Skeletal Radiology (2019) 48:1345–1355
https://doi.org/10.1007/s00256-019-3156-0

SCIENTIFIC ARTICLE

Cementoplasty of pelvic bone metastases: systematic assessment of lesion filling and other factors that could affect the clinical outcomes

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Received: 23 February 2018 / Revised: 7 January 2019 / Accepted: 9 January 2019 / Published online: 2 February 2019
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Abstract

Objectives To evaluate lesion filling and other factors that could affect the clinical outcomes of cementoplasty for pelvic bone metastases.

Methods We retrospectively reviewed the files of 40 patients treated for 44 pelvic bone metastases, collected the parameters related to patients (pain relief evaluated on a visual analog scale, subsequent fractures, and need for surgery), lesions (size, cortical breach score, fracture, soft-tissue extension), and cementoplasty procedures (number of needles, volume of cement, percentage of lesion filling, cement leaks, residual acetabular roof defect), and performed a statistical analysis.

Results The lesions were on average 43.2 mm in diameter and the mean cortical breach score was 2.5 out of 6, with a pathological fracture in 14 lesions. The number of needles inserted was one in 32 out of 44, two in 10 out of 44, and three in 2 out of 44. On average, the volume of cement injected per lesion was 10.3 ml and the filling was 54.8%. Mild or moderate asymptomatic cement leakage occurred in 20 lesions (45.5%). The mean pain score was 84.2 mm before the procedure (with no correlation with lesion size, cortical breach score or fracture) and 45.6 mm at follow-up. The pain relief of 38.6 mm was statistically significant ($p < 0.001$) and did not correlate with the filling percentage. There were no fractures of the treated lesions at a mean follow-up of 355 days.

Conclusions Cementoplasty of pelvic bone metastases appears effective for providing pain relief and may prevent subsequent fractures. We were unable to demonstrate a correlation between the lesion filling and the degree of pain relief.

Keywords Pelvic bone · Metastasis · Cementoplasty · Pain relief

Introduction

Cementoplasty of pelvic bone metastases is largely derived from vertebroplasty and aimed at providing bone support and pain relief [1–3]. Bone areas subjected to compressive stress are best suited to this technique and the acetabular location is the most frequently treated [4], hence the term percutaneous acetabuloplasty suggested by Weill et al. [2].

Cementoplasty of the pelvis is a minimally invasive procedure representing a valuable alternative to conventional surgery. Undeniably, reconstruction of the acetabulum is a major procedure entailing a high risk of complications (infection, instability, implant failure) in patients who often have limited life expectancy [4–6]. The results of cementoplasty have been reported in several case series, with pain relief in 82–100% of patients and reduction of pain scores measured on an analog visual scale of 20–60 mm [2, 3, 7–16].

The importance of lesion filling during cementoplasty of pelvic bone metastases has been briefly discussed in a few of these papers, essentially demonstrating no correlation with pain relief [2, 3, 10]. Also, the size of the lesion, the degree of cortical destruction and the presence of fracture or soft-tissue extension could complicate or even contraindicate the procedure for some authors, but it is not precisely known how they affect clinical outcomes [13, 14, 17]. Finally, techniques to improve lesion filling of large lesions and reduce the risk of extraosseous leakage have not been specifically described, to the best of our knowledge.

The purpose of this study was first to describe our technique of optimized bone filling through multiple injection

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needles and second to analyze lesion filling and other parameters that could influence the clinical outcome after cementoplasty of pelvic metastases.

Materials and methods

This study was approved by our institutional review board and patients' consent for the retrospective review of data was waived.

Patients

Through a search of our picture archiving and communication system (PACS), we identified the patients who underwent cementoplasty of the pelvis for metastatic disease from 2009 to 2016. There were 44 metastatic lesions in 40 patients (4 patients were treated for two lesions during the same procedure), including 21 women and 19 men with a mean age of 63 (range 35–91, SD 12.6). The primary cancer was lung ($n = 15$; 37.5%), breast ($n = 9$; 22.5%), kidney ($n = 7$; 17.5%), and others ($n = 9$; 22.5%), including thyroid; non-Hodgkin lymphoma, prostate, esophagus, colon, and nasopharynx. The location of these metastases was acetabular ($n = 30$; 68.2%), iliac ($n = 4$; 9.1%), sacral ($n = 3$; 6.8%) or involved the entire hemipelvis ($n = 7$; 15.9%). Most lesions categorized as hemipelvis and iliac either directly involved or weakened the acetabulum. Hence, cement augmentation of this area was deemed necessary in most of our patients. The laterality was right in 18 (40.9%) and left in 26 (59.1%) lesions. There were 38 (86.4%) osteolytic and 6 (13.6%) mixed metastatic lesions (Table 1).

All the patients included in this series were evaluated by a multidisciplinary team from a quaternary care hospital, including specialists in oncology and radiation oncology, orthopedic surgery, and musculoskeletal interventional radiology. The bulk of our patients were in palliative care after failure of other treatments and with no surgical indication. All of them had received radiation therapy before the cementoplasty procedure and presented with persisting pain. In the context of palliative care and refractory pain, there were only a few absolute contraindications to performing the procedure, such as major bone loss with disruption of the pelvic ring, displaced fracture of the acetabulum with severe protrusion of the femoral head, local infection, uncorrectable coagulation disorder, and the inability to tolerate the procedure. Patients were met by the interventional radiologist before the procedure and 1 month after, whenever possible. The overall survival time following the procedure was recorded from the patients' files.

