

QUESTION 2: What are the radiological signs indicative of infection in patients with an arthroplasty component in place?

RECOMMENDATION: The radiographic signs associated with periprosthetic joint infection (PJI) at the site of hip and knee are early loosening, component migration, radiolucent lines and/or bone erosions around the prosthetic components, particularly if seen at less than five years postoperatively. However, it is important to note that plain radiographs are generally normal in the setting of PJI.

LEVEL OF EVIDENCE: Strong

DELEGATE VOTE: Agree: 98%, Disagree: 1%, Abstain: 1% (Unanimous, Strongest Consensus)

RATIONALE

Conventional radiography is a simple, safe, relatively inexpensive and clinically valuable method used for routine evaluation of total joint arthroplasty (TJA). However, it is not considered informative enough to contribute to the diagnostic workup in the case of PJI [1]. On the other hand, osteolytic lesions, heterotopic ossifications, loosening and effusion of periprosthetic soft tissues, all being seen on early radiography of TJA, can increase the suspicion of PJI. Other imaging modalities are not thought to have a direct role in the diagnosis of PJI. Artifacts due to the presence of metal are a well-known problem in cross-sectional imaging, especially in magnetic resonance imaging (MRI) [2].

Currently, the attention of the orthopaedic community is focused on data obtained from analysis of joint fluid/periprosthetic tissues/retrieved implants [3,4]. The reason is that removed implants, aspirated joint fluid as well as sampled periprosthetic tissues were in direct contact with invading bacteria at the time of sampling/reoperation. Therefore, data gleaned from these methods are both highly sensitive and specific in relation to PJI, making this diagnosis almost certain or excluding the diagnosis [5]. As a result, imaging methods, with the only exception of specific nuclear medicine studies [6,7], do not contribute significantly to the PJI diagnostic workup due to its high costs, especially at the early stages of infection. However, it does not mean that radiography is of no clinical value.

1. Application of conventional radiography in daily routine.

There is no doubt that conventional radiography is the most common imaging method used in clinical practice for the diagnosis of TJA complications. According to a recent survey, conventional radiography was the most common imaging exam used in patients undergoing investigation for PJI (87.6% of orthopaedic surgeons surveyed) followed by single photon emission computed tomography-computed tomography (SPECT-CT) scans (41.7% of surgeons) [8].

2. Radiographic features associated with PJI.

Importantly, plain radiographs can be normal in appearance in the early stages of infection. The primary radiological signs suspicious of PJI are early loosening, periprosthetic radiolucency and bone erosions (osteolysis) [9]. These features may be present on serial radiographs of patients with either infection or aseptic loosening of the prosthesis [10–12]. Radiographic signs of rapid prosthetic migration (at least 2 mm within 6 to 12 months), rapidly progressive periprosthetic osteolysis and/or irregular periprosthetic osteolysis are highly suspicious of PJI [13,14]. Similarly, bony erosions and new bone formation on plain radiographs occurring within three to six months postoperatively may also suggest PJI [15]. On plain radiographs and computed tomography (CT), diffuse or multifocal osteolysis surrounding the prosthesis (> 2 mm or progressive) raises concern for infection, however this is not always present and can be seen in the setting of aseptic loosening and particle disease too [16].

Inconsistently, there may be other features present, such as scalloping, ectopic ossification, periosteal reaction and sclerosis. A small, very dense bone fragment isolated from the other trabeculae, corresponding to a sequestrum (fragment harboring a pathogen) is highly suggestive of active infection, but this is a rare event (< 8%). The presence of gas around the prosthesis could suggest an infection by an anaerobic organism [17].

Periosteal new bone formation or adjacent soft tissue collection is highly suggestive of infection but are infrequently present. A wide band of radiolucency at the metal-bone interface (or cement-bone interface) with bone destruction could also suggest that infection is present. CT scans rarely may help diagnosis of PJI despite that the presence of a periosteal reaction or soft tissue accumulation near the area of osteolysis, seen on CT scan, is highly suggestive of infection [18].

In a retrospective study [19] of 102 total hip arthroplasties (THAs), 65 stems and 50 cups were loose at the time of surgery, as reported from a set of radiographic findings. The gold standard used to define PJI was culture (which has its own limitations). They found only five stable non-infected stems and three of these had associated radiolucency. Radiolucency of at least 2 mm was seen in 12 of 27 infected loose cups and 4 of 15 infected stable cups. None of the 9 non-infected stable cups had a radiolucent zone reaching 2 mm. Sclerosis was seen in 24 of 65 loose stems, 18 of which were infected (while 6 of 26 uninfected loose stems showed sclerosis also).

In another study [20], radiographs of 20 confirmed infected hip prostheses were examined for the presence or absence of radiolucency, type of lucency (focal or non-focal), rapidity of radiographic change, periostitis, subsidence and cement fracture. No evidence of periprosthetic lucency was seen in 11 of 20 THAs, and focal osteolysis was seen in only 4 patients in the cohort. Most infected THAs showed no abnormal findings at all (10 prostheses together had normal radiography). The authors concluded that the radiologist should be aware that septic prostheses can appear completely normal.

A retrospective case-control study on 100 total hip replacements assessed the incidence of particular features in the groups of infected THAs, aseptic prosthetic hip failures and successful THAs [21]. The group of failures secondary to infection included 12 of 100 hips. Extensive myositis ossificans was seen in 3 of 12 hips. Resorption of 3 mm in the femoral neck length was noted in 1 hip. Cortical thickening opposite the tip of the stem was seen in one case. Periosteal bone formation was noted in four hips. It involved the proximal part of the femur and usually was circumferential.

In a retrospective case-control study on 41 patients [22], the authors examined which radiographic signs predicted failure of two-stage revision arthroplasty, if present after the first-stage surgery. These radiologic signs were: retained metal implants, new metal implants, retained cement,

retained cement restrictor, new fracture, the local antimicrobial delivery system (for example gentamicin loaded beads) and use of a drain. None of these radiographic variables examined was associated with subsequent failure.

A study [23] of 52 patients (32 knees and 20 hips) revised for supposed aseptic loosening and found that there was an association between severity of periprosthetic osteolysis and positive sonication cultures from the retrieved implants (in 30 patients at least 1 sonicated component was positive).

3. Accuracy of conventional radiography for PJI detection.

In a study by Cyteval et al. [24], conventional radiography achieved the following diagnostic characteristics for bone abnormalities (lucency, periostitis): sensitivity 75%, specificity 28%, positive and negative predictive values 19% and 83%, respectively, accuracy 37%. CT images for the same types of findings were similar (75%, 30%, 20%, 84%, 49%, respectively). However, soft tissue abnormalities (joint distension, fluid-filled bursae, fluid collections in muscles and perimuscular fat) were identified on CT as opposed to plain radiography.

In a study by Stumpe et al. [25], serial radiographs had a sensitivity of 84% for the finding of rapid prosthetic migration (at least 2 mm within 6 to 12 months), and/or rapidly progressive periprosthetic osteolysis, and/or irregular periprosthetic osteolysis, whereas specificity was only 57%. In the same study, the inter-observer agreement was very low, limiting the diagnostic value of this technique.

Conclusion

Findings such as early implant loosening, progressive radiolucent lines, early bone erosions (osteolysis) and periosteal reactions (periostitis) can suggest the presence of PJI, especially in the presence of additional supportive clinical data. However, isolated radiographic findings have limited clinical value due to their low specificity.

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