Radiophosphate Uptake in Asymptomatic Knee Arthroplasty

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The utility of radiophosphate bone scanning in the detection of complications following total knee replacement (TKR) is not yet fully established. A difficulty associated with the use of bone scanning is the persistent increased uptake seen around the prosthetic joint long after surgery, despite the absence of symptoms. In order to better characterize the time course of radiophosphate uptake, bone scans obtained 1 mo–12 yr after surgery were analyzed in 30 asymptomatic patients with 37 TKR. Uptake was graded 0–4+ in the femoral and tibial components. Scans of 18 implants were obtained 1 yr or less after surgery (Group 1), and 19 were obtained >1 yr after surgery (Group 2). Mean uptake scores were as follows: femoral component Group 1 = 3.0 ± 1.1; Group 2 = 1.8 ± 0.9 ($p < 0.05$); tibial component Group 1 = 3.2 ± 0.8; Group 2 = 2.6 ± 1.1 (not significant). Persistent increased uptake, particularly in the tibial component, reflects mechanical stresses peculiar to knee prostheses, and tends to undermine confidence in diagnosing loosening on the basis of a single study.

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Total knee arthroplasty has become a valid therapeutic option in the treatment of severe pain, decreased mobility, and disabling instability due to severe joint disease. Diseases most often leading to joint destruction include degenerative arthritis, rheumatoid arthritis, posttraumatic arthritis, osteonecrosis, and burnt-out infection. Although results have improved over the years, complications still occur in a significant number of patients; these include mechanical loosening, infection, fracture, instability, heterotopic bone, and patellofemoral pain (*1,2*). Conventional radiography and arthrography are used to detect complications after knee arthroplasty. Radionuclide scanning has been proposed as an adjunct to radiographic studies in the evaluation of postoperative complications (*3–6*). Hunter et al (*4*) found a significant difference in the degree of radiophosphate bone uptake associated with knee prosthesis between abnormal and control groups. Our experience suggests that radiophosphate uptake can remain high in asymptomatic patients long after knee surgery. This study was undertaken to determine the natural evolution of bone scans following total knee replacement (TKR) and clarify the significance of increased radiophosphate uptake in asymptomatic knee arthroplasty.

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MATERIALS AND METHODS

Subjects included in the study had radiophosphate (technetium-99m methylene diphosphonate; [^{99m}Tc]MDP) scans at the Montreal General Hospital between 1980 and 1985, and were asymptomatic at the time of last follow-up. Thirty patients with 37 knee prostheses had bone scans in an interval ranging from 1 mo to 12 yr after surgery. There were nine men ranging in age from 31 to 81 yr (average, 76.7 yr) and 21 women ranging in age from 44 to 77 yr (average, 66.1 yr). Underlying disorders included osteoarthritis (14 knees), rheumatoid arthritis (19 knees) and osteonecrosis (four knees).

There were four Marmor unicompartment prostheses and 30 multiradii semiconstrained total condylar implants.

Radionuclide scans of the knees were obtained in the anterior and lateral projections 2–3 hr after injection of 15–20 mCi of radiophosphate. The anterior images were acquired for 400k counts and the duration of the acquisition was noted. Lateral images were then acquired for the same length of time.

A grading system was used to quantify the amount of radiophosphate uptake in the bones surrounding the prosthetic components. It was established as follows: 0, uptake that is equal to or slightly greater than nonarticular bone, and which can be seen in normal nonimplanted knees; 1+, 2+, 3+ and 4+, progressively higher concentrations, respectively, immediately adjacent to the entire surface of the implant, as illustrated in Figure 1. The images were studied by three observers and scored by consensus. Concentration of radiophosphate in the subprosthetic bone was graded according to the highest concentration seen, which could be either in the lateral or anterior views. Femoral and tibial components were