Table 1 Patients' demographics and lesion types

Characteristics	Data
Demographics	
Gender (female/male)	21/19
Age, mean (range, SD)	63 (35–91, 12.6)
Type of cancer, *n* (%)	
Lung	15 (37.5)
Breast	9 (22.5)
Renal	7 (17.5)
Other (thyroid, non-Hodgkin lymphoma, prostate, esophagus, colon, and nasopharynx)	9 (22.5)
Lesions, *n* (%)	
Acetabular	30 (68.2)
Involving the entire hemipelvis	7 (15.9)
Iliac	4 (9.1)
Sacral	3 (6.8)
Right/left	18 (40.9)/26 (59.1)
Osteolytic/mixed	38 (86.4)/6 (13.6)

Cementoplasty procedure

The procedures were performed by two experienced radiologists either in a CT suite, using the CT device combined with a mobile C-arm unit, or in an angiography suite. The target and approach were planned on CT images. Prophylactic antibiotics (cefazolin 2 g or vancomycin 15 mg/kg in the case of allergy to beta lactams) were routinely administered before the procedure.

After sterile draping, local anesthesia and conscious sedation, 11- or 13-gauge needles 10 or 15 cm long (Osteo-Site bone biopsy needle set; Cook Medical, Bloomington, IN, USA) were percutaneously inserted into the lesion under imaging guidance. For acetabular lesions, the extremity of the needle is typically positioned in a location overhanging the femoral head for optimal bone support and the distance to the joint line varies between 1 and 3 cm, depending on the presence of articular communication (Fig. 1). In other locations, the needle is positioned in a way that allows filling of the lesion, but also anchoring cement in the surrounding bone. For larger lesions, typically over 40 mm in diameter, we routinely insert two or more needles concurrently to ensure adequate lesion filling. What we empirically consider to be optimal lesion filling is when at least 50% of the bone defect is filled with cement and when there is a vertical column of cement bridging the lesion or buttressing from the intact iliac bone to the subchondral acetabular bone (Figs. 2, 3, and 4).

The injection of radiopaque cement (SpinePlex; Stryker, Kalamazoo, MI, USA) with a precision delivery system (PCD; Stryker) was performed under fluoroscopy. Each system can deliver up to 10 ml of cement and therefore, two or more systems are required to treat large lesions. In this

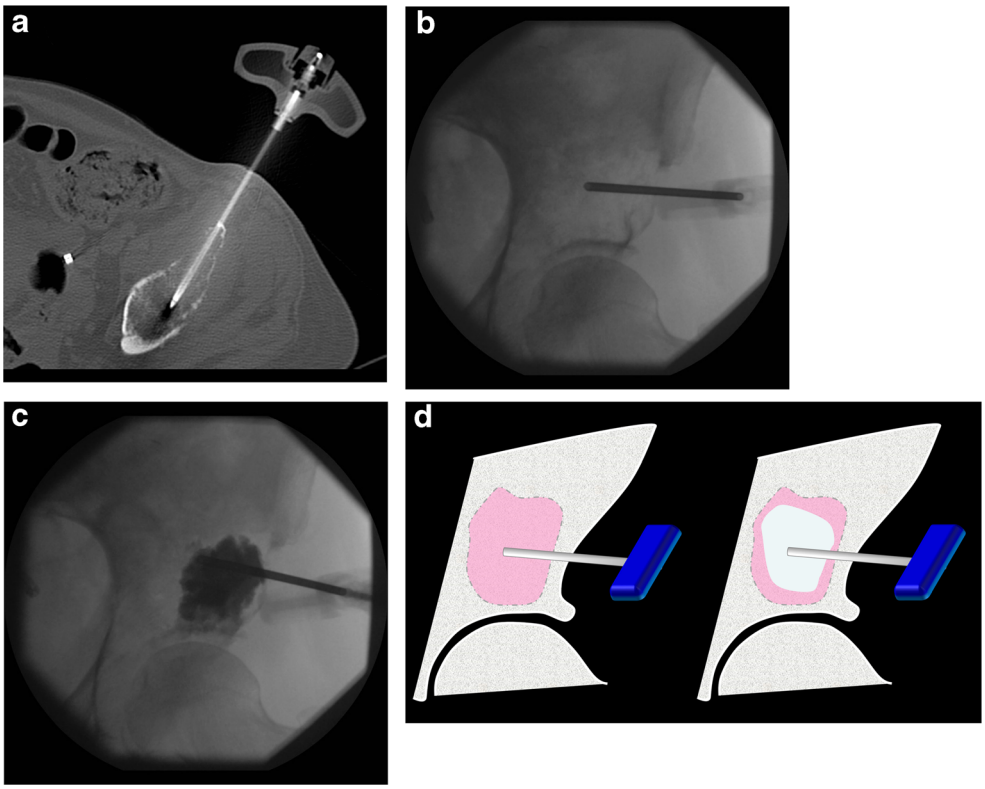

Fig. 1 A 50-year-old woman with metastatic lung cancer and painful acetabular lesions treated with cementoplasty. **a** Transverse CT image demonstrating the positioning of the 11G trocar needle in the lesion. **b**, **c** Anteroposterior C-arm fluoroscopy images demonstrating the positioning of the needle and the injection of 10 ml of cement filling the lesion. **d** Diagrammatic representation of the positioning of the needle and injection of cement

situation, we usually opt for the insertion of several needles and carry the injection of cement simultaneously through the different needles, the rationale being to obtain a single, more solid block of cement (Figs. 2, 3, and 4). Another advantage of this simultaneous injection technique is to reduce the fluoroscopy time, resulting in a less irradiative and faster procedure. The viscosity of the cement can be tailored to the type of lesion and the presence of cortical breaches by adjusting the mixing time between 90 and 120 s.

A CT was systematically obtained immediately after the procedure to document cement distribution. The images were reformatted in 2-mm sections at 1-mm intervals in all three major planes.

