Quantitative Analysis of Radiophosphate Uptakes in Asymptomatic Porous-Coated Hip Endoprostheses

Leonard Rosenthall, Malcolm E. Ghazal, and C. Emerson Brooks

Division of Nuclear Medicine, Department of Orthopedics, The Montreal General Hospital and McGill University, Montreal, Canada

A quantitative analysis of the uptake of radiophosphate adjacent to the femoral component of a porous-coated cementless prosthesis was undertaken in asymptomatic patients in order to establish normal temporal changes. The group consisted of 55 patients with 62 arthroplasties of 1.6–49-mo duration. Ratios of the stem, stem tip, greater trochanter, lesser trochanter and calcar, and normal femur to the reference sacroiliac joint were obtained, as well as tip-to-stem, and stem-to-normal femur in unilateral arthroplasties. The ratios remained stable at 12 months and beyond, except for the tip and lesser trochanter. Tip-to-stem and tip-to-sacroiliac joint ratios decreased by 24% and 33%, respectively, between 12 and 49 mo. There was also a decrease in the relative uptakes at the lesser trochanter and calcar in the same time interval. Evidence is given that different designs of prostheses may not have the same normal temporal uptakes of radiophosphate.

J Nucl Med 1991; 32:1391–1393

The normal uptakes of radiophosphate, as a function of time, in bone adjacent to the femoral component in asymptomatic cemented implants have been fairly well determined (*1*). The application of this data has resulted in sensitivities reported to range from 74% to 94% in the disclosure of loosening with or without infection (*2–4*). Normal temporal concentrations of radiophosphate surrounding porous-coated endoprostheses, which rely on bone ingrowth for fixation rather than cement, are still to be established, and indeed, may vary with the different designs of this genre of prosthesis. We report on a quantitative assessment of the radiophosphate uptakes associated with a particular brand of porous-coated prosthesis in asymptomatic patients.

Received Nov. 2, 1990; revision accepted Jan. 29, 1991.

For reprints contact: Leonard Rosenthall, MD, Nuclear Medicine, The Montreal General Hospital, 1650 Cedar Ave., Montreal, Canada H3G 1A4.

MATERIALS AND METHODS

There were 55 patients and 62 hips this retrospective study. Eleven patients had bilateral total-hip arthroplasties, and in four of these one of the implants was cemented. The age of the implants varied from 1.6 to 49 mo; mean ± s.d. = 22 ± 14 mo; median = 19 mo. The group consisted of 30 women (ages 25–76 yr; mean ± s.d. = 61.2 ± 11.6 yr) and 25 men (ages 39–78 yr; mean ± s.d. = 60.2 ± 9.9 yr). Seventeen hips were <12 mo duration and 45 were ≥12 mo.

The device under investigation was the porous-coated anatomic medullary locking (AML) prosthesis (DuPuy, Warsaw, IN). Of the 62 implants, 42 had one-third porous-coated stems, and 20 were two-thirds porous-coated. As there was no significant difference between the various parameters of uptake used, the two types were combined for final quantitative analysis.

Approximately 3 hr after the injection of 20 mCi ^{99m}Tc-methylene diphosphonate (MDP) anterior, posterior and lateral images of the hip implant were obtained at equal preset times. On computer playback, regions of interest (ROIs) were placed over the sacroiliac joints (SiJ), and the average counts per pixel for each was calculated. The mean of the two SiJ values was used as reference (Fig. 1). ROIs were placed over the midstem and corresponding level in the normal femur both in the anterior and posterior projections. The geometric means of each site were related to the SiJ reference, viz., stem/SiJ and normal femur/SiJ. The tip/stem ratios were calculated from the ROIs of the anterior projection only. Counts per pixel were also obtained for the greater trochanter and lesser trochanter and calcar on the side of the prosthesis and compared with the SiJ (GrTr/SiJ and LTr/SiJ, respectively). Comparisons with the contralateral side were made in patients with unilateral arthroplasties (GrTr/normal GrTr and LTr/normal LTr, respectively). From the lateral projection, anterior and posterior counts per pixel in the intertrochanteric zone were calculated and compared to the SiJ (Ant IT/SiJ and Post IT/SiJ, respectively). All ratios thereby obtained are listed in Table 1. Preferential locations of MDP uptake about the tip, i.e., medial, lateral and distal, were not recorded (*5*).

