Retrospective Review

# CT-Guided Percutaneous Femoroplasty for the Treatment of Proximal Femoral Metastases

Helin Feng, MD[1], Jin Wang, MM[1], Peng Guo, MM[1], Jianfa Xu, MM[1], Wei Chen, MD[2], and Yingze Zhang, MD[2]

From: [1]Department of Orthopedics, The Fourth Hospital of Hebei Medical University, China; [2]Department of Orthopedics, The Third Hospital of Hebei Medical University, China

Address Correspondence: Yingze Zhang Department of Orthopedics, The Third Hospital of Hebei Medical University, 139 Ziqiang Road, Shijiazhuang, Hebei 050051, P. R. China E-mail: yzling_liu0311@126.com

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**Background:** The spine, pelvis, skull, and femur are the most common sites of bone metastases, and pain is the main symptom of metastatic tumors. Percutaneous femoroplasty (PFP) is becoming increasingly popular for treating proximal femoral metastases.

**Objectives:** To assess the clinical value and feasibility of PFP performed under the guidance of computed tomography (CT).

**Study Design:** A retrospective clinical review comparing pain intensity and the ability to perform activities of daily living before and after treatment with PFP.

**Setting:** Single academic medical center.

**Methods:** Sixteen patients with proximal femoral metastasis were treated with PFP under CT guidance and followed up for 6 – 12 months. Pain intensity was evaluated using the visual analog scale (VAS) and patients' quality of life was evaluated using the Barthel Index of Activities of Daily Living (BIADL) preoperatively and at both 7 days and 6 months after PFP.

**Results:** The mean VAS score decreased from 7.44 ± 0.81 preoperatively to 2.69 ± 0.79 at 7 days postoperatively and 1.25 ± 0.93 at 6 months postoperatively. The BIADL score increased from 44.06 ± 9.53 preoperatively to 69.06 ± 8.61 at 7 days postoperatively and 83.13 ± 6.55 at 6 months postoperatively. No patients suffered from pulmonary embolism or complications such as pathologic fracture of the proximal femur. The median overall survival was 12 months. One patient experienced cement leakage into the hip, and the injection was immediately stopped. Then dexamethasone was injected intravenously to prevent potential pulmonary fat embolism caused by localized high pressure.

**Limitations:** The study evaluated a single group of patients before and after CT-guided PFP and did not include a comparison with conventional fluoroscopic approaches in a large patient sample.

**Conclusion**: Use of CT-guided PFP was associated with a low risk of complications and improvement in patients' quality of life. CT guidance made the operation easy and safe, and thus, this approach represents a potential treatment option for proximal femoral metastases if indications are observed closely.

**Key words:** CT guidance, percutaneous femoroplasty, proximal femoral metastasis, pain relief, cementoplasty

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Malignant tumors often emerge as bone metastases (1,2), and the proximal femur, spine, and pelvis are the most common sites of such metastases. Proximal femoral metastases can cause chronic, intolerable pain and even pathologic fractures and thus negatively influence patients' quality of life (QoL) (3). As an effective and widely accepted surgical treatment option for patients with vertebral tumors, percutaneous vertebroplasty (PVP), which is associated with mild trauma and a good analgesic effect, is widely applied in clinical practice (4,5). The concept of PVP also has been applied in the treatment of femoral metastases through percutaneous femoroplasty (PFP) (5). Our previously published series included 23 PFP procedures performed under conventional fluoroscopy in 21 patients who had proximal femoral metastases, and we observed an encouraging effect (6).

In computed tomography (CT)-guided PVP, a precise puncture is made in the vertebral body and early detection of small cement leakage is possible (7,8). Notably, a previous study showed that CT-guided PVP achieved good outcomes in the surgical treatment of upper cervical metastases (9). Taking all of the previous research into consideration, we speculated that the addition of CT guidance could make conventional PFP more intuitive and easier, giving surgeons a better sense of control during the operation.

## Objective

We sought to analyze the clinical effectiveness of CT-guided PFP by evaluating pain relief and QoL in patients with metastatic bone disease of the proximal femur.