Patients were instructed to avoid weight-bearing for 2 h after completion of the procedure and to resume their activities progressively. A follow-up visit with the radiologist was scheduled at 1 month to evaluate the clinical outcome (pain relief, potential complications, and need for further treatment).

Evaluated parameters and statistical analysis

The patients' files in the PACS were reviewed by two radiologists in consensus and the following parameters were determined:

1. Pain relief corresponding to the difference in pre- and post-procedure pain scores rated on a visual analog scale from 0 to 100 mm. A decrease of 30 mm or more of the score was considered clinically relevant and indicated therapeutic response [18, 19].
2. Mean diameter of the lesion calculated by the sum of the three dimensions divided by three and volume estimated by the product of the three dimensions multiplied by 0.54
3. Harrington classification of acetabular defects [6]: class I (lateral, superior, and medial walls intact), class II (deficient medial wall), class III (deficient superior and lateral walls)
4. Cortical breach on a semiquantitative scale from 0 to 6, where each of the three cortices (external, internal, and articular or foraminal) is given a score of 0 (no cortical disruption), 1 (cortical disruption of less than 50% of the lesion diameter) or 2 (cortical disruption of 50% or more of the lesion diameter)
5. Extraosseous extension with soft-tissue mass
6. Pathological fracture through the lesion
7. Volume of cement injected, based on the report of the procedure
8. Percentage of lesion filling, based on a subjective evaluation of the postoperative CT
9. Residual acetabular roof defect after cementoplasty: absent (no defect, roof of the acetabulum normal or neoacetabulum), partial (defect of 50% or less) and significant (defect of more than 50%)
10. Extraosseous cement leakage, quantified as absent, mild, moderate or substantial
11. Occurrence of subsequent fractures or need for surgery in the treated area

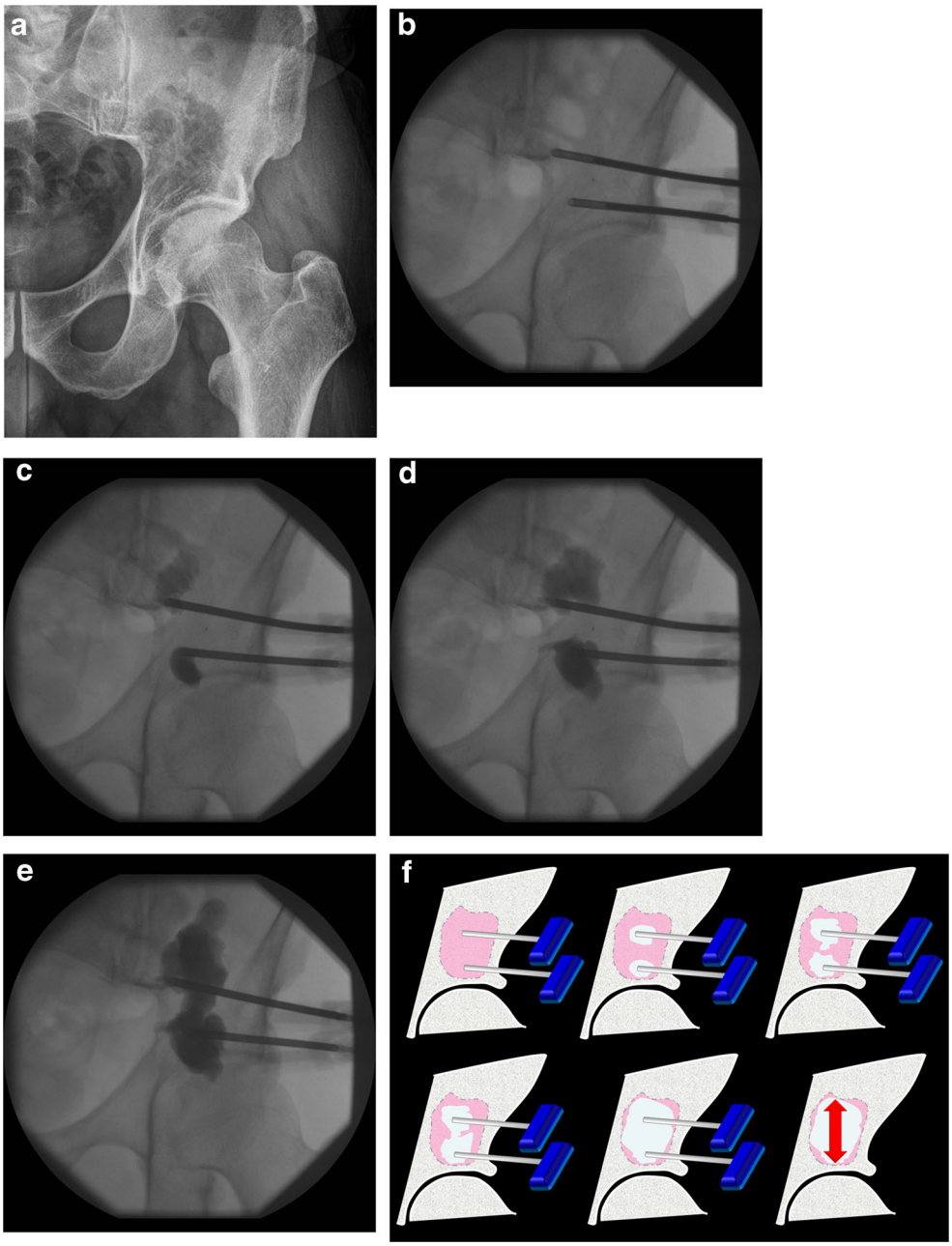

Fig. 2 A 56-year-old man with metastatic follicular thyroid carcinoma and a painful pelvic metastasis. **a** Anteroposterior radiograph showing the large osteolytic lesion involving the left hemipelvis. **b**–**e** Anteroposterior C-arm fluoroscopy images demonstrating the positioning of two 11G trocar needles in the lesion and the simultaneous injection of 20 ml of cement. The two streams of cement coalesce progressively to fill the lesion. **f** Diagrammatic representation of the double needle and simultaneous injection technique ensuring an optimized filling of large osteolytic lesions to increase bone strength. This patient experienced substantial pain relief with a decrease in the pain scores from 100 mm before the procedure to 50 mm at the 1-month follow-up visit

