



Percutaneous cementoplasty for acetabulum in patients with bone metastasis

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The purpose of this study is to demonstrate the surgical technique and to show the results of percutaneous cementoplasty (PC) for acetabular metastases using lateral approach under regional anesthesia. Forty-two cases underwent PC for acetabular metastases. The PC was performed using spinal anesthesia, lateral approach and fluoroscopic guidance. We assessed visual analogue scale (VAS) and revised musculoskeletal tumor society (MSTS) rating system and maximum standardized uptake value (SUVmax) of the acetabular lesion using F-18-FDG PET/CT before and after the PC. The mean injected volume of polymethylmethacrylamide to the pelvis was 21 ± 11.8 ml. The mean of regional VAS (6.2 ± 1.1 vs. 3.1 ± 2.7 , $p < 0.001$), MSTS (10.3 ± 3.9 vs. 18.3 ± 3.2 , $p < 0.001$) and local SUVmax (8.6 ± 5.2 vs. 5.7 ± 3.6 , $p = 0.012$) on PET/CT showed significant reductions after surgery. Twenty-three patients (55%) died of disease at mean 11.8 ± 4.8 months after surgery. PC using lateral approach and regional anesthesia could be a simple and safe surgical method for relieving pain and maintaining skeletal stability against acetabular metastasis.

Keywords : Percutaneous Cementoplasty ; Acetabulum ; Metastasis ; F-18-FDG PET/CT

INTRODUCTION

Acetabular metastasis may cause analgesic drug-resistant pain and structural weakening of the pelvis affecting poor quality of life. (Maccauro 2008) Radiotherapy is the standard palliative treatment for metastatic bone lesion and it is helpful for not

only pain relief but also inhibiting progression of lesions, especially, in non-weight-bearing region. (Gaze 1997, Jeremic 1998) However, it results in minimal, delayed bone strengthening to fail to relieve ambulatory pain in weight-bearing region, such as acetabulum and femur, after the therapy. (Gilbert 1977, Shepherd 1988) Conventional surgery is reserved for patients with unremitting pain causing severe functional impairment. Many of these patients are unsuitable candidates for major surgeries and this shows the emergence of minimally invasive percutaneous techniques as a viable treatment option. (Jakanani 2010)

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No benefits or funds were received in support of this study. The authors report no conflict of interests.

Percutaneous injection of polymethylmetacrylate (PMMA) through posterior, posterolateral, or lateral access under fluoroscopic control and local anesthesia to treat malignant acetabular osteolytic lesions was first reported in 1995.(Cotten 1995) Since then, various other surgical approaches have been tried under regional or general anesthesia. (Basile 2008, Gupta 2012, Jakanani 2010, Lane 2011, Maccauro 2008) Local anesthesia has many limitations, such as use of thin trocars, imprecise image guidance and motion of patients, to inject large volume cement injection for extensive lesions. On the other hand, general anesthesia could be dangerous for patients with metastasis to multiple internal organs.

The authors have been performed percutaneous cementoplasty with fluoroscopy for acetabular metastasis under regional spinal anesthesia. Our goals were to inject a sufficient volume of PMMA without complication in a short operation time, including anesthesia. The aims of current study are to evaluate the reliability of percutaneous cementoplasty using lateral approach and regional anesthesia as a treatment method in the acetabular metastasis and to assess the functional outcomes of those patients

PATIENTS AND METHODS

Subjects

We retrospectively reviewed records of patients with advanced malignancy treated by percutaneous cementoplasty (PC) for acetabular metastases from June 2008 to December 2013. Prior institutional review board (IRB) approval was obtained for this study. The indications of PC were hip pain that worsened when ambulating, ineffectiveness of radiotherapy and estimated life expectancy less than one year as predicted by the primary oncologist. Contraindications were local or systemic infection and coagulopathy. The patients with other bone metastasis of the lower extremity, except for the femoral neck, were excluded. We identified 42 patients. Mean duration of follow up was 13.2 months. 31 Patients were died of disease at last

follow. Detailed demographic data were described in Table 1.