## Methods

### Patients

This case series included a total of 16 lesion sites in 16 patients with proximal femoral metastases. We recorded the following variables: age, gender, type of primary tumor, pathological examination, volume of polymethylmethacrylate (PMMA) injected, and survival time (Table 1). The pain level in patients' hips was assessed using the visual analog scale (VAS; 0 = no pain, 10 = worst ever pain). The Barthel Index of Activities of Daily Living (BIADL) was used to assess the patients' QoL preoperatively and at 7 days and at 6 months after PFP. The case series included 5 men and 11 women ranging in age from 34 to 81 years. The primary malignancies of patients were as follows: 6 cases of lung cancer, 5 cases of breast cancer, 4 cases of esophageal cancer, and one case of liver cancer (Table 1). Pathological examination of resected specimens showed the same origins. Before surgical treatment, patients were carefully examined via x-ray imaging (Fig. 1A), bone scintigraphy (ECT), CT (Fig. 1B), and magnetic resonance imaging (MRI) (Fig. 1C).

The clinical study was approved by the Ethical Committee of the Third Hospital of Hebei Medical University, and all participants signed an exhaustive informed consent form after being informed of the benefits and risks of the procedure.

Table 1. *Demographic and clinical characteristics of 16 patients.*

| Case | Age (years) | Gender | Left or right | Single or multiple bone metastasis | Primary tumor/ biopsy | Volume of PMMA injected (ml) | Survival (months) |
|---|---|---|---|---|---|---|---|
| 1 | 66 | M | R | multiple | lung cancer | 6 | 13 |
| 2 | 81 | M | L | single | lung cancer | 8 | 12 |
| 3 | 67 | F | R | single | breast cancer | 12 | 22 |
| 4 | 76 | F | R | multiple | breast cancer | 10 | 18 |
| 5 | 64 | M | L | multiple | esophagus cancer | 7 | 7 |
| 6 | 45 | F | R | multiple | esophagus cancer | 10 | 9 |
| 7 | 42 | F | L | single | esophagus cancer | 7 | 30 |
| 8 | 34 | F | L | single | esophagus cancer | 6 | 33 |
| 9 | 66 | F | L | single | breast cancer | 5 | 23 |
| 10 | 56 | F | R | multiple | breast cancer | 8 | 8 |
| 11 | 71 | M | R | multiple | lung cancer | 10 | 10 |
| 12 | 65 | F | L | single | lung cancer | 9 | 13 |
| 13 | 59 | F | L | multiple | breast cancer | 6 | 18+ |
| 14 | 49 | M | L | multiple | lung cancer | 11 | 8 |
| 15 | 67 | F | R | single | lung cancer | 12 | 6 |
| 16 | 64 | F | R | multiple | liver cancer | 8 | 7 |

Note: M: male, F: female, R: right, L: left.

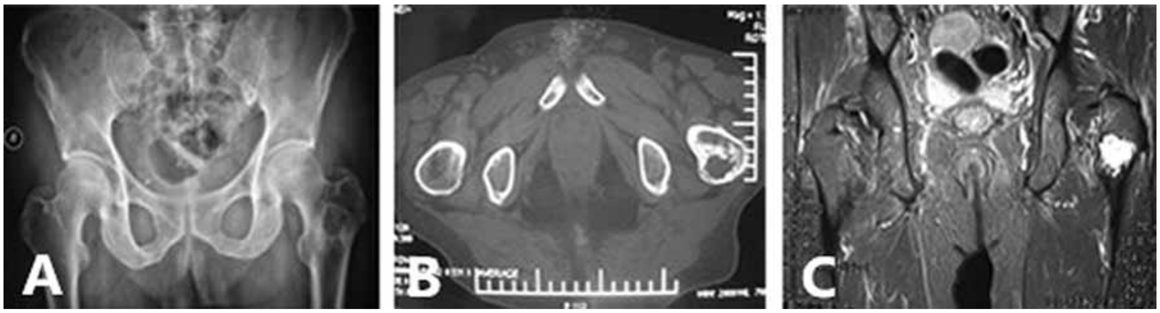


Fig. 1. *Images of the lesion site in an 81-year-old man presenting with lung cancer and left proximal femoral metastases. (A) Pre-operative anteroposterior (AP) radiograph of the pelvis demonstrates a left intertrochanteric lytic lesion with sclerotic rim. (B) Pre-operative CT through the same left intertrochanteric lesion demonstrates the mixed density intertrochanteric lesion. No acute, displaced fracture or definite cortical breakthrough. (C) Coronal T2W MRI of the left intertrochanteric lesion demonstrates diffuse high T2 signal.*