The statistical analysis was performed using SPSS version 24 (IBM corporation, Armonk, NY, USA) using the Mann–Whitney *U* test, Student's *t* test, ANOVA, and Spearman correlation.

Results

Lesions

The mean lesion diameter was 43.1 mm (range 20.7–82.0; SD 15.4) and the mean lesion volume was 46.9 cm^3 (range 3.9–213.4; SD 48.0). The mean cortical breach score was 2.6 out of 6 (range 0–6; SD 1.6) and a pathological fracture was present in 14 lesions (31.8%; Table 2). Soft-tissue invasion was present in 7 lesions (15.9%). Using the Harrington classification, of the 37 lesions involving the acetabulum, 4 lesions (10.8%) were class 1, 8 lesions (21.6%) were class 2, and 25 lesions (67.6%) were class 3.

Cement injection

On average, the volume of cement injected was 10.3 ml (range 3–27; SD 5.8) per lesion and the lesion filling was 54.8% (range 20–90%; SD 19.7; Tables 2, 3). The number of needles inserted was one in 32 lesions (72.7%), two in 10 lesions

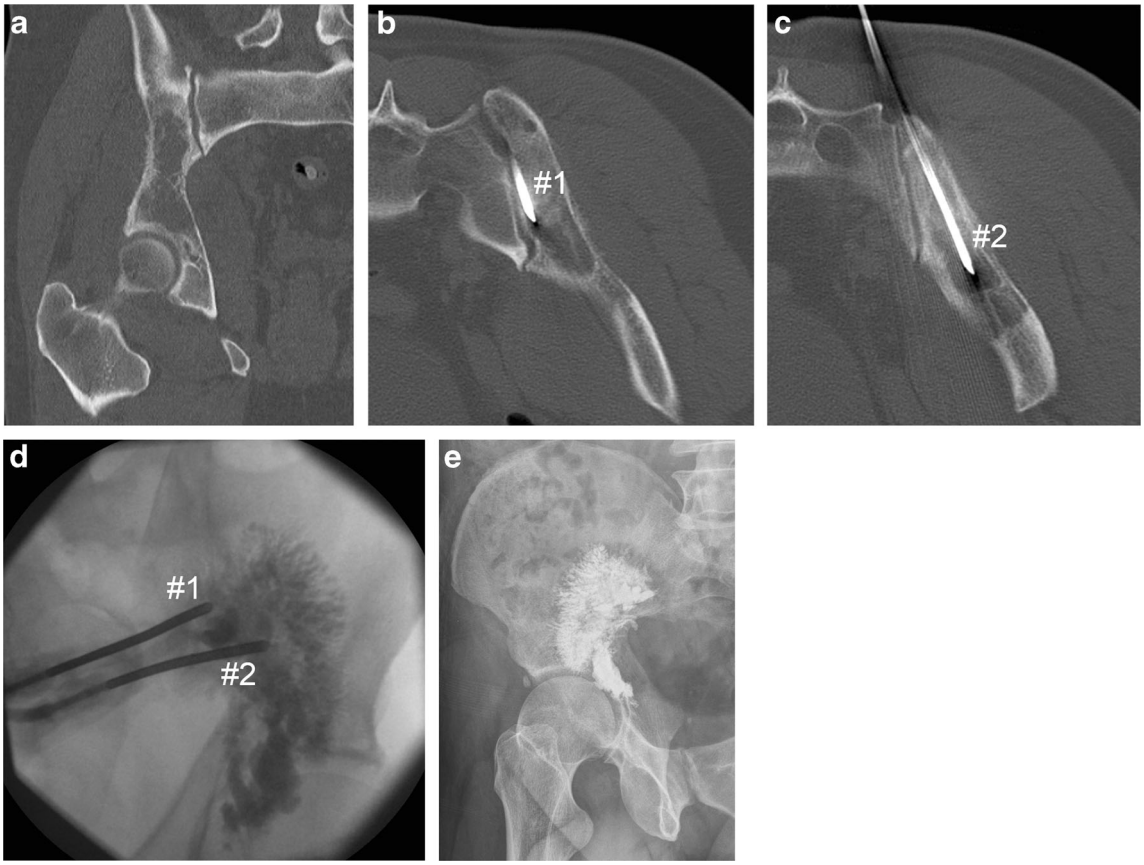

Fig. 3 A 53-year-old man with metastatic medullary thyroid carcinoma and a painful pelvic metastasis. **a** Coronal CT reformation showing the large osteolytic lesion involving the right hemipelvis. **b**–**d** CT images and posteroanterior C-arm fluoroscopy image demonstrating the positioning of two 11G trocar needles in the lesion and the simultaneous injection of 20 ml of cement. **e** Oblique radiograph of the hip demonstrating adequate filling of the lesion. This patient experienced substantial pain relief, with a decrease in the pain scores on a visual analog scale of 0 to 100 mm, from 100 mm before the procedure to 30 mm at the 1-month follow-up visit. *#1* first needle, *#2* second needle

(22.7%), and three in 2 lesions (4.5%). Of the 12 lesions in which multiple needles were inserted, the injection of cement through the different needles was sequential in 4 and simultaneous in 8 lesions. A moderate association was found between the size of the lesion and the number of needles inserted (R = 0.437; $p = 0.003$) and the volume of cement injected (R = 0.489; $p = 0.001$), larger lesions being more frequently treated with two or more needles and a superior amount of cement. However, the percentage of lesion filling did not increase with the number of needles inserted and remained relatively constant for lesions of different sizes.