Surgical technique

The procedure is performed under regional spinal anesthesia. Patients are positioned in lateral decubitus position. Anterior superior iliac spine (ASIS) is marked with Gentian Violet pen. After having prepared a sterile field, skin is punctured by a percutaneous vertebroplasty (PV) needle (10 gauge, 11 cm ; peverty needle®, Kyungwon Medical, Seoul, Korea) 10 cm posterior to ASIS and the needle is advanced from posterior to anterior at an angle of 70 degrees from the horizontal plane (Fig 1a). Under fluoroscopy, with AP and Judet view for a corresponding hip joint, PV needle penetrates the cortex and the tip is positioned in the lesion (Fig 1b). Low-viscosity radiopaque bone cement (Exolent Spine®, Elmdown, London, England) is mixed and transferred to 30 ml syringe soon. To facilitate injection by even low pressure of fingers, PMMA is divided and transferred to several 1ml syringes soon again. Injection of cement is initiated after 2 minutes and 30 seconds after mix. Using iliac oblique fluoroscopic view to avoid sciatic nerve injury by leakage, bone cement is injected

Table 1. — Clinical Characteristics

Characteristics	No. (%)
Total number of Patients	42
Gender	
Female	23 (55%)
Male	19 (45%)
Age at diagnosis, mean (yrs)	59.2 (ranged: 21 - 83)
Follow-up duration, mean (Months)	13.2 (ranged: 6 - 28)
Primary neoplasm	
Lung	11 (26%)
Breast	8 (19%)
Liver	5 (12%)
Kidney	4 (10%)
Others	14 (33%)
Adjuvant treatment	
Chemotherapy	33 (21%)
Radiotherapy	15 (36%)