### Procedure

After mixing to a semi-liquid consistency and loading into a 5-mL syringe, PMMA (Mendec Spine High Barium Content Acrylic Resin, Tecres S.P.A, Italy) bone cement was prepared. The administration of PMMA was carried out under CT imaging guidance. We determined the quantity of PMMA to be injected based on the extent of the metastatic lesion and size of the patient. Filling was stopped once sufficient distribution of cement within the metastatic area was achieved. We used a special guide to apply 5 – 12 mL of the total amount of PMMA during the surgery into the target area.

First, the patient was placed in the supine position, and slight padding was placed ipsilaterally. Once the patient was moved into the prone position and was as comfortable as possible, axial images through the affected femur were acquired. Images were then reconstructed into coronal and sagittal planes. The multiplanar images enabled us to choose the best anatomic approach depending on individual proximal femoral metastases. One percent xylocaine was used for local anesthesia (Xylocaine; Astra, Sodertalje, Sweden; Fig. 2A). After the administration of local anesthesia, the angle and entry site of the needle were fixed under CT guidance (Fig. 2B-C). In most cases, the center of the lesion was used to select the needle entry site. In the first step, a lesional biopsy was taken and sent to the department of pathology of our hospital for pathological examination (Fig. 2D-E). Next, we adjusted the position and angle of the needle to inject bone cement under CT guidance. Then the bone cement was injected into the lesion site (Fig. 2F-H). During the injection, once the bone cement began to leak into the femoral marrow beyond the tumor margin or into the hip joint space, we stopped the injection of PMMA and completed the operation, or readjusted the positions of instruments before continuing the injection. Each patient's vital signs were monitored carefully, particularly pulse oximetry, as was the amount of cement injected. Upon completion of the surgery, the patients were immobilized in a bed in the supine position for at least for 15 minutes while the bone cement solidified.

### Evaluation of Pain Relief and QoL

The VAS and BIADL were used to evaluate pain and QoL, respectively. Both scales were applied to obtain preoperative data and postoperative data at 7 days and again at 6 months after CT-guided PFP.

### Statistical Analysis

The data were recorded in a Microsoft Excel 2010 spreadsheet and analyzed. Mean and standard deviation values are reported for quantitative variables. To analyze the association between the main results of clinical effectiveness (pain relief according to VAS scores and improved functionality according to BIADL scores) at different time points, a generalized linear model with analysis of variance for repeated measures was applied. Statistical analyses were completed using SPSS 19.0 software (SPSS, Inc., Chicago, IL, USA). The patient-reported pain levels before and after the operation were compared using t-tests. *P*-values less than 0.05 were considered to indicate statistically significant differences.