Cement leakage was absent for 24 lesions (54.5%), articular for 6 lesions (13.6%), muscular or venous for 13 lesions (29.5%), and foraminal for one sacral lesion (2.3%). Based on their volume, 11 leaks were considered to be mild (55%) and 9 moderate (45%). None of them was symptomatic. No other complications occurred during the procedures. Cement leakage did not correlate with lesion size, number of needles, volume of cement injected or the percentage of lesion filling.

The residual acetabular roof defect after cementoplasty was absent in 13 patients (32.5%), partial in 20 patients (50%), significant in 2 patients (5%), and not applicable in 5 patients in whom the acetabulum was not involved (12.5%).

Pain scores

Among the patients treated, 23 (57.5%) died with a median survival of 355 days (10 patients died before 120 days); 8 (20%) were still alive and 9 (22.5%) were lost to post-procedural follow-up. None of our patients presented with subsequent fracture in the area treated with cementoplasty (Tables 2, 3). One patient experienced a contralateral femoral neck fracture requiring surgery. Another patient was operated after a year for a total hip replacement with Harrington reconstruction of the acetabulum.

For 32 patients with complete pain information, the pain score was on average 84.2 mm (range 30–100; SD 18.1) before and 45.6 mm (range 0–90; SD 23.6) after the procedure, resulting in a mean pain relief of 38.6 mm (range 0–100; SD 23.6). This difference was statistically significant ($p < 0.001$). Of these 32 patients, 25 (78.1%) had clinically relevant pain relief of 30 mm or more (median 48.4 mm; range 30–100; SD

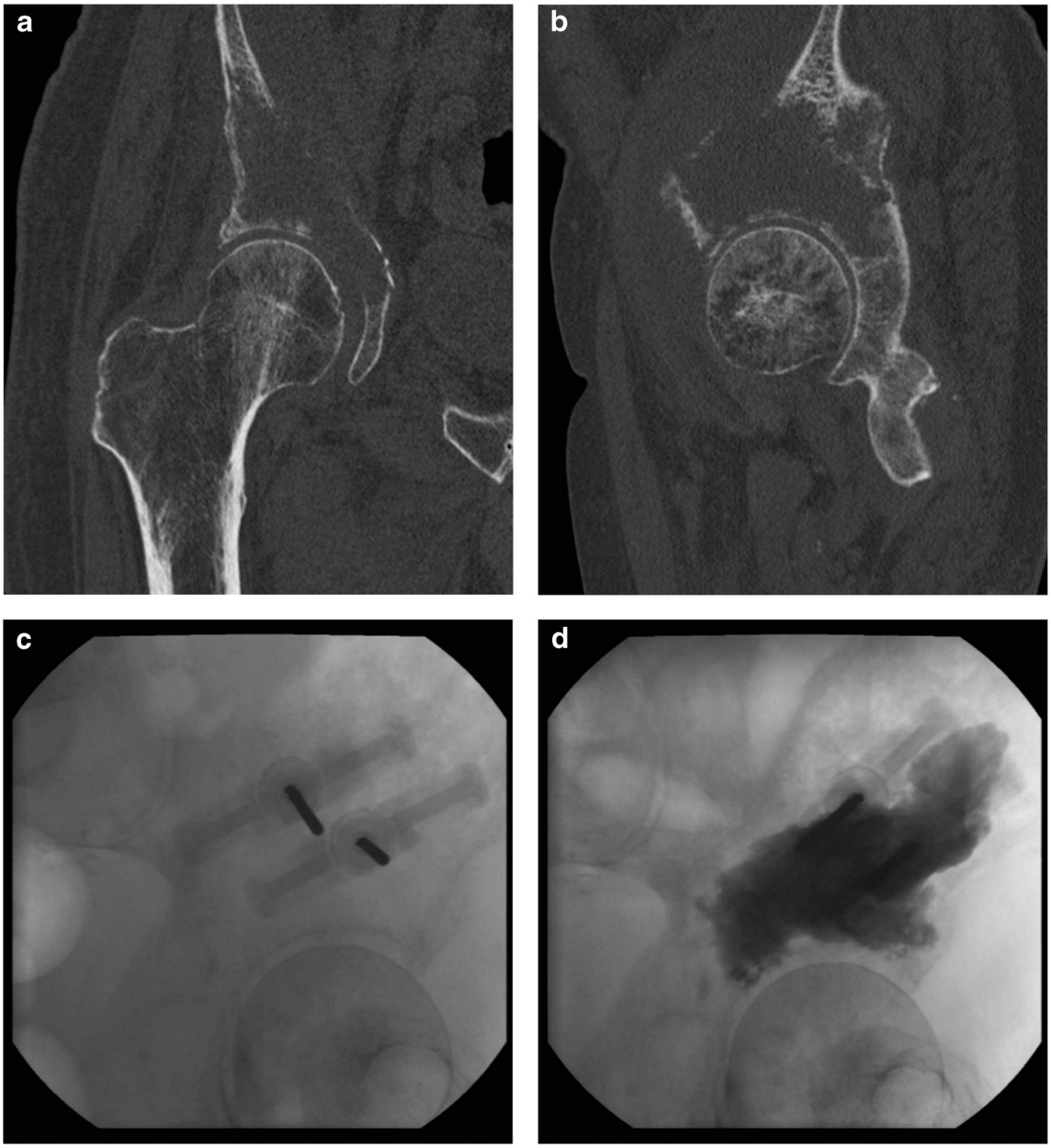

Fig. 4 An 85-year-old man with metastatic lung cancer and painful pelvic metastasis. **a**, **b** Coronal and sagittal CT reformation showing the large osteolytic lesion involving the right acetabulum with anterior and medial cortical breaches (Harrington class III). **c**, **d** Posteroanterior C-arm fluoroscopy images demonstrating the positioning of two 11G trocar needles in the lesion and the simultaneous injection of 20 ml of cement resulting in adequate filling of the lesion with no extraosseous leakage

