
Radiophosphate Visualization of the Foreign Body Reaction to Wear Debris from Total Knee Prosthesis

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Three patients with total knee arthroplasties, in which the tibial and patellar articulating surfaces consisted of a polyethylene-carbon fiber composite, demonstrated technetium-99m methylene diphosphonate (MDP) deposition in the intraarticular space, whereas, the gallium-67 citrate images were normal. This was shown to be due to a synovial giant cell foreign body reaction to particulate carbon fiber debris in one patient who required surgical revision of the prosthesis.

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The shedding of metallic, polyethylene, and cement particles from implanted prosthetic devices are known to induce nonseptic chronic inflammatory and foreign body reactions in the surrounding area (1-4). The disclosure of these inflammatory changes by gallium-67 (^{67}Ga) and technetium-99m methylene diphosphonate (MDP) have not been reported, nor have they been seen in our laboratory until a new, total knee prosthesis was introduced in which the tibial and patellar articulating surfaces were composed of polyethylene reinforced with carbon fibers,* as opposed to the previously used polyethylene alone. During the last 2 yr, three patients with this type of total knee prosthesis demonstrated MDP concentration in the joint space between the femoral and tibial components. One of these patients required surgical revision of a loose tibial component and this afforded the opportunity to correlate the histologic features of the synovium with the radio-nuclide portrayal.

CASE REPORTS

Case 1

This 75-yr-old osteoarthritic woman had bilateral total knee arthroplasties, in which the tibial and patellar articulating surfaces consisted of carbon fiber reinforced polyethylene. The right and left knees were implanted 16 and 19 mo, respectively, prior to the initial imaging studies for left knee

pain. There was intra-articular MDP deposition in both knees, but the ^{67}Ga uptakes in the corresponding areas were normal. Superimposed focal increased MDP and ^{67}Ga uptakes were noted on the medial side of the left tibial plateau (Fig. 1). Four months later she had a surgical revision of the left knee. At operation it was noted that there was considerable staining of the synovium by carbon fiber debris, the tibial component was loose, and a fracture was present in the medial tibial plateau. Histologic sections of the synovium demonstrated reactive hyperplasia, chronic inflammation, foreign body giant cell reaction to nonbirefringent material, disseminated clumps of dystrophic calcification, and islands of woven bone formation. There was no evidence of infection.

Case 2

A left Miller/Galante total knee arthroplasty was performed 14 mo ago in this 44-yr-old woman with rheumatoid arthritis. She was scanned with MDP and ^{67}Ga because of left knee pain, but soon afterward the pain disappeared and the knee remained asymptomatic during the ensuing year. However, there was an accumulation of MDP in the intraarticular space, but no corresponding ^{67}Ga uptake (Fig. 2).

Case 3

Bilateral total knee arthroplasties were performed 12 mo ago in this 58-yr-old man using the Miller/Galante prosthesis. MDP and ^{67}Ga images were obtained because of persistent pain and swelling of the knees. The MDP images showed bilateral intraarticular accretion, but the ^{67}Ga images were normal (Fig. 3). Pain and swelling subsided thereafter and, 1 yr later, the knees were relatively asymptomatic.

DISCUSSION

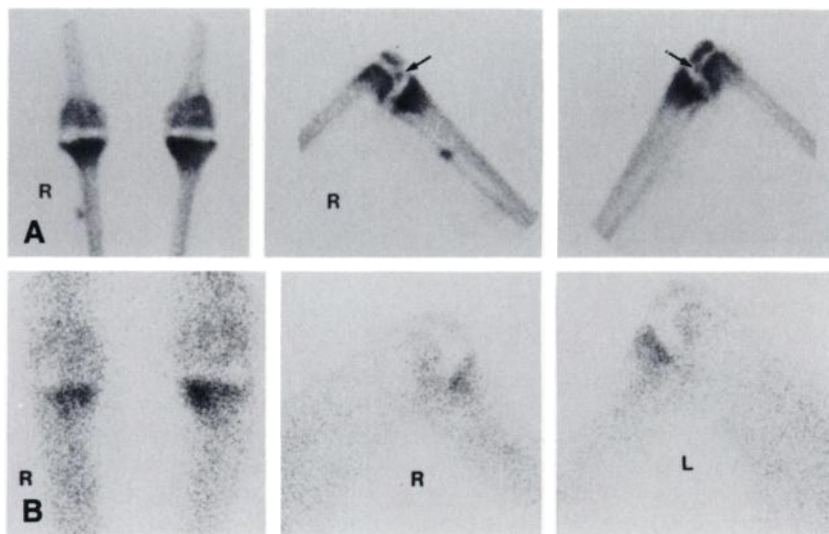
The inflammatory response to metal and polyethylene wear debris, which can range from simple chronic