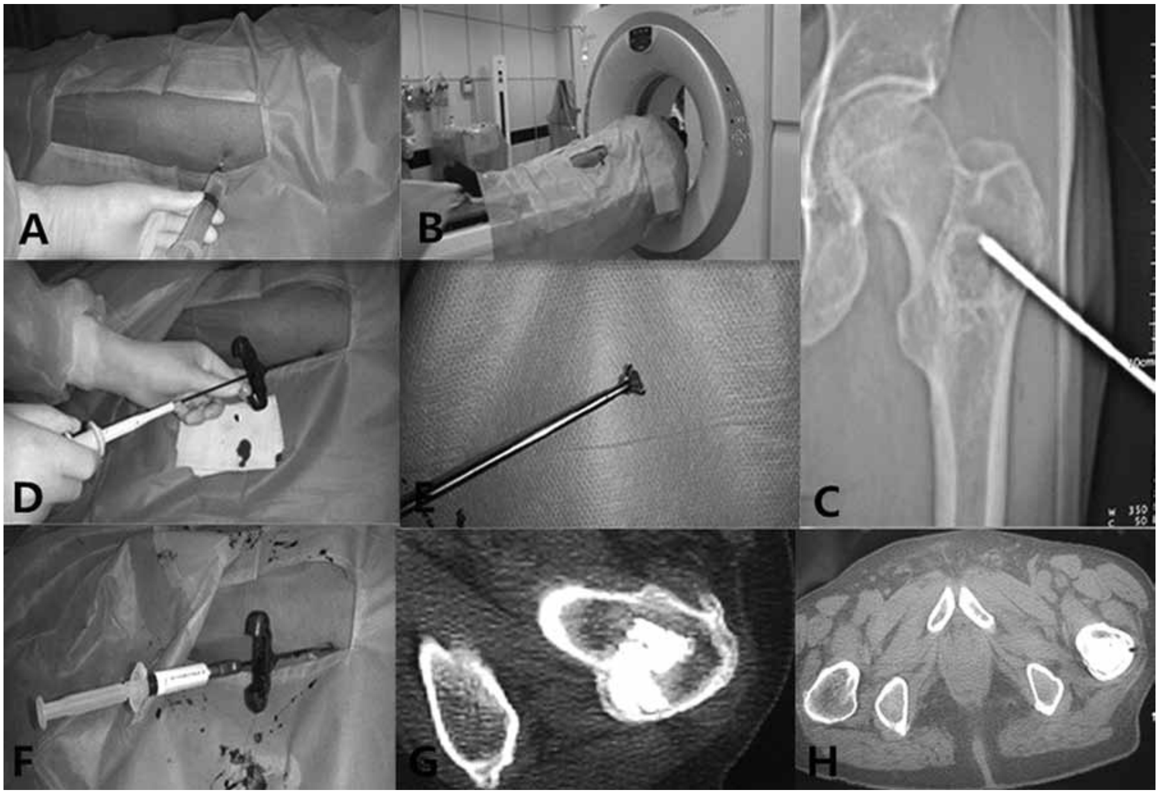


*Fig. 2. Images of the lesion site in an 81-year-old man during CT-guided PFP. (A) Local anesthesia with 1% lidocaine. (B) Patient placement for CT scanning of the tumor. (C) Combined CT fluoroscopic image of the tumor with the needle in place. (D and E) Excision of biopsy specimens. (F) Photograph of bone cement injection. (G) Axial post-procedural CT image of the proximal left femur demonstrates intralesional cement filling. (H) Coronal post-procedural image of the same left intertrochanteric lesion demonstrates complete intralesional cement filling without extravasation. Lateral cortical disruption is secondary to trocar placement.*

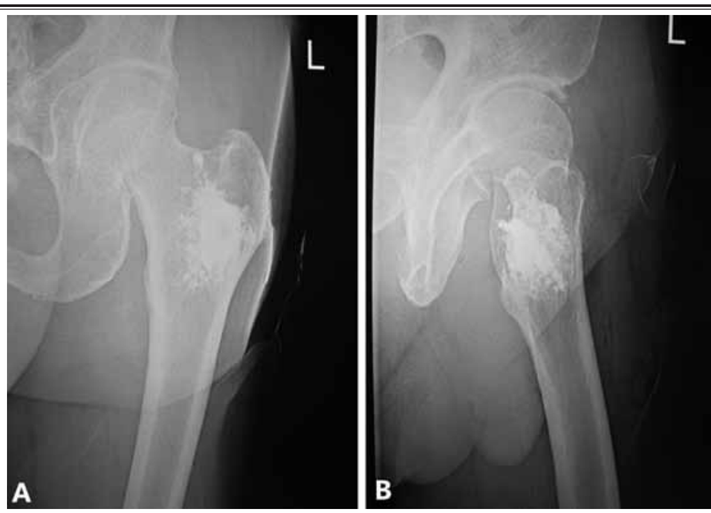


*Fig. 3. Six-month follow-up AP (A) and lateral (B) radiographs of the left post-procedural intertrochanteric lesion demontrate continued integrity of the proximal femur, intralesional cement filling, no definite progression of the lesion, and no cement extrasvasation.*

## Results

CT-guided PFP was successfully conducted in each case of proximal femoral metastasis (Fig 3. A-B). Leakage of bone cement into the hip joint space occurred in only one case. One patient presented with irritating pain in the lower limbs during the operation, which resolved immediately when the injection was stopped. No other complications, such as pulmonary embolism or pathological fracture in the proximal femur, were observed in these 16 patients. The total amount of PMMA injected varied from 5 to 12 mL. The median duration of the total surgery was 42 minutes (range, 30 – 50 minutes), and the median blood loss was 16 mL (10 – 40 mL). In all patients, post-operative radiographs demonstrated good placement of the PMMA in the area