17.0). There was no correlation between the pain relief and the percentage of lesion filling (R = 0.294; $p = 0.102$). Of the 7 patients who had a pain relief of less than 30 mm, 5 died before 120 days. Conversely, among the 10 patients who died before 120 days (range 18–120), the mean pain relief was 21.0 mm (range 0–40; SD 17.3;) and only 5 (50%) had a pain relief of 30 mm or more. There was a statistically significant moderate correlation between the pain relief and the survival time (R = 0.529; $p = 0.014$). The pain relief also had a moderate inverse correlation with age (R = −0.419; $p = 0.019$).

The pain score before the procedure did not correlate with the size of the lesion, the cortical breach score, the Harrington classification of acetabular defect, the presence of a fracture, and had a low correlation with soft-tissue invasion (R = 0.378; $p = 0.03$).

Discussion

This study confirms that cementoplasty is an effective technique for providing substantial pain relief in most patients

Table 2 Parameters evaluated in 40 patients treated with cementoplasty for 44 pelvic bone metastases

Parameters	Data
Lesions	
Lesion diameter	43.1 mm (range 20.7–82.0; SD 15.4)
Lesion volume	46.9 cm^3 (range 3.9–213.4; SD 48.0)
Cortical breach score	2.6/6 (range 0–6; SD 1.6)
Pathological fracture	14 lesions (31.8%)
Soft-tissue invasion	7 lesions (15.9%)
Harrington classification for 37 lesions	Class 1 in 4 lesions (10.8%), class 2 in 8 lesions (21.6%), class 3 in 25 (67.6%)
Cement injection	
Volume of cement	10.3 ml (range 3–27; SD 5.8)
Lesion filling	54.8% (range 20–90%; SD 19.7)
Number of needles	One in 32 (72.7%), two in 10 (22.7%) and three in 2 (4.5%)
Multiple needles injection for 12 lesions	Sequential in 4 and simultaneous in 8
Cement leaks for 20 lesions	Absent in 24 (54.5%), articular in 6 (13.6%), muscular or venous in 13 (29.5%) and foraminal in 1 (2.3%); all asymptomatic (mild in 11 [55%], moderate in 9 [45%], and significant in 0 [0%])
Residual acetabular roof defect	Absent in 13 (32.5%), partial in 20 (50%), important in 2 (5%) and not applicable in 5 (12.5%)
Pain scores	
Before treatment	84.2 mm (range 30–100; SD 18.1)
After treatment	45.6 mm (range 0–90; SD 23.6)
Pain relief	38.6 mm (range 0–100; SD 23.6)
Subsequent fractures and need for secondary surgery	Absence of subsequent fracture in the treated area
	One contralateral femoral neck fracture
	One arthroplasty of the hip performed one year after cementoplasty

with pelvic bone metastases, even after failure of other treatment modalities. We observed a therapeutic response in 78.1% of our patients with a mean pain relief of 38.6 mm. In comparison with previously published studies, these values fall within the lower range (Table 4) [2, 3, 7–15, 20].

Table 3 Correlations between pain relief and evaluated parameters in 32 patients

Parameter	Correlation with pain relief
Lesion diameter	$R = 0.050$; $p = 0.786$
Lesion volume	$R = 0.087$; $p = 0.635$
Harrington's type of acetabular defect	$R = 0.043$; $p = 0.828$
Cortical breach score	$R = 0.197$; $p = 0.280$
Extension to soft tissues	$R = 0.181$; $p = 0.322$
Pathological fracture	$R = 0.019$; $p = 0.920$
Volume of cement	$R = 0.107$; $p = 0.562$
Percentage of lesion filling	$R = 0.294$; $p = 0.102$
Residual acetabular roof defect	$R = 0.302$; $p = 0.093$
Extra osseous cement leakage	$R = 0.208$; $p = 0.254$
Survival	$R = 0.529$; $p = 0.014$

However, there is a marked heterogeneity in the evaluation criteria and associated treatments, making the comparison of these studies difficult. In addition, we included numerous patients with advanced metastatic disease and severe pain that were refractory to other treatments, including radiation therapy, and observed that patients with a survival time lower than 120 days responded less well. In this subset of patients, only half experienced clinically relevant pain relief.