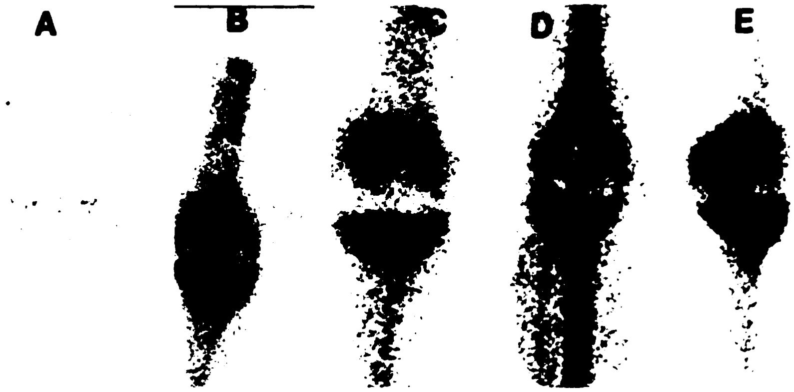

FIGURE 1
Grading of the tibial components in asymptomatic knees. A, grade 0 (36-mo-old implant); B, grade 1 (36-mo-old implant); C, grade 2 (14-mo-old implant); D, grade 3 (1-mo-old implant); E, grade 4 (31-mo-old implant).

assessed separately, and these scores were then tabulated and analyzed statistically.

RESULTS

Asymptomatic knees demonstrated a diffuse subprosthetic bone uptake of radiophosphate in both the femurs and tibias (Figs. 1 and 2). The radiophosphate scores of the femoral components as a function of time are shown in Figure 3. The mean uptake scores ±s.d. were 3.0 ± 1.0 for implants of 12 mo duration or less (18 prostheses), and 1.8 ± 0.9 for implants or >12 mo duration (19 prostheses). There was a significant difference ($p < 0.05$) between these two groups by the Mann–Whitney test. The tibial component scores as a function of time are shown in Figure 4. For implants of ≤12 mo duration (18 prostheses) the mean was 3.2 ± 0.8, whereas, the mean score for implants of >12 mo duration (19 prostheses) was 2.6 ± 1.1. There was no significant difference between these two groups by the Mann–Whitney test.

Table 1 details the relative radiophosphate uptake scores in the femoral and tibial components of the total knee implants. When all knees are considered, the tibial component shows significantly greater uptake than the femoral component by the paired Student t-test. Further analysis demonstrated that the major contribution to this significant difference was from prostheses of ≥13 mo duration, because there was no significant difference in uptake between the tibial and femoral components in those implants of ≤12 mo duration.

DISCUSSION

Radionuclide bone scanning has been shown to be useful in the evaluation of postoperative complications of total hip arthroplasty (*4,7*). Although radiophosphate uptake may be high for the first year after surgery due to the normal healing process, beyond that interval uptake about the hip prosthesis should approximate uptake in the surrounding normal bone (*8*). Unlike the hip joint, which has inherent stability due to its ball and socket configuration, the knee joint is much more complex. Nonhinged multiradii knee prostheses have

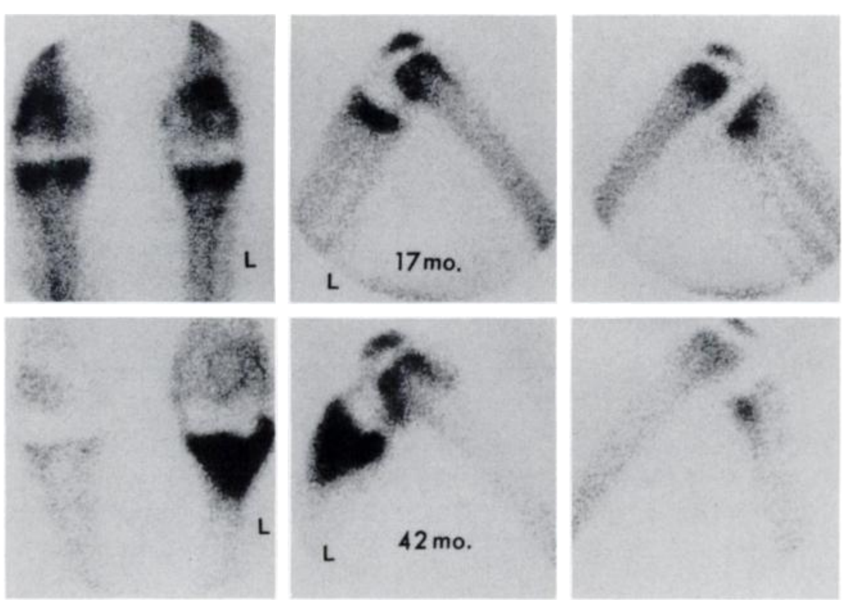

FIGURE 2
This 65-yr-old woman with longstanding rheumatoid arthritis had bilateral TKRs. At 17 mo postimplant, the knees were asymptomatic, but the MDP scores were 3+ for the femoral and tibial components bilaterally. Two years later (42 mo) the left tibial component failed, the intensity increased to 4+, and there was extension of the area of abnormal accretion. At surgery the left femoral component, which had a 3+ score at 42 mo, was firmly fixed, but the posterior surface of the tibial plateau collapsed and the tibial component sank with it. The right knee decreased from a score of 3+ to 1+ between 17 and 42 mo. (The focal spot in the right lateral view represents the tibiofibular joint.)