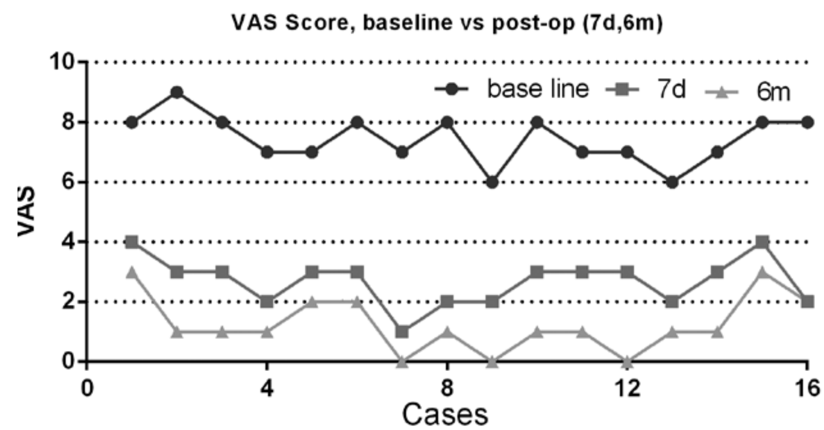


*Fig. 4. VAS scores for pain.*

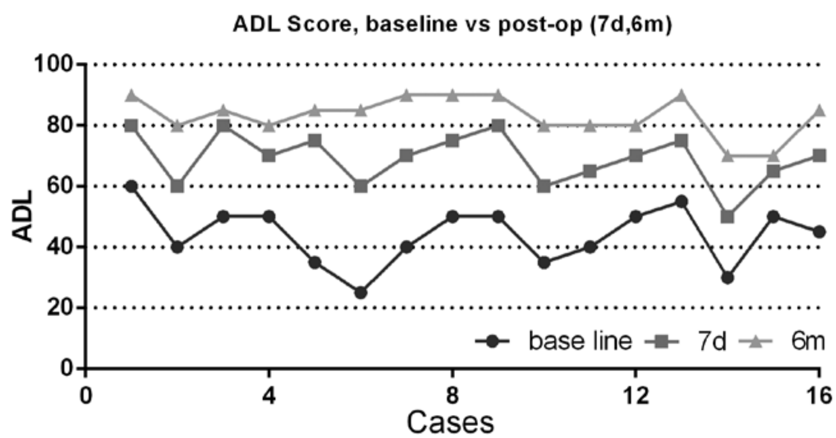


Fig. 5. *BIADL scores for patients' QoL.*

of proximal femoral metastasis (Fig. 3A-B).

The mean VAS score for the 16 patients decreased significantly from 7.44 ± 0.81 preoperatively to 2.69 ± 0.79 at 7 days postoperatively and 1.25 ± 0.93 at 6 months postoperatively (both $P < 0.01$; Fig. 4). The mean BIADL score increased significantly from 44.06 ± 9.53 preoperatively to 69.06 ± 8.61 at 7 days postoperatively and 83.13 ± 6.55 at 6 months postoperatively (both $P < 0.01$; Fig. 5). The overall survival curve for the cohort is shown in Fig. 7, and the median overall survival was 12 months.

### Complications

One patient experienced cement leakage into the hip joint space, and the injection was immediately stopped. Then dexamethasone was injected intravenously. No patients suffered from pulmonary embolism or complications such as pathologic proximal femoral fracture.