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FIGURE 1

Case 1. Bilateral total knee arthroplasties. A: MDP deposition in the intraarticular space of both total knee arthroplasties (arrows), which was presumably associated with the giant cell foreign body reaction in the carbon stained hyperplastic synovium. There was also a focal accentuation of MDP uptake in the left medial tibial plateau. This was shown to be due to a fracture at surgical revision of a loose tibial component. A healing fracture of the left fibula is present. B: ^{67}Ga does not show a corresponding intraarticular uptake. The fracture of the left medial tibial plateau is seen as a focal increased concentration, but there is no enhanced uptake in the fibular fracture.

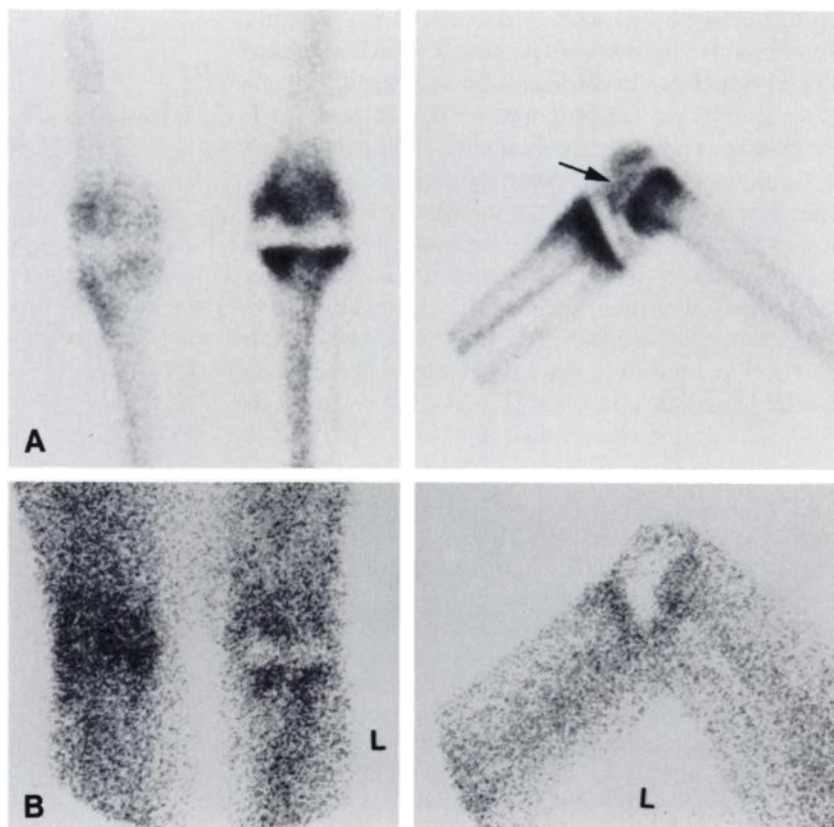


inflammation to a giant cell foreign body reaction with particles located in the intracellular and extracellular spaces, has been implicated as a factor promoting prosthetic loosening. There is still no consensus on this topic, because gross reactive synovial changes are seen in both loose and well functioning joint arthroplasties. To improve the wear resistance and compressive strength, a carbon fiber reinforced ultra-high molecular polyethylene composition has been advocated. All three patients with intraarticular MDP deposition had com-

posite carbon fiber and polyethylene tibial components, and in one patient the tibial component became loose, most likely for reasons unrelated to the foreign body reaction. However, the MDP deposition in the synovium of patients with unreinforced polyethylene components has not been reported, nor previously observed in this laboratory, even though chronic inflammatory and foreign body reactions were observed histologically. By inference, it seems that the carbon content provokes a response that conduces to MDP deposition. It is