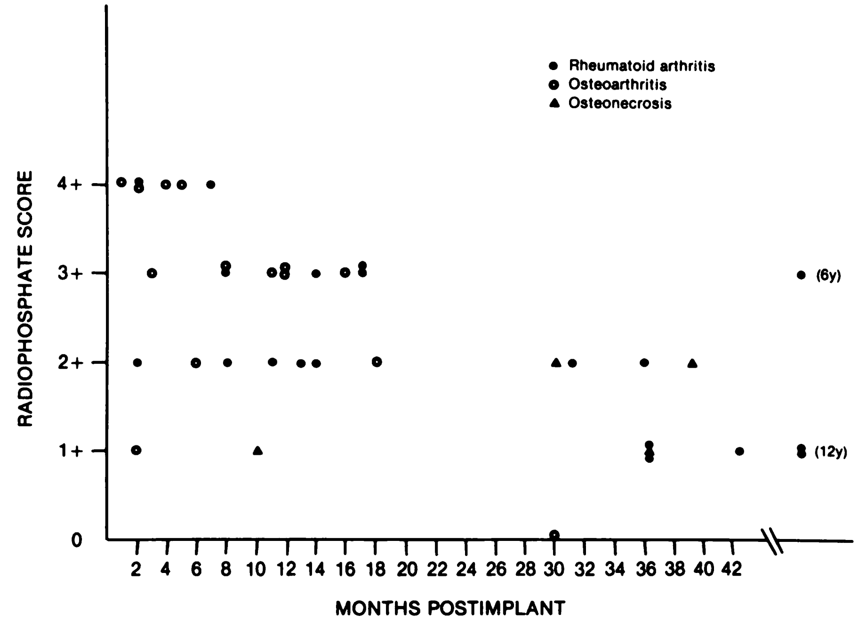

FIGURE 3
Painless knee prostheses. Scatter diagram of the [^{99m}Tc]MDP scores of the femoral component versus the age of the implant.

more stringent requirements of proper insertion and alignment than those of the hips, and minor deviations combined with an inhomogeneous system (i.e., bone, methylmethacrylate, metal and polyethylene) lead to nonuniform distribution of forces and significant interfacial stresses. In contrast to total hip arthroplasty, where increased bone turnover due to the healing process subsides after 1 yr, our results suggest that increased bone activity can persist long beyond 1 yr after knee arthroplasty. In knees studied 13 mo–12 yr after surgery, 89% of the tibial components and 63% of the femoral components had a radiophosphate uptake score of 2+ or greater. This is in agreement with results reported by Ramos-Gabatin et al., who studied the scintigraphic evolution of 27 TKRs and found that no patient had a totally quiescent scan despite the absence of symptoms and good prosthetic function 4–62 mo following surgery (*9*).

An analysis of the intensity of periprosthetic radiophosphate uptakes showed a significantly greater concentration about the tibial component relative to the femoral component in implants of >12 mo duration, but not in the newer implants. This was due to a reduction in femoral concentration with time, rather than an increase in the tibial concentration. The disparate temporal concentration may be a reflection of