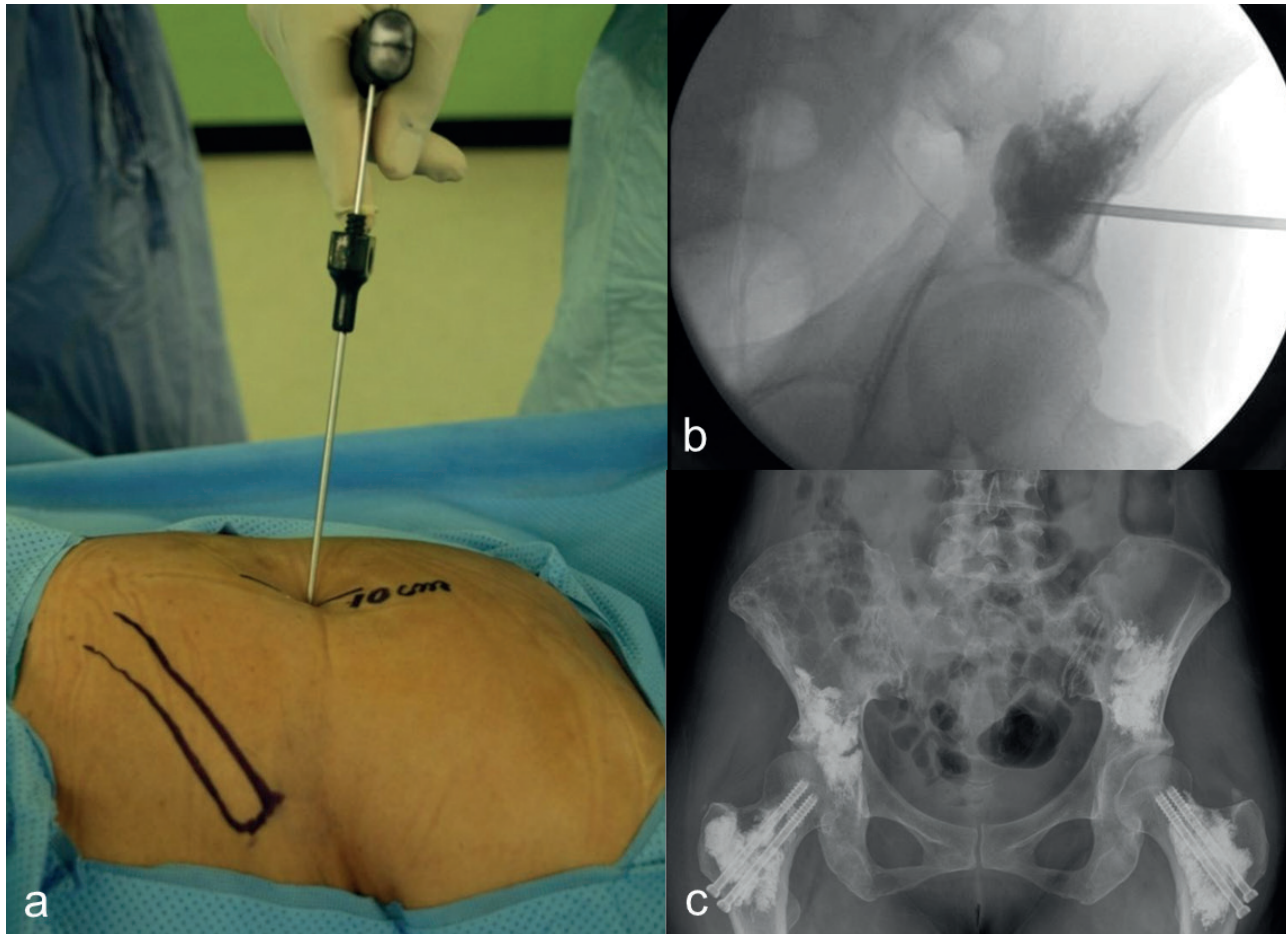


Fig 1. — Consistent surgical technique. (a) Preparation for skin puncture and PV needle advancement. The site at 10cm posterior to ASIS was marked and punctured. A PV needle is advanced from posterior to anterior at an angle of 70 degrees from the horizontal plane. (b) Fluoroscopic guidance. Low-viscosity radiopaque bone cement is injected, checking up Judet view. (c) Hollow perforated screw. Percutaneous surgery is simultaneously performed in the case associated with metastatic osteolytic lesion at proximal femur.

as much as possible. Drainage to the venous system or leakage to the surrounding soft tissue has to be carefully observed in its initial stage. Hypotension followed by the injection should be monitored. If injection isn't simply done, stylet is used to push PMMA in lumen of the needle. The cement become hard after 8 minutes and the operator ought to complete injection within 10 minutes. PV needle is removed at 15 minutes. Percutaneous surgery using hollow perforated screw is performed simultaneously in the case associated with metastatic osteolytic lesion at proximal femur (Fig 1c).(Kang 2009) During injection of PMMA, anesthesiologist is called for monitoring the change of blood pressure and pulse rate due to toxicity of

bone cement carefully. In the case of huge lesion encroaching on most ilium, another VP needle can be utilized in the same way.

F-18-FDG PET/CT image acquisition and analysis

F-18-FDG PET/CT (PET/CT) was performed twice on 15 patients out of 42 patients before and after the PC. PET/CT was performed at a mean of 2 weeks (range, 1-14 weeks) before surgery. Postoperative PET/CT was done at a mean of 8 weeks (range, 1-34 weeks) after surgery. All the patients fasted for at least 6 hours before imaging, and their blood glucose level was within normal range before FDG administration (80-122 mg/dl).

The injected dose of FDG was between 370 and 555 MBq and PET/CT scan was performed using a PET/CT scanner (Biograph LSO ; Siemens Medical Systems). Emission scans were obtained 60 minutes after intravenous administration of FDG. The acquisition time was 3 minutes per bed position by three dimensional modes. We measured maximum standardized uptake value (SUVmax) from each PET/CT by drawing volume of interest (VOI) for the pelvis surgical site. These measures were all checked twice by Siemens workstation manually and averaged.

Data analyses

The medical records on technical success, volume of injected PMMA, additional therapy, complication, radiologic evaluation and survival were reviewed for all the patients. Each subject was asked to quantify regional pain on a numeric visual analog scale (VAS) a day before surgery, 1 weeks after it, and at interval of 6 weeks from postoperative 1 weeks to last follow-up. (Scott and Huskisson 1976) A difference in VAS ≥ 2 points, meaning at least a 30% reduction in pain, was considered a clinically significant result. (Farrar 2003, Farrar 2001) Revised musculoskeletal tumor society (MSTS) rating system was also planned to be applied for functional assessment a day before surgery, 1 weeks after surgery, and at interval of 6 weeks from postoperative 1 weeks to last follow-up.

Statistics

The effects of variables were estimated using Fisher's exact test and spearman correlation analysis. Functional outcomes (VAS and MSTS scores) were evaluated using Wilcoxon signed rank test. Statistical analyses were performed using SPSS® software (Version 18.0 ; SPSS Inc, Chicago, IL, USA). Significance was set at $P < 0.005$.

Ethics

We obtained the approval of the Institutional Review Boards of National Cancer Center of Korea (NCC 2014-0215).

