Higher reliability of triple-phase bone scintigraphy in cementless total hip arthroplasty compared to cementless bipolar hemiarthroplasty

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HIGHLIGHTS

- Triple-phase bone scintigraphy is effective in ruling out infection with its higher sensitivity.
- Triple-phase bone scintigraphy has relatively low specificity compared to its high sensitivity.

ABSTRACT

Purpose: Periprosthetic infection is one of the main reasons for revision surgery after hip arthroplasty. The purpose of the present study is to compare the reliability of triple-phase bone scintigraphy (TPBS) in the diagnosis of periprosthetic infection between cementless total hip arthroplasty (THA) and bipolar hemiarthroplasty (BHA).
Methods: In this retrospective study, 52 patients were analyzed; 33 of them were performed with THA and 19 of them were performed with BHA. The exclusion criteria were cementation in previous surgery, romatological joint disorders, periprosthetic fracture and malignancy history. C reactive protein (CRP) and erythrocyte sedimentation (ESR) rate results were recorded preoperatively. Tissue samples from the different areas periprosthetic tissue were obtained for histopathological examination and sample tissue culture.
Results: In the present study, the sensitivity, specificity and accuracy were 90.9%, 77.3% and 81.8%, respectively, for THA and 77.8%, 60.0% and 68.4%, respectively, for BHA. Positive predictive values for THA and BHA were 66.7% and 63.6%, and negative predictive values were 94.4% and 75.0%, respectively.
Conclusions: Due to the higher sensitivity, specificity and accuracy, TPBS has a more reliable diagnostic value for cementless THA in the diagnosis of periprosthetic infection compared to cementless BHA.

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1. Introduction

Hip arthroplasty is a successful orthopedic procedure in the treatment of patients with painful and diseased hips [1,2]. With the increasing number of hip arthroplasties, the number of failures due to septic loosening, infection, dislocation and fracture is also increasing with the necessity of revision surgery [2,3]. Differential diagnosis between aseptic loosening and infection is of great importance because the peri-prosthetic infection differs with the catastrophic complications, and the surgeon might choose two-stage revision surgery instead of one-stage definitive surgery in the case of infection [1,4–6]. However, there is currently no single and reliable diagnostic method to differentiate between septic and aseptic loosening [1,7].

Although screening serum C reactive protein (CRP) and erythrocyte sedimentation (ESR) values can be used in the diagnosis of periprosthetic infections, they can be affected by other infectious and non-infectious diseases with poor specificity [1,8,9]. Recent studies examining the effectiveness of TPBS in hip arthroplasty exhibited a significantly heterogeneous study design regarding the etiology, cementation, surgical choice and presence of previous surgeries [5,7,10]. To the best of our knowledge, there was no study comparing the reliability of TPBS in the diagnosis of periprosthetic infection between cementless total hip arthroplasty (THA) and cementless bipolar hemiarthroplasty (BHA).

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In the present study, we investigated the effectiveness of TPBS in the diagnosis of periprosthetic infection in cementless hip arthroplasty patients. We asked whether there was a difference in the reliability of TPBS between cementless THA and BHA.

2. Methods

This retrospective study included 52 patients who underwent THA (n = 33) with primary hip osteoarthrosis history and BHA (n = 19) with proximal femur fracture history according to the inclusion and exclusion criteria described below. The inclusion criteria were primary hip osteoarthrosis for the THA group, proximal femur fracture for the BHA group and removal of the implant for both of the groups. The exclusion criteria were rheumatological joint diseases, previous hip surgery, cementation, shorter than two years duration after primary surgery and metabolic bone disease. None of the patients had any chronic hepatic or hematological disease and malignancy history. The age, sex distributions and durations from primary surgery of the groups are shown in Table 1. Considering the demographic data and duration from the primary surgery, there were no significant differences between the groups.

Patients with a previous hip arthroplasty who had groin and thigh pain were suspected of septic or aseptic loosening of implants. In this situation, standard pelvic anteroposterior radiographs were obtained to evaluate the radiolucent lines and migration of components according to the Gruen zones for the femoral stem and the DeLee zones for the acetebular cup. Blood markers such as CRP, ESR and white blood cells (WBCs) were also screened. All patients underwent TPBS in the suspicion of loosening and infection. Because the bone scan may remain abnormal up to two years after implantation [1,3] patients who had primary surgery within the last two years were not included in this study.