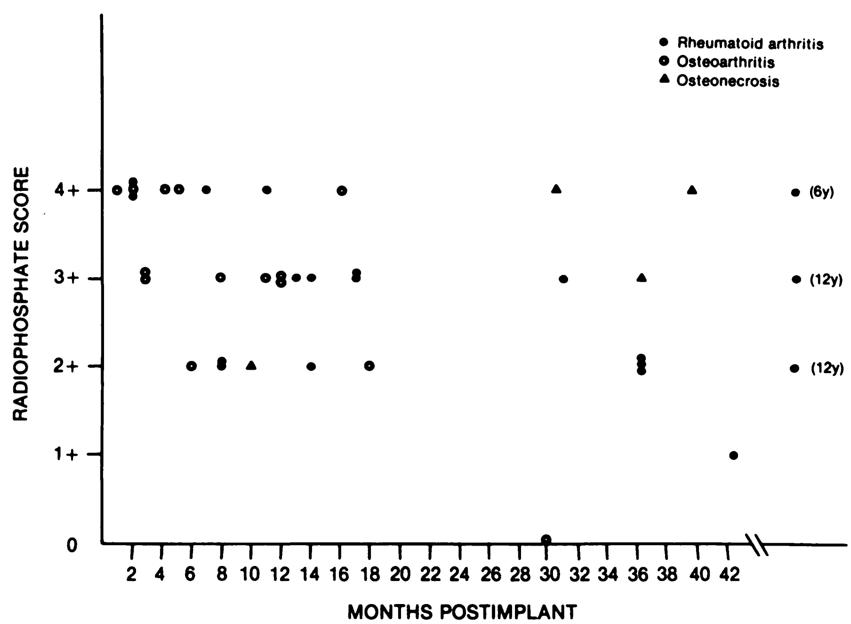

FIGURE 4
Painless knee prostheses. Scatter diagram of the [^{99m}Tc]MDP scores of the tibial component versus the age of the implant.

TABLE 1
Total Knee Implants

Duration of implant	Number	Mean T/F ratio	Mean difference T−F	t	p
1 mo–12 yr	37	1.39	0.51	3.89	<0.005
1 mo–12 mo	18	1.20	0.22	1.29	N.S.
13 mo–12 yr	19	1.56	0.79	4.37	<0.005

T, tibia; F, femur.

the fact that the subchondral bone of the distal femur is stronger in its ability to resist compressive forces than is the bone of the proximal tibia. It also correlates with the increased incidence of loosening in the tibial component as opposed to the femoral component (*10*).

One of the radiographic signs of loosening is the presence of a radiolucent zone at the cement–bone interface that is >2 mm in width or a lucency that shows progressive widening (*6*). The radiolucent zone can also appear at the cement–bone interface within the first 6–12 mo after surgery in the absence of any evidence of symptomatic loosening. These radiolucencies are generally less than 2 mm in width and show no progress with time. In one series of 51 nonhinged total knee arthroplasties, followed for a mean period of 4.5 yr, radiolucent lines at the tibial bone–cement interface were noted in 43% of cases (*11*). Mechanisms proposed to explain the occurrence of these radiolucent zones include both acute events such as direct surgical trauma to vessels or chemical interaction of methylmethacrylate cement with bone, and the more chronic effect of micromotion of the prosthesis (*2,12*). It is of interest to note that these radiolucencies are more commonly associated with the tibial rather than the femoral component (*6*). This parallels the findings in our study of persistent increased radiophosphate deposition about the tibial component. The higher radionuclide frequency is most likely due to its greater sensitivity in detecting the bone reaction to nonphysiologic stresses than the occurrence of a radiographically detectable lucency. Despite the absence of symptoms in patients with increased radiophosphate uptake in our series, it is conceivable that loosening was present in some of them. At the moment this question cannot be answered, because an adequately functioning prosthesis will not be revised on the basis of radionuclide or radiographic results alone.

Hunter et al. (*5*) suggest that radionuclide bone scanning can serve as a useful adjunct to radiographic studies in the evaluation of loosening of the total knee prosthesis. However, they showed that reciprocal changes occurred in sensitivity and specificity with increasingly stringent criteria for the diagnosis of loosening, and that bone scanning could not be used as the sole diagnostic method. Schneider et al. (*6*) state that although mild to moderate increased uptake of radiophosphate is often seen for many years after surgery without the presence of clinical abnormalities, intense uptake around the prosthesis suggests loosening or infection. Our findings suggest that this may be true for the femoral component, because none of the 19 asymptomatic prostheses, implanted for >12 mo, had intense radiophosphate uptake, i.e., a score of 4+. On the other hand, four of 19 (21%) tibial components in asymptomatic prostheses showed intense uptake at 13 mo–6 yr postimplant, and this undermines its ability to detect loosening. Our results suggest that the diagnosis of postoperative complications cannot be based solely on an assessment of the degree of overall radiophosphate uptake on a single study. A possible exception would be the presence of an intense focal uptake suggesting an asymmetrical distribution of stress from a local complication. Empirically, it would seem that progressive changes on serial scans such as an extension of increased radiophosphate uptake to areas of previously normal uptake, or an increase in the degree of radiophosphate uptake with time, are more suggestive of loosening, with or without infection (Fig. 2).

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