RESULTS

PC performance results

Sufficient volume of PMMA to pack osteolytic cavity was injected in a short operative time. (Fig. 2a-c) Mean volume of injected PMMA per lesion was 21 ± 11.8 ml (range, 7-53 ml). The mean operative time from skin puncture to removal of PV needle was 21 minutes (range, 17-38 minutes). No major complication occurred after PC. In 2 cases (5%), cortical discontinuity with soft tissue tumor extension resulted in extraosseous leakage of PMMA. They were asymptomatic and did not require additional surgical treatment. One patient (2%) developed transient hypotension during PMMA injection, but had rapid recovery of blood pressure by temporary stoppage of PMMA injection. Further PMMA injection had to be resumed more slowly, and did not produce hypotension. In the long term, the patients who died of the disease had not undergone additional surgery and no local osteolytic progression was observed until last follow up.

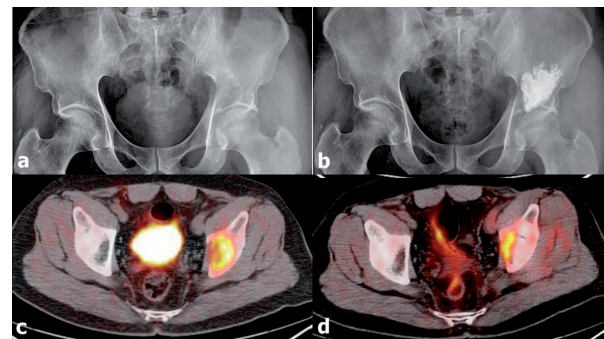


Fig 2. — A 51 year old male patient with renal cell carcinoma and bone metastases. (a) Pelvis plain radiograph and CT scan shows left acetabular osteolytic lesion with cortical breakdown (b) Sufficient volume of PMMA without leakage was injected on postoperative pelvis plain radiograph and CT scan. (c) Reduction in F-18-FDG uptake at left acetabulum was observed on postoperative PET/CT in comparison with preoperative one.

Pain score changes after PC

Hip pain was reduced after PC, which was sustained (Fig. 4). The VAS score was significantly decreased and durable in all the cases ($p = 0.017$).

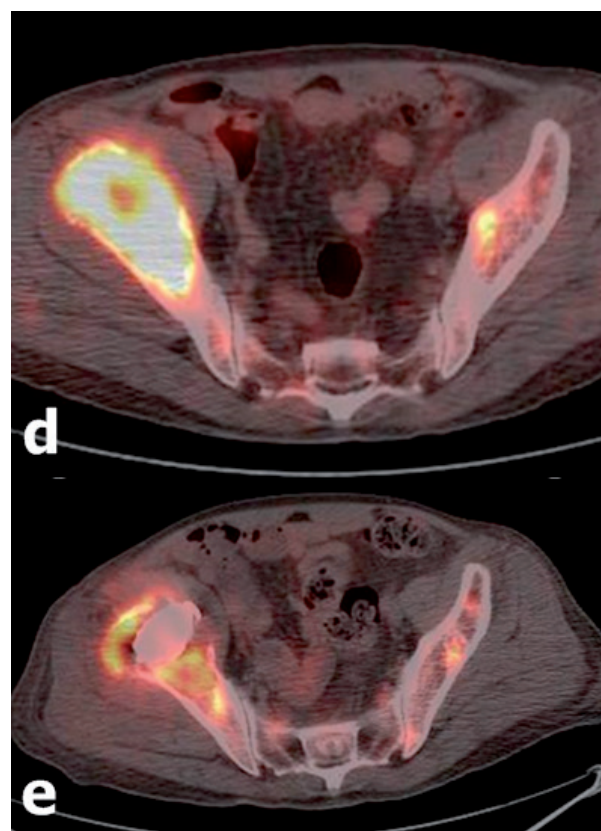
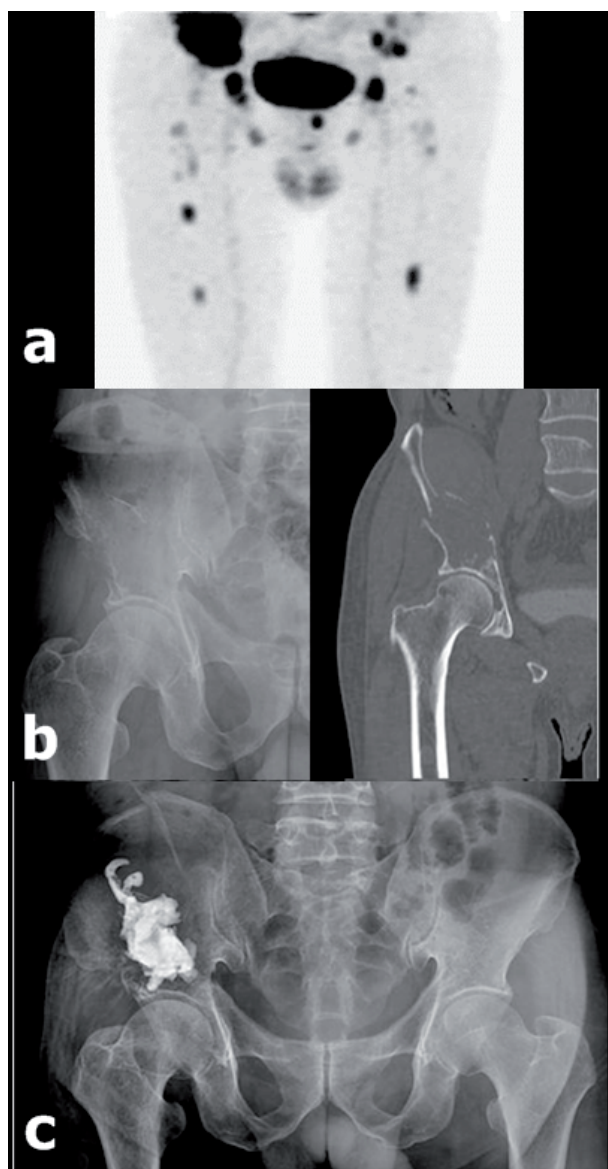


