance. a) Two small calcifications in the infraspinatus and subscapularis, appear as low signal foci on T2 weighted image. b) Calcification in the supraspinatus appear as low signal foci on proton-density image; this patient had bilateral calcifications in the supraspinatus (not shown)

References: Serviço de Imagologia, Centro Hospitalar de Vila Nova de Gaia/Espinho - Vila Nova de Gaia/PT

Complications

Sub-bursal or intra-bursal extrusion can occur when the calcific deposit slides and evacuates the tendon, causing severe pain:

- Sub-bursal migration: the deposit slides between the tendon and the bursa and displaces the collapsed bursa. This is commonly associated with edematous changes in the surrounding fatty tissues.
- Intra-bursal extrusion: the calcification enters the subacromial-subdeltoid bursa, causing a microcrystalline bursitis. The bursa shows thick walls and appears completely filled with hyperechoic fluid. In some cases, a fluid-calcium level can be seen.
- On plain films the calcification may be dispersed in the subacromial subdeltoid bursa or just deep to the bursa.
**Fig. 7:** Sub-bursal migration of calcification. On plain film the calcified deposit appears linear, indicating location between the tendon and the bursa. There is not enlargement of the bursa and no significant bursal fluid on T2 weighted MRI image.

**References:** Serviço de Imagiologia, Centro Hospitalar de Vila Nova de Gaia/Espinho - Vila Nova de Gaia/PT
Fig. 8: Another patient with sub-bursal extrusion, showing no signs of bursitis. Notice in the coronal image, the calcification is outside the infraspinatus tendon.

References: Serviço de Imagiology, Centro Hospitalar de Vila Nova de Gaia/Espinho - Vila Nova de Gaia/PT
**Fig. 9:** Bursal extrusion of calcifications of the infraspinatus and supraspinatus. Subacromial-subdeltoid bursa is enlarged with fluid, and low intensity signal foci can be seen inside, indicating microcrystalline bursitis.

**References:** Serviço de Imagologia, Centro Hospitalar de Vila Nova de Gaia/Espinho - Vila Nova de Gaia/PT
Fig. 10: Another patient with bursal extrusion, showing complex fluid with calcification inside the bursa. The bursa appears enlarged with thick walls, indicating microcrystalline bursitis.

References: Serviço de Imagiologia, Centro Hospitalar de Vila Nova de Gaia/Espinho - Vila Nova de Gaia/PT

Differential Diagnosis and Imaging Pitfalls

- Greater tuberosity fractures: may simulate calcific tendinitis. Clinical history and CT help in the differential diagnosis, the latter showing a defect on the surface of the greater tuberosity. These fractures arise from an acute avulsion injury caused by the supraspinatus tendon. On ultrasound they appear as a break or step-off deformity of cortical bone, suggesting an elevated fragment. The contiguous supraspinatus tendon appears abnormally thickened and heterogeneous.
**Fig. 11**: Plain film mimicking calcific tendinitis of the supraspinatus. CT confirms defect on the surface of the greater tuberosity of the humerus.

**References**: Serviço de Imagiologia, Centro Hospitalar de Vila Nova de Gaia/Espinho - Vila Nova de Gaia/PT
Fig. 12: Another example of greater tuberosity fracture mimicking calcific tendinitis. Fracture confirmed at CT.

References: Serviço de Imagioologia, Centro Hospitalar de Vila Nova de Gaia/Espinho - Vila Nova de Gaia/PT

- Neoplasm: rarely, calcific tendinitis can show an aggressive appearance, with cortical erosion, periosteal reaction or bone marrow involvement. CT is the best imaging modality to characterize the cortex and depict the continuity of the tendinous, cortical, and medullary processes. Bone marrow involvement is best shown on MRI, although associated soft-tissue calcification and cortical destruction may lead to the presumption of neoplasm, particularly chondroid lesions. This is accentuates the need for correlation with radiographs. Findings that suggest calcific tendinitis over neoplasm include characteristic location and the lack of a soft tissue mass.

- If radiologic findings are diagnostic, despite osseous involvement, biopsy may be avoided. If performed, the pathologist must recognize chondroid metaplasia as a component of the histology as opposed to suggesting chondroid neoplasm.

- Isolated cortical erosions at muscle insertions: as the calcifications in calcific tendinitis may reabsorb rapidly, it must be considered in the differential diagnosis. Bilateral involvement is a clue.

- High grade rotator cuff tears: Signal heterogeneity in the tendon may be falsely interpreted as a tear on MRI, if one does not recognize the low signal areas corresponding to calcification. In doubtful cases, plain films, ultrasound and CT can be used for correlation. Unnecessary surgery with variable results must be avoided.
Fig. 13: a) Heterogenous supraspinatus tendon on proton density image. b) Low signal foci are evident on T1 weighted image. Despite the low signal foci in the supraspinatus, this case was initially described as a rotator cuff tear on MRI. Plain films and ultrasound (not shown), confirmed calcific tendinitis.

References: Serviço de Imagioologia, Centro Hospitalar de Vila Nova de Gaia/Espinho - Vila Nova de Gaia/PT

Fig. 14: Calcific tendinitis of the infraspinatus. Sinal heterogeneity on proton-density weighted image (a), showing extensive edema on T2 weighted image (b). Calcification foci is readily identified in the miotendinous junction of the infraspinatus on T2GRE (c).

References: Serviço de Imagioologia, Centro Hospitalar de Vila Nova de Gaia/Espinho - Vila Nova de Gaia/PT

Conclusion

Calcific tendinitis of the shoulder is a common source of morbidity.

The radiologist should perceive plain films and ultrasound as the first line imaging modalities. Besides diagnosis, the presumptive stage in the calcification process should be addressed, based on deposit morphology and vascularity. Complications, such as bursitis, should be described, as these can alter treatment planning.

CT and MRI are reserved for indeterminate cases (e.g. cortical erosion, bone marrow involvement) or to exclude underlying pathology that alters management (e.g. rotator cuff tears). It is crucial to recognize common pitfalls, especially on MRI, as this condition can mimic neoplasm and rotator cuff tears, leading to unnecessary interventions and devastating results.
Personal information

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Head of Department - Dr. Pedro Portugal

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