FIGURE 2

Case 2. Asymptomatic left total knee arthroplasty. A: MDP concentration in the intraarticular space (arrow). B: No ^{67}Ga deposition in the territory of the MDP soft-tissue uptake.



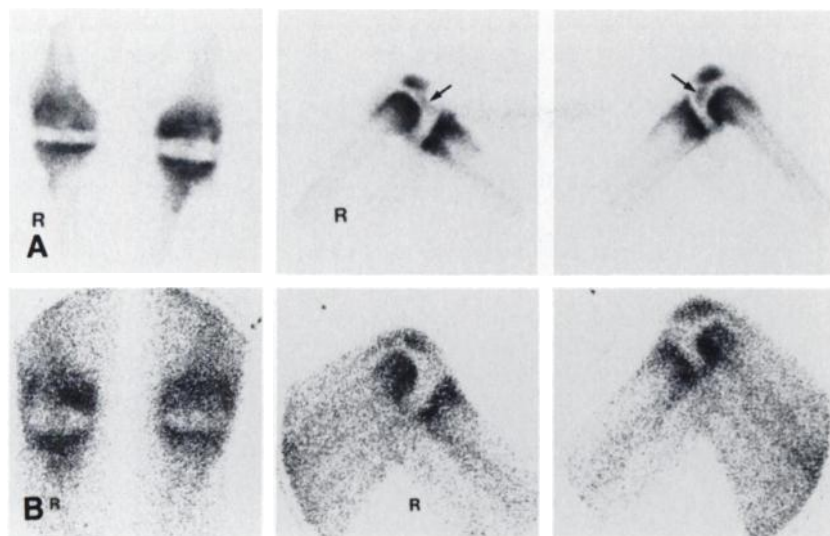


FIGURE 3
Case 3. Bilateral total knee arthroplasties. A: MDP concentration in the intraarticular space of both knees (arrows). B: No ^{67}Ga uptake in the intraarticular spaces.

probably related to the membranous bone formation and, perhaps too, the disseminated clumps of dystrophic calcification that were present in the histologic sections. The added carbon fiber has been implicated as the causative factor in the increase in the number of wear particles and the aggravated tissue reaction by other investigators (2,4). If the MDP deposition is peculiar to the carbon laden polyethylene and it is related to the rate of wear, and possibly to future loosening, then the observation of MDP uptake in the intraarticular space may be a harbinger of prosthetic complications. The frequency of intraarticular MDP deposition associated with carbon reenforced polyethylene implants is unknown, and will remain so unless all such implants are imaged routinely, with or without sound clinical indication. This is unlikely to occur. It can be anticipated that the frequency will increase with the age of the implant, because the foreign body reaction to the accumulating debris takes time to develop.

It would appear, from the limited experience of three patients with five prosthetic knees, that the inflammatory reaction does not abet the visible uptake of ^{67}Ga citrate, a tracer that has a propensity to concentrate in septic and aseptic inflammatory tissues. There is no obvious reason for this, but it is a desirable attribute, as it will be one less nonspecific variable of ^{67}Ga uptake

with which to deal. It is doubtful that this is a function of low count rate and poor resolution, because a minimum of 150,000 counts were accumulated for each view. In any event, more correlative observations are required over an extended period of time in order to establish the significance and evolution of the intraarticular deposition of radiophosphate.

NOTE

* Miller/Galante knee prosthesis, Zimmer, Inc., Warsaw, IN.

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