Fig. 3. — A 65 year old male patient with HCC (a) Whole body PET/CT shows multiple metastases. (b) Pelvis plain radiograph, CT scan, MRI show left acetabular osteolytic lesion with cortical breakdown. (c) Enough volume of PMMA occupies osteolytic area on postoperative pelvis plain radiograph and 3 dimensional CT scan. (d,e) Reduction in F-18-FDG uptake at right acetabulum was observed on postoperative PET/CT in comparison with

Mean regional VAS score was 6.2 ± 1.1 (range, 6-10) on the day before surgery, 2.1 ± 0.8 (range, 1-5) one week after surgery and 2.2 ± 1.1 (range, 1-6) at last follow up. In 13 cases (31%), VAS score at last follow up was increased compared to a week after surgery.

Functional changes after PC

Functional improvement was observed after PC. The MSTS score was significantly improved after

surgery. Mean MSTS score was increased from 10.3 ± 3.9 (range, 5-15) to 18.3 ± 3.2 (range, 14-24) at a week after surgery ($p < 0.001$).

PET/CT results after PC

Local SUVmax at PC site on PET/CT was reduced after PC (Fig 2d, 3d). Preoperative and postoperative mean SUVmax was 8.6 ± 5.2 (range, 2.4-19.5) and 5.7 ± 2.6 (range, 2.3-11.6), respectively, which was statistically significant ($p = 0.012$).

DISCUSSION

Successful clinical results of the PC have mostly been reported in symptom improvement and low complication rate from the recent literature. (Cotten 1995, Lane 2011, Maccauro 2008) Our report is the largest study of cementoplasty for acetabular metastasis to date. The unique features of the current surgical preparation and technique that differed from those of previous studies included the consistent use of spinal regional anesthesia, lateral

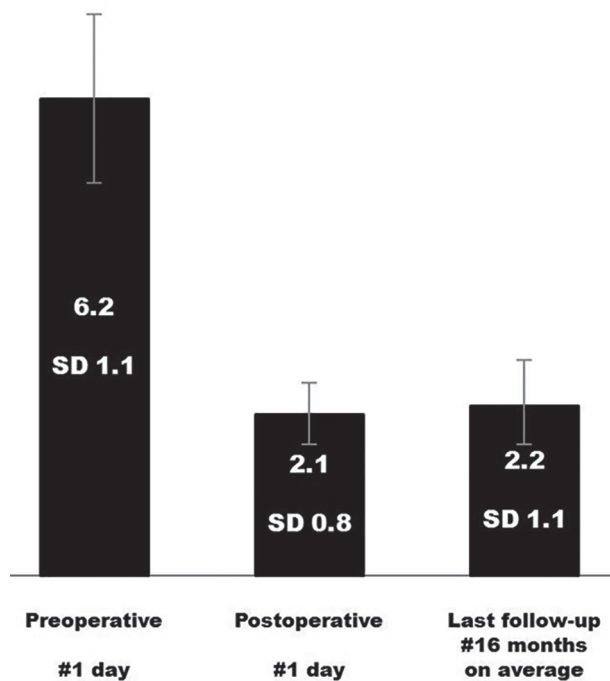


Fig 4. — VAS score changes after PC. Vas score decreased significantly 1 day after surgery and the reduction was durable. Abbreviations: SD, standard deviation

surgical approach and intraoperative fluoroscopic guidance. Spinal regional anesthesia contributed to the precise and safe operation. Lateral approach and intraoperative fluoroscopic guidance could make the PC more simply and easily accessible when performed by other operators, which will lead to the result of shortening operative time and reducing exposures to intraoperative radiation.