Prior to the MDP study, all patients were examined in the Orthopedic Clinic to verify the absence of symptoms referable to the endoprosthesis under scrutiny. The median Harris score, a quantitative measure of function, was 94, where 100 is a perfect score.

All patients had primary implants, not revisions. There were no bone graft applications and no osteotomies of the greater trochanter other than its partial resection to accommodate the prosthesis.

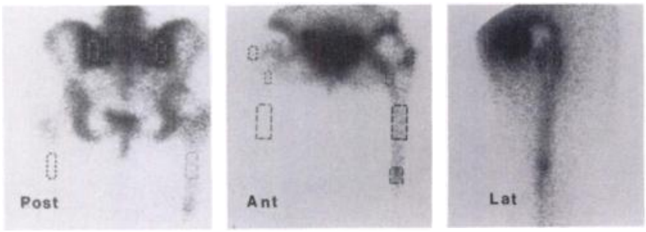

FIGURE 1. Illustration of the various ROIs used to obtain the data given in Table 1.

RESULTS

The results are detailed in Table 1. Means of the various ratios are significantly higher in implants <12 mo of age than those ≥12 mo by the unpaired Student's t-test. An exception is the normal femur/SiJ ratio in which there is no significant difference, but this is to be expected since neither site was subjected to surgery.

Linear regression of the ratios versus age of the implant for those implants ≥12 mo were not significant, except the tip/stem, tip/SiJ, LTr/SiJ and LTr/normal LTr, which had weak but significant negative correlations.

DISCUSSION

The implication of these results is that most of the parameters, in particular, the stem/normal femur and stem/SiJ, are stable 12 mo and onward. Important exceptions are the tip/stem and tip/SiJ ratios which decreased by 24% and 33%, respectively, between 12 and 49 mo. The persistent high concentration at the tip of the stem is probably related to elastic movement of bone about a rigid tip, but this would be expected to persist unchanged over time. Similarly, the LTr/SiJ and LTr/normal LTr ratios decreased 32% and 25%, respectively, during the same time interval. We speculate that the lesser trochanter and calcar and tip are reflecting minimal subsidence of the femoral component which tends to stabilize with time, but this is yet to be proved.

We have evidence that different designs of cementless prostheses may have different normal ratios for a given parameter. In progress is a prospective quantitative assessment of the S-ROM prosthesis (Joint Medical Products Corp., Stamford, CT) that features a forked or slotted stem which makes it more flexible at the tip. For implants <12 mo duration, the S-ROM tip/stem ratio was 1.25 (n = 80) compared to 1.63 for the AML ($p < 0.001$). It would seem that normal MDP parameters may have to be determined for each design.

Although we have established the normal range of MDP uptakes as a function of time about the femoral component of the AML prosthesis in asymptomatic patients, it remains to be proved whether it has any value in detecting a failed implant. What is required is a large group of patients with surgical documentation of loosening and a statistical comparison of the various ratios to the normal data base. Thus far too few of our patients have had complications from which to draw any conclusions. Other methods of quantifying bone uptakes, based on either visual grading or computer-assisted measurements, have been reported, but their efficacy in disclosing implant complications is yet to be determined (*6–8*). Potentially, the most effective procedure would be to have the patients imaged serially about every 6 mo for the first two or three years while asymptomatic in order to establish a normal temporal record of ratios. An increase in one or more of the ratios might signal a complication, even though the magnitude of the ratio(s) is still within the normal data range. In view of the large number of implants being performed, the attendant expense incurred by the MDP test, and a probable lack of compliance on part of the patient and referring physician, it is most likely unattainable in the majority of cases. The initial patient MDP study is usually prompted by the clinical suspicion of a

TABLE 1
Data Obtained from the Various Parameters of MDP Concentration Adjacent to the AML Endoprosthesis