We described our approach to optimizing cement filling of the largest lesions with the insertion of two or three needles and the simultaneous injection of cement (Figs. 2, 3, and 4). To the best of our knowledge, this technique has not been described previously. Earlier in our practice, we observed that sequential injection through several needles does not always allow the coalescence of the cement streams, which was thought to be more stable. Another pitfall to avoid with a sequential injection is the leakage of cement along the tract of the first needle (Fig. 5). Therefore, if sequential injection is performed, we recommend leaving the first needle inserted with the stylet while injecting through the second needle. Injecting simultaneously through several needles produces a more compact and solid block of cement and reduces the radiation exposure of the operator and the patient. This

Table 4 Studies evaluating the therapeutic response of cementoplasty for pelvic bone metastases

Reference	Lesions (patients)	Therapeutic response (%)	Delta VAS (mm)	Cement volume (ml)	Lesion filling (correlation with pain relief)	Symptomatic cement leaks	Associated treatments[c]
Cotten et al. [3]	12 (11)	82	20[b]	15	N/A (no)	0	± Radiation therapy
Weill et al. [2]	18 (18)	83	N/A	10	50% (no)	2	± Radiation therapy, embolization
Marcy et al. [11]	18 (18)	89	32[b]	6	N/A	0	N/A
Hierholzer et al. [12]	4[a](5)	100	50	15	N/A	0	N/A
Anselmetti et al. [7]	25[a] (50)	100	70	6	N/A	0	± Radiofrequency ablation
Basile et al. [8]	6[a] (13)	100	45	3.5	N/A	0	± Radiofrequency ablation
Maccauro et al. [13]	30 (25)	100	58	N/A	N/A	0	± Surgery
Scaramuzzo et al. [14]	24 (20)	95	N/A	N/A	N/A	0	± Surgery
Gupta et al. [15]	11 (11)	82	60	N/A	N/A	0	
Iannessi et al. [10]	13[a] (20)	80	41	4.3	50% (no)	0	
Botton et al. [9]	20[a](42)	84	N/A	6	N/A	0	± Radiation therapy
Colman et al. [20]	11 (11)	N/A	40	N/A	60%	0	± Embolization, radiation therapy
Choi et al. [16]	(42)	100	31	21	N/A	0	± Surgery
Current study	44 (40)	78	39	10	55% (no)	0	Radiation therapy

VAS visual analog scale

[a] Only pelvic lesions were considered in these case series including multiple locations

[b] Delta VAS was extrapolated by converting the rheumatological scoring system (1–5)

[c] We included cases series with optional radiofrequency ablation, but not those with systematic combination

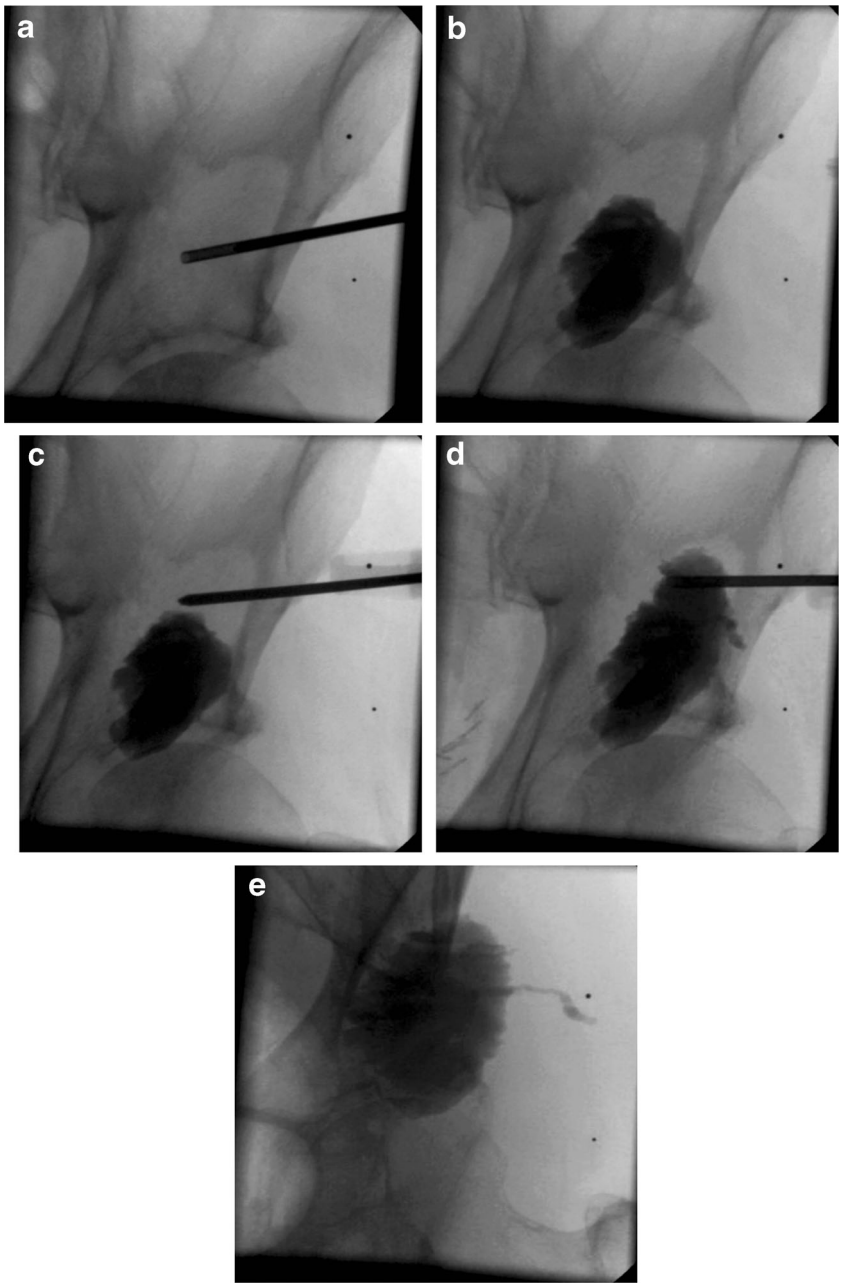

Fig. 5 A 67-year-old man with metastatic renal cell carcinoma and a painful pelvic metastasis. Posteroanterior fluoroscopy images demonstrating **a** the positioning of a first 11-G trocar needle in the osteolytic acetabular lesion and **b** after injection of 10 ml of cement with incomplete lesion filling. It was decided **c** to insert a second needle and **d** to sequentially inject an additional 9 ml of cement. **e** The final image shows satisfactory filling of the lesion with cement and a small cement leak along the tract of the first needle. This could be prevented by not removing the first needle until the injection through the second needle is complete