## Discussion

The proximal femur is the most common site in the appendicular skeleton for metastatic disease and

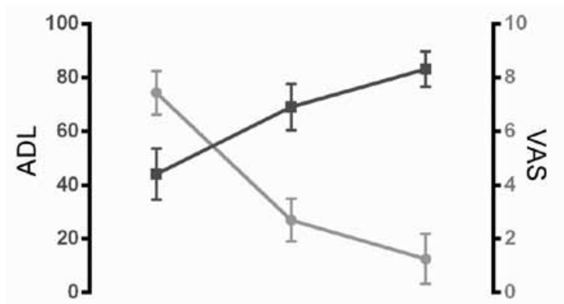


Fig. 6. *Changes in VAS and BIADL scores after CT-guided PFP.*

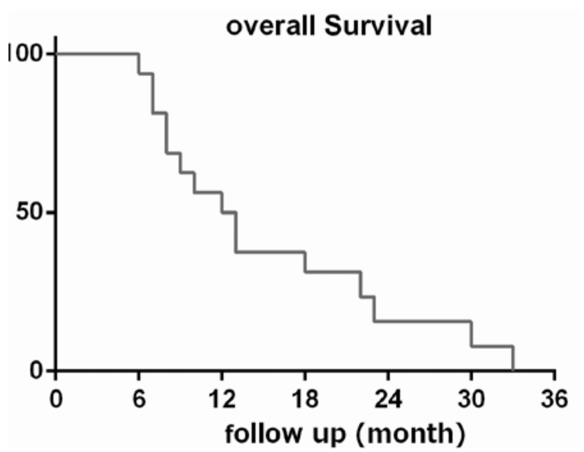


Fig. 7. *Overall survival curve.*

the second most common site of bone metastasis after the centrum. One reason for this is that the proximal femur is richly vascularized due to the persistence of red marrow, since the proximal femur is one of the last areas in the lower appendicular skeleton to retain red bone marrow, which itself is richly vascularized (10,11). Traditional treatments for proximal femoral metastasis involve radiotherapy, local tumor resection with internal fixation, and proximal femoral resection with hip prosthetic replacement. Radiotherapy has neither an immediate curative effect nor does it effectively repair osteolytic damage caused by bone metastases. Many patients with advanced cancer are not able to tolerate these high-risk or intense surgical procedures.

PVP has been widely applied in the treatment of lesions in the cervical, thoracic, and lumbar vertebrae. One previous study reported pain alleviation in 82% of patients and recovery of mobility in 52% of patients with vertebral fractures caused by malignant metastases after treatment with PVP (3). In recent years, the same percutaneous approach used to instill PMMA for PVP has also been widely used to treat proximal femoral metastases via PFP. However, all previously reported cases involved bone cement leakage, a common complication that is hard to avoid under conventional fluoroscopy (9,12,13). Due to the particular location of bone metastases, more than one C-arm is usually required. However, the use of more than one C-arm typically requires that a patient be kept in one position during surgery. This restriction is uncomfortable for the patient and is known to cause pain.

Because of these fluoroscopic limitations, CT has been used for targeted therapy. CT-guidance for PVP (or PFP) procedures allows for precise placement of bone cement injection. Therefore, the use of CT guidance in PVP has been shown to reduce the risk of complications in comparison with conventional fluoroscopy alone as well as to facilitate the detection of small amounts cement leakage (7,8,14-16).

In our study, effective pain relief following CT-guided PFP was quite obvious, with a significant reduction in VAS scores at the postoperative follow-ups. Moreover, the significant increase in the BIADL scores of patients postoperatively indicates that patients' self-care abilities were effectively improved. Filling of the osteolytic lesion with sufficient bone cement to achieve stabilization of the bone should prevent further pathological fracture. Overall, our results provide a preliminary demonstration of the relative safety, effectiveness, and feasibility of CT-guided PFP.

Several indications and contraindications must be considered before CT-guided PFP is applied in the treatment of proximal femoral metastasis. First, the patient must be able to tolerate this type of surgery. Steady vital signs must be observed, and they should not have other complications such as adjacent or overlying infection, severe heart disease, or severe lung disease. Secondly, the lesion must be osteolytic. Because osteogenic bone metastases are usually limited to a small localized volume, we can perform surgical excision to completely remove the tumor, radiofrequency ablation (RFA), or focused radiation. Finally, to avoid leakage of bone cement, the cortex around the lesion, especially in the calcar femorale, must be complete and without pathological fracture. Notably, patients with osteoblastic metastases and those patients whose epiphyseal line is not healed are not good candidates for this procedure. Also, given that a great amount of bone cement is injected through the trocar, the injection must be completed before the bone cement begins to solidify. During surgery, it is critical to monitor the patient's pulse, heart rate, and oximetry closely in order to identify and treat a pulmonary embolism in a timely manner. Bone cement leakage is a potentially common complication of PFP even under CT guidance, and once it occurs, the procedure should be halted and the needle should be adjusted under CT guidance to prevent further leakage.

