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Short Communication

The Imaging and Dosimetry for Targeted Ra-223 Treatment for Metastatic Castration-Resistant Prostate Cancer

Matsuo S[1]*, Mizokami A[2], Wakabayashi H[1], Nakajima K[2], Kudo T[3] and Kinuya S[1]

[1]Department of Nuclear Medicine, Kanazawa University Hospital, Kanazawa, Ishikawa, Japan

[2]Department of Urology, Kanazawa University, Japan

[3]Department of Radioisotope Medicine, Nagasaki University, Japan

***Corresponding author:** Shinro Matsuo, Department of Nuclear Medicine, Kanazawa University Hospital, Takaramachi, Kanazawa, Japan

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Prostate cancer at stage IV spreads to bone frequently, which occurs in up to 90% [1]. Bone metastasis is a substantial source of morbidity since it is related to bone pain and skeletal-related events [1]. ^{223}Ra selectively targets bone metastases with alpha particle [2-3]. ^{223}Ra was approved for the treatment of metastatic castration-resistent prostate cancer patients (CRPC) [2]. ^{223}Ra also releases gamma rays accompanying alpha or beta rays. However, the therapeutic effect and its radiation dose assessment have not yet been adequately studied. The side effects and therapeutic effects of ^{223}Ra radiation therapy by using radiation dosimetry for patients with castration - resistant prostate cancer needs to be evaluated [4-7].

Firstly we performed the investigation of phantom study using four types of collimators including low-energy general purpose, extendent low energy general purpose, middle energy general purpose and high energy general purpose type (Figure 1). We observed that middle energy general purpose image was more efficient than a dedicated alpha detector which showed remarkably decreasing counting rates. We therefore constructed procedures and standards for handling ^{223}Ra in clinical practice.

Bone scintigraphy can detect bone metastasis accurately. Bone scintigraphy was performed before and after the therapy in all subjects with CRPC, as well as the measurement of prostate specific antigen (PSA). Bone scan index and other indices by boneNAVI software version 1.0.1 of EXNI or FUJIfilm RI farma were calculated [8]. BoneNAVI is a first update of the Japanese version. This software, using artificial intelligence, has a high sensitivity for diagnosing bone metastasis. Our preliminary findings obtained in our institution was that bone scan index was useful in monitoring the patients regarding pre- and post-treatment and it can be a future prognostic indicator for ^{223}Ra treatment when alpha treatment can be monitored with bone scan index of boneNAVI (Figure 2).

For evaluation of whole body distribution of ^{223}Ra, planar images and SPECT/CT imaging can be carried out by using SPECT/CT apparatus. Detailed information on bone metastasis site and non-bone metastasis accumulation site and irradiation dose evaluation was possibly obtained with radiation dosimetry (Figure 3). Absorbed dose can be calculated by using OLONDA/EXM ver.1.1 (HERMES) [9-11]. The accumulation of normal tissue was found to be low in

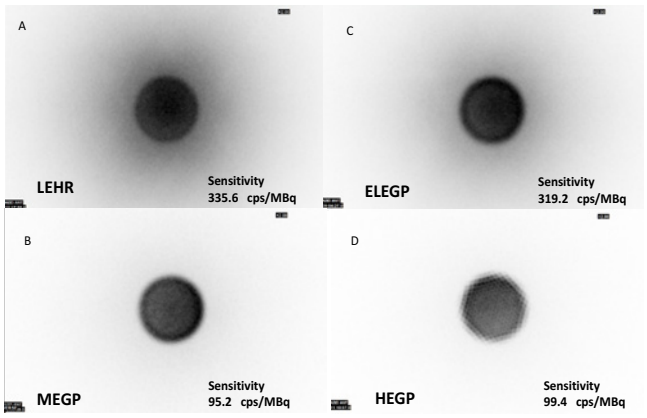

Figure 1: Phantom study to determine sensitivity of each collimator. A: Low-energy general purpose (LEHR); B: Middle energy general purpose (MEGP), C: Extendent low energy general purpose (ELEGP); D: High energy general purpose (HEGP) type.

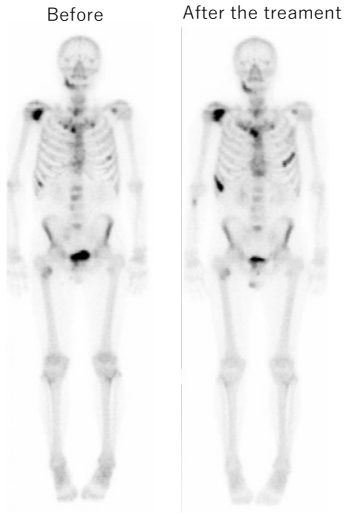

Figure 2: Bone scintigraphy of a patients with prostate cancer. Bone scan index with artificial network analysis showed severity of the disease. Bone Scan Index (BSI) before Ra-223 treatment was 2.00. BSI decreased after the treatment (2.41). Hot Spot before Ra-223 treatment was 29, and changed to 25.

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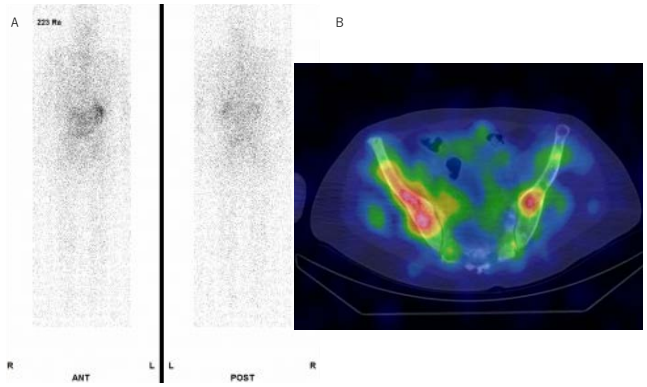

Figure 3: Image of Ra-223. Biodistribution of activity in a patient with castration-resistant prostate cancer was imaged. A: Ra-223 imaging; B: Ra-223 image by SPECT/CT.

relation to targeted tumor cell. We also observed symptom bone pain regarded as side effects in half of the subjects. The side effects included as well as side effect of bone pain loss, exacerbation, loss of appetite etc. during the treatment. There was a significant relationship between the site of ^{223}Ra accumulation and the symptom of side effects by the treatment [12]. The evaluation of radiation exposure dose in the non-target organ including intestine, bone and urinary cyst could be recognized with ^{223}Ra imaging. Alpha treatment can be monitored by nuclear medicine survey detectors under optimization of measurements. Side effect might be predicted with imaging of ^{223}Ra.

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