The advantages of PC are light burden of surgery and wide indication. The burden of major surgery should be well considered. Marco et al reported that the mean operative time of acetabular

reconstruction for metastasis was 290 ± 72 minutes. (Marco 2000) Mean estimated volume of blood loss was ranged between 2,200 ml to 2,740 ml. (Kiatisevi 2015, Marco 2000) Mean operative time of this study was 21 minutes and the volume of blood loss was minimal. Resection and reconstruction of acetabular metastasis was restricted to patients with a few metastasis, good prognosis and major functional impairments. (Muller and Capanna 2015) The authors performed PC regardless of the number of metastases and primary cancer. As with the many reports of PC, risk of major complication is lower than the resection and reconstruction. (Basile 2008, Cotten 1995, Gupta 2012, Kiatisevi 2015, Lane 2011, Maccauro 2008, Marco 2000, Muller and Capanna 2015) The authors experienced leakage of cement in 2 cases with cortical breakage and transient hypotension with cement injection.

The injected PMMA by this lateral approach was usually seated in the posterior column of acetabulum. A biomechanical study demonstrated that increases in cortical stresses were highest along the posterior column of the acetabulum. (Li 2007) Meanwhile, we noted that it was difficult to force PMMA intrusion into the anterior column of acetabulum and ischial tuberosity. Improvement of surgical technique is required.

PC is palliative treatment option, do not disturb the scheduled plan for chemotherapy or radiation. Postoperative radiotherapy was performed for the patients with extrasosseous extension within 6 days after surgery. Kim et al. reported that postoperative radiation therapy was performed on 7 patients mean of 4 days after minimally invasive surgery of humeral metastasis using flexible nail and intramedullary cementing. (Kim 2011) Punctured skin of current PC technique did not disturb early radiation therapy.

VAS scoring system was used to estimate degree of pain confined to acetabular lesion. However, the system can be representative for the sum of generalized whole body symptom. Meanwhile, in this current study it is used to estimate symptom only for pain caused by acetabular metastasis. Therefore, this pain score could be under- or over-estimated by pain severity of other sites such as lumbar spine and proximal femur. We considered all possibilities

for scoring on regional buttock pain and significant pain reduction was resulted in and maintained during follow-up period.

F-18-FDG PET-CT is known to show good detectability of bone metastases in multiple type of cancers and widely used for treatment response evaluation (Masala 2011). In our study, we interpreted that heat generated by PMMA could be the cause of hypometabolic activity of F-18-FDG PET-CT after cementoplasty. Cytotoxic effect by the heat cause destruction of the tumor, and glucose metabolism of the tumor cells may be decreased, which means less tumor burden for the cementoplasty area (Kim 2013). Reduction in SUVmax on postoperative PET/CT was distinctly different from other metastatic sites where an increase in SUVmax was generally observed in the same patients. If F-18-FDG uptake is representative of tumor cell viability, then reduction in F-18-FDG uptake with effective tumor therapy should reflect the tumor cell killing rate. New criteria or indices in tumor response using functional estimation with F-18-FDG PET/CT have been developed instead of anatomic tumor response metrics. If the correlation between maintenance of symptom relief with mechanical stability and level of reduction in F-18-FDG uptake after PC can be validated, this could be helpful in efforts to evaluate and improve minimally invasive surgery, such as PC in bone metastasis.

Several shortcomings must be acknowledged. First, the size of cohort was not large and different types of malignancy were not considered separately as sub-groups. Second, influence of radiotherapy and medical treatment were not considered. Third, differences in the time of preoperative and postoperative PET/CT scans may have been a source of variation.

In conclusion, PC using lateral approach and regional anesthesia could be a simple and safe surgical method for relieving pain and maintaining skeletal stability against progressive osteolysis of acetabular metastasis in patients with advanced malignancy.

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