Bone scintigraphy images were obtained after injecting technetium-99 m-labeled diphosphonate using an Infinia & Hawkeye 4 gamma camera of GE. The TBPS consists of three phases: blood flow phase, blood pool phase and late phase. The blood flow phase occurred immediately after infusion of technetium-99 m-labeled diphosphonate, the blood pool phase consisted of the acquisition of anterior and posterior static spot images of the hips between 3 and 5 min later, and the late phase reflected the same images of the blood pool phase 3–4 h after infusion. Images were obtained while the energy peak was set at 140 keV and a 20% window with an image matrix size of 256 × 256 pixels. After obtaining the TPBS images, the images were examined according to the density of area compared with the contralateral side using a digital viewing system. An increase in the radioisotope uptake in all three phases of TPBS was considered to be a peri-prosthetic infection. A true positive result of THA and false positive result of BHA are shown in Figs. 1 and 2, respectively, with antero-posterior X-rays of the patients and typical TPBS images.

Due to the effect of the antibiotic treatment on the culture results [1,3,4] antimicrobial therapy was discontinued at least two weeks prior to the surgery in our routine clinical practice. After an evaluation of the standard antero-posterior pelvic radiographies, screening of blood values and outcomes of TPBS, all operations were performed using the modified anterolateral (Watson Jones) approach by the same senior surgeon group in the supine position. Five samples close to the prosthesis, including the joint, proximal femur and acetabular ground, were obtained for microbiological examination. In addition, five samples from the area described above were obtained for histopathological examination.

We used criterias which were accepted by work group of the Musculoskeletal Infection Society (MSIS) for definitive diagnosing of periprosthetic infection [11]. We recorded ESR and CRP values preoperatively and evaluated intraoperative macroscopic appearance, report of the histopathological specimens, synovial leukocytes count and results of the sample cultures for diagnosing of periprosthetic infection. The intraoperative macroscopic appearance was defined and in the presence of purulence appearance recorded by a senior surgeon. In frozen and permanent histopathological examinations, five or more polynuclear leukocytes on a highly magnified view (×400) were considered positive. Besides this we investigated synovial leukocyte count and percentage of polymorphonuclear leukocytes (PMNL) for the infected hip arthroplasty [11]. The culture results were recorded by the same microbiology laboratory. According to the preoperative TPBS results and postoperative evaluation of infection according to the MSIS criteria, a false-positive result was assumed when the TPBS was positive instead of a negative post-operative result and a false-negative result was assumed when the TPBS was negative instead of a positive post-operative result.

This study was approved by the local ethics committee with ID number E-14-138. All data were calculated as the mean and standard deviation for the patient characteristics. The Chi-square test was used for statistical analysis of the patient data. A value of $p < 0.05$ was considered statistically significant. The sensitivity, specificity, accuracy, positive predictive value and negative predictive value for the TPBS in the diagnosis of infection were calculated. Intra-observer interclass correlation coefficients (ICC) and inter-observer ICC were assessed. Statistical calculations were performed using SPSS 13.0 (SPSS Inc., Chicago, IL, USA.).

3. Results

Among 52 patients, 32 hip arthroplasties underwent a revision THA after the diagnosis of aseptic loosening on the basis of intraoperative findings as well as histopathological results. Regarding the primary surgery, 22 patients had THA and 10 had BHA. In these patients, there was one infection (3.1%) after the revision THA. This patient was from the BHA group and had a reoperation one year after revision arthroplasty. Twenty hip arthroplasties underwent a removal of the implant and placement of antibiotic-impregnated cement spacers after the septic loosening diagnosis. Regarding the primary surgery, 11 patients had THA and 9 had BHA.

Regarding the results of the frozen and permanent histopathological specimens, there was no discordance. All of the samples that were negative for histopathology were also negative for the bacterial culture. Among 20 patients who had a positive histopathological result, six patients (30%) had positive culture results. MRSA was detected in two patients, staphylococcus epidermis was found in two patients, acinetobacter baumanii was observed in one patient, and pseudomonas aeruginosa was found in one patient. Regarding the TPBS measurement, the inter-observer ICC was 0.81 and the intraobserver ICC was 0.89. Intra-observer and interobserver agreements were good and reliable during the TPBS evaluations.

As the results were evaluated for all of the patients as hip arthroplasty, the sensitivity, specificity and accuracy were 85.0%,

Table 1
Demographic and clinical data of the patients.

	THA	BHA	*P*-value
Number of patients	33	19	
Age (years)	66.4 ± 9.1	69.5 ± 8.0	0.214
Sex (female/male)	21/12	14/5	0.548
Duration (years)	7.2 (2–14)	6.6 (2–12)	0.536

The values are expressed as the mean and number of patients with the standard deviation and range in parentheses. THA: total hip arthroplasty, BHA: bipolar hemiarthroplasty.