

HK42: Is there a role for the use of bone scans in the diagnosis of periprosthetic joint infection (PJI)?

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Response/Recommendation: In rare circumstances, when despite performing serological and synovial tests, a diagnosis of periprosthetic joint infection (PJI) cannot be refuted or confirmed, a bone scan with the combined use of white blood cell (WBC) tracers (with or without bone marrow scintigraphy) may be ordered.

Level of Evidence: Moderate

Delegate Vote:

Rationale:

Accurately diagnosing periprosthetic joint infection (PJI) is crucial as it directly influences treatment decisions and patient outcomes. Traditionally, a variety of imaging techniques, including radiography, ultrasonography, computed tomography, magnetic resonance imaging, bone scintigraphy, leukocyte scintigraphy, and fluorodeoxyglucose positron emission tomography (FDG PET), have been employed to detect and evaluate PJI. Each modality offers unique insights, yet their comparative diagnostic efficacy remains a subject of ongoing debate among clinicians and researchers.

This systematic review aims to analyze and compare the diagnostic accuracy of bone scans against other nuclear imaging modalities in diagnosing PJI. A comprehensive literature search was conducted through PubMed, Embase, and Cochrane. A total of 2,953 articles were identified, with 169 selected for further review based on titles and abstracts. Of these, 69 articles underwent full-text evaluation and extraction using the QUADAS-2 tool for quality assessment.

A bone scan is a nuclear imaging technique that uses a small amount of radioactive material, typically technetium-99m, injected into the bloodstream to evaluate bone metabolism and activity (1). The tracer accumulates in areas of high bone turnover, representing increased osteoblast activity, such as sites of infection, inflammation, or cancer, allowing for detailed imaging of skeletal anomalies and abnormalities, including PJI. Two comprehensive systematic reviews with meta-analyses were conducted by Verberne in 2016 (2) and 2017 (3) that analyzed the effectiveness of various nuclear imaging techniques for diagnosing PJI in hip and knee prostheses, covering studies published between 1988 and 2014. For hip prostheses, the reviews evaluated bone scintigraphy in eight studies encompassing 492 prostheses, demonstrating a pooled sensitivity of 80% and specificity of 69%. In comparison, for knee prostheses, bone scintigraphy was studied in six studies involving 216 prostheses, yielding a sensitivity of 93% but a lower specificity of 56%. There were five studies that were published subsequent to those included in the systematic review of Verberne et al., which encompassed a total of 708 hip or knee arthroplasties, of which 151 were infected, corroborating the previously reported sensitivities and specificities (4-8). These recent studies report sensitivities ranging from 60 to 100% and specificities from 13 to 97.1%, depending on whether the imaging was analyzed

during the bone phase, blood flow, or blood pool phase. This data reinforces the findings on the diagnostic performance of bone scans in PJI, aligning closely with earlier findings and highlighting the continued issue of varying low specificity in certain modalities.

Verberne et al. (2, 3) found that combined modalities of bone and leukocyte scintigraphy were reviewed in three studies for hip prostheses (172 prostheses) and four studies for knee prostheses (114 prostheses), demonstrating specificities of 95 and 93%, respectively. Similarly, bone and gallium scintigraphy, analyzed in three studies for 121 hip prostheses, showed a notable specificity of 97% (2). These findings underscore the heterogeneous diagnostic performance of various imaging techniques and suggest that combined imaging modalities may offer enhanced diagnostic accuracy, particularly in specificity, highlighting their effectiveness in ruling out PJI (3). Similarly, three studies published after Verberne et al.'s systematic reviews, covering a total of 226 hip and knee arthroplasties, of which 45 were infected, reported sensitivities ranging from 70 to 100% and specificities between 93 and 100% (9-11).

Based on the vast literature published, the utility of bone scans in diagnosing PJI is constrained by a low specificity (as low as 50%). The reviews suggest that while bone scans can serve as an initial diagnostic tool, their effectiveness is markedly improved when used in conjunction with other modalities such as leukocyte or gallium scintigraphy, which enhance diagnostic specificity up to 93 to 100%. Therefore, bone scans are best utilized as part of a multimodal imaging strategy rather than in isolation. A 2020 European multidisciplinary consensus paper by Roman et al. (12) highlights the importance of bone scan timing post-arthroplasty for PJI diagnosis due to variable uptake patterns. It advises cautious interpretation of positive scans for up to two years after hip surgeries and five years for knees, however, noting that a negative scan markedly lowers the risk of PJI even within these periods.

For most cases of PJI, diagnosis should primarily rely on serological and synovial fluid tests. When these tests are inconclusive, imaging techniques such as WBC scintigraphy (with SPECT/CT) with ^{99m}Tc-HMPAO-labeled WBC are recommended, especially during the early postoperative period (13, 14). The WBC scintigraphy has demonstrated sensitivity and specificity ranging from 88 to 100% and 70 to 95%, respectively (2, 3, 13). Alternatively, ^{99m}Tc-labelled monoclonal antibodies can also be used to assess PJI (2, 3, 15, 16). [18F]-FDG-PET/CT offers valuable diagnostic capabilities with sensitivity and specificity between 80 to 100% and 85 to 100%, although its application is constrained within the first three to six months post-surgery (2, 3, 17-21). Current evidence does not show a definitive advantage of [18F]-FDG-PET over WBC scintigraphy, but it can be beneficial in cases with a low probability of infection. However, interpretation of data from individual studies should be approached with caution due to variability in labeling methods, imaging protocols, interpretation techniques, and patient selection presented in the studies. The majority of studies included fewer than 20 PJI cases, which may limit the robustness of their findings.

In conclusion, bone scintigraphy (with SPECT/CT) alone is not suitable for diagnosing PJI, lacking the necessary specificity, but a negative bone scan can rule out a PJI. WBC scintigraphy (with or without bone marrow scintigraphy) can be used to confirm a suspected PJI, but should not be regarded as a stand-alone test. Combining bone marrow and WBC scintigraphy may effectively rule out infection in cases with a low likelihood of infection.

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