Ratio	Mean of implants (0–49 mo of age)	Mean of implants <12 mo of age	Mean of implants ≥12 mo of age	P between <12 mo and ≥12 mo means	r, ratio vs. implant ages ≥12 mo (P)
Stem/normal femur	1.25 ± 0.37	1.59 ± 0.48	1.13 ± 0.23	<0.02	0.22 (ns)
Stem/SiJ	0.32 ± 0.11	0.41 ± 0.14	0.29 ± 0.08	<0.005	0.06 (ns)
Tip/stem	1.46 ± 0.39	1.64 ± 0.42	1.40 ± 0.35	<0.050	0.40 (<0.02)
Tip/SiJ	0.50 ± 0.20	0.68 ± 0.22	0.43 ± 0.13	<0.01	0.40 (<0.01)
GrTr/SiJ	0.50 ± 0.19	0.69 ± 0.24	0.43 ± 0.12	<0.005	0.20 (ns)
LTr/SiJ	0.46 ± 0.22	0.64 ± 0.33	0.40 ± 0.13	<0.005	0.34 (<0.05)
GrTr/normal GrTr	1.43 ± 0.48	1.90 ± 0.66	1.26 ± 0.25	<0.005	0.34 (ns)
LTr/normal LTr	1.33 ± 0.72	2.04 ± 1.11	1.09 ± 0.24	<0.005	0.41 (<0.05)
Ant. IT/SiJ (lateral)	0.70 ± 0.24	0.90 ± 0.24	0.63 ± 0.19	<0.005	0.23 (ns)
Post. IT/SiJ (lateral)	0.85 ± 0.31	1.17 ± 0.38	0.74 ± 0.18	<0.005	0.14 (ns)
Normal femur/SiJ	0.27 ± 0.07	0.28 ± 0.08	0.26 ± 0.07	0.44 (ns)	0.17 (ns)

P = Level of significance; ns = not significant; r = coefficient of correlation; SiJ = sacroiliac joint; GrTr = greater trochanter; LTr = lesser trochanter and calcar; and IT = intertrochanteric zone.

complication, and the normal data base is the only reference.

REFERENCES

1. Utz JA, Lull RJ, Galvin EG. Asymptomatic total hip prosthesis: natural history determined using Tc-99m-MDP bone scans. *Radiology* 1986;161:509–512.
2. Weiss PE, Mall JC, Hoffer PB, Murray WR, Rodrigo JJ, Genant HK. Tc-99m-methylene diphosphonate bone imaging in the evaluation of total-hip prostheses. *Radiology* 1979;133:727–729.
3. Williamson BRJ, McLaughlin RE, Wang GJ, Miller CW, Teates CD, Bray ST. Radionuclide bone imaging as a means of differentiating loosening and infection in patients with a painful total-hip replacement. *Radiology* 1979;133:723–725.
4. Rosenthall L, Aldis AE. Radiophosphate evaluation of loose hip prostheses. *J Can Assoc Radiol* 1985;36:189–193.
5. Oswald SG, Van Nostrand D, Savory CG. Three-phase bone scan and indium-white cell scintigraphy following porous-coated hip arthroplasty: a prospective study of the prosthetic tip. *J Nucl Med* 1989;30:1321–1331.
6. Schicha H, Perner K, Voth E, Reith HG, Webber HG, Emrich D. Cementless implantation of Zweymueller-Endler total endoprostheses of the hip; radiological and scintigraphic follow-up for 2 years. *Nuklearmedizin* 1986;11:417–420.
7. Eckart L, Gericke M, Grunert B, Reyes R, Felix R. Bone scintigraphy in cementless hip arthroplasty 6 years after implantation [Abstract]. *Eur J Nucl Med* 1990;16(suppl):S140.
8. Brecht-Krauss D, Trepte CT, Bitter BA, Glatz S, Adam WE, Puhl W. Investigation-independent quantitative bone scintigraphy in patients with cementless endoprosthesis of the hip [Abstract]. *Eur J Nucl Med* 1990;16(suppl):S140.