## References


1. Hage WD, Aboulafia AJ, Aboulafia DM. Incidence, location, and diagnostic evaluation of metastatic bone disease. *Orthop Clin North Am* 2000; 31:515-528.
2. Janjan N. Bone metastases: Approaches to management. *Semin Oncol* 2001; 28:28-34.
3. Shimony JS, Gilula LA, Zeller AJ, Brown DB. Percutaneous vertebroplasty for malignant compression fractures with epidural involvement. *Radiology* 2004; 232:846-853.
4. Saliou G, Kocheida EM, Lehmann P, Depriester C, Paradot G, Le GD. Percutaneous vertebroplasty for pain management in malignant fractures of the spine with epidural involvement. *Radiology* 2010; 254:882-890.
5. Chang SW, Murphy KP. Percutaneous CT-guided cementoplasty for stabilization of a femoral neck lesion. *J Vasc Interv Radiol* 2005; 16:889-890.
6. Feng H, Feng J, Li Z, Feng Q, Zhang Q, Qin D, Chen W, Li Z, Zhang Y. Percutaneous femoroplasty for the treatment of proximal femoral metastases. *Eur J Surg Oncol* 2014; 40:402-405.
7. Caudana R, Renzi BL, Ventura L, Aitini E, Rozzanigo U, Barai G. CT-guided percutaneous vertebroplasty: Personal experience in the treatment of osteoporotic fractures and dorsolumbar metastases. *Radiol Med* 2008; 113:114-133.
8. Pizzoli AL, Brivio LR, Caudana R, Vittorini E. Percutaneous CT-guided vertebroplasty in the management of osteoporotic fractures and dorsolumbar metastases. *Orthop Clin North Am* 2009; 40:449-458.
9. Guo WH, Meng MB, You X, Luo Y, Li J, Qiu M, Liao ZY. CT-guided percutaneous vertebroplasty of the upper cervical spine via a translateral approach. *Pain Physician* 2012; 15:E733-741.
10. Menendez LR, Ahlmann ER, Kermani C, Gotha H. Endoprosthetic reconstruction for neoplasms of the proximal femur. *Clin Orthop Relat Res* 2006; 450:46-51.
11. Potter BK, Chow VE, Adams SC, Letson, GD, Temple HT. Endoprosthetic proximal femur replacement: Metastatic versus primary tumors. *Surg Oncol* 2009; 18:343-349.
12. Plancarte-Sanchez R, Guajardo-Rosas J, Cerezo-Camacho O, Chejne-Gomez F, Gomez-Garcia F, Meneses-Garcia A, Armas-Plancarte C, Saldaña-Ramirez G, Medina-Santillan R. Femoroplasty: A new option for femur metastasis. *Pain Pract* 2013; 13:409-415.
13. Plancarte R, Guajardo J, Meneses-Garcia A, Hernandez-Porras C, Chejne-Gomez F, Medina-Santillan R, Galindo-Hueso G, Nieves U, Cerezo O. Clinical benefits of femoroplasty: A nonsurgical alternative for the management of femoral metastases. *Pain Physician* 2014; 17:227-234.
14. Kim YI, Kang HG, Kim SK, Kim JH, Han SK. Clinical outcome prediction of percutaneous cementoplasty for metastatic bone tumor using (18)F-FDG PET-CT. *Ann Nucl Med* 2013; 27:916-923.
15. Pitton MB, Herber S, Bletz C, Drees P, Morgen N, Koch U, Böhm B, Eckardt A, Düber C. CT-guided vertebroplasty in osteoprotic vertebral fractures: Incidence of secondary fractures and impact of intradiscal cement leakages during follow-up. *Eur Radiol* 2008; 18:43-50.
16. Vogl TJ, Proschek D, Schwarz W, Sietsma MS. CT-guided percutaneous vertebroplasty in the therapy of vertebral compression fractures. *Eur Radiol* 2006; 16:797-803.