technique could be seen to be more challenging because it requires two or more operators and the monitoring of different streams of cement, but is actually feasible. Cementoplasty of pelvic bone metastases is relatively safe and we observed only minor complications represented by frequent but asymptomatic cement leaks. Symptomatic cement leaks requiring surgical removal have been uncommonly reported in the literature and in this regard, the most critical locations include the hip joint, the sciatic nerve within the sciatic notch and at the posterior aspect of the acetabulum, and the sacral nerve roots in their foramina [2, 21].

With this technique, the percentage of lesion filling was on average 54.8%, which is comparable with two other published studies [2, 10]. In line with these studies and a study of vertebroplasty for malignant lesions [22], we observed that the pain relief was not proportional to the filling percentage. However, the motivation to optimize the lesion filling and manage large lesions in our patients was not only to control pain, but also to reinforce bone to allow the best possible quality of life by allowing weight-bearing and reducing the risk of subsequent fractures. The absence of subsequent fractures in the areas we treated tends to support this hypothesis. Unfortunately, there is not much evidence on the optimal cement filling of metastatic lesions. Several experimental and clinical studies on vertebroplasty of osteoporotic fractures have estimated that between 20 and 30% filling would be

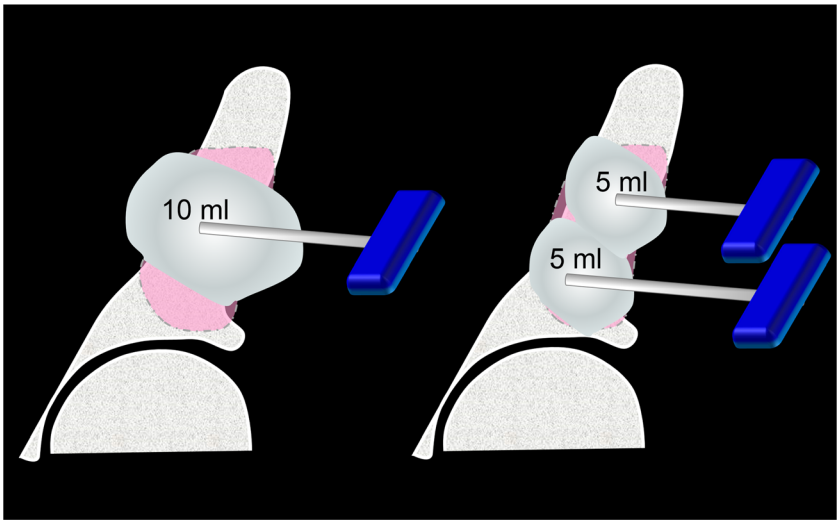

Fig. 6 Diagram illustrating the advantages of the multiple injection technique to reinforce the anterior and superior acetabular bone in the presence of cortical destruction (Harrington class III). For an equivalent volume of cement injected through two needles, the distribution is more satisfactory, resulting in a buttress between the intact bone and subchondral plates with minimal extraosseous leaks. An alternative technique for obtaining this kind of distribution would be to inject the cement step by step while withdrawing the needle, but this approach is not convenient along the vertical axis of the iliac wing and may be limited by the volume of cement available in the delivery system

appropriate to provide pain relief and restore bone strength and stiffness [23–26]. It is unlikely that these results can be applied to the cementoplasty of pelvic metastases because of a different pathological condition and bone geometry. Finite element studies have shown that a large portion of the compressive stresses are supported by the anterior and superior acetabular bone, mostly through the cortical shell [27]. Therefore, it is logical to restore the load transfer by buttressing the subchondral bone with cement up to the intact trabeculae and aligning several needles along this vertical axis is in our opinion an effective way to control the cement distribution and bridge the bone defect (Fig. 6).

A potential limitation of our study is its retrospective descriptive nature, with no comparison with other treatment such as surgery. However, this would not be feasible in these patients and our series of pelvic cementoplasties is one of the largest reported so far. The heterogeneity of the disease and treatments in these patients also makes the evaluation of cementoplasty extremely difficult, because the pain can be related to other bone lesions and respond to other simultaneous treatments, such as chemotherapy, pain medications, and radiation therapy. We were not able to evaluate the influence of the filling percentage on the risk of subsequent fractures because no such fractures were observed in our series, but we strongly believe that it is important to always attempt a biomechanically meaningful bone reinforcement. For this purpose, the multiple needle technique seems useful, particularly in bone areas subjected to compressive stress where it could be utilized alone. To reinforce bone areas subjected to tensile stress and particularly in patients with severe bone involvement and pelvis disruption (in such cases classified as entire hemipelvis in our study, the current trend is to combine cement injection with percutaneous screw fixation) [28, 29].

In summary, we confirmed that percutaneous cementoplasty is an effective procedure for obtaining pain relief in patients with pelvic bone metastases, and described an optimized lesion filling with the simultaneous injection of cement through two or more needles, which could be useful for treating larger lesions with a low risk of complications. However, in line with previous studies, we were unable to demonstrate a correlation between lesion filling and the degree of pain relief.

Acknowledgements The authors wish to thank Sepideh Babaei, MD, for the editorial assistance provided during the preparation of this manuscript.

Compliance with ethical standards

Conflicts of interest The authors declare that they have no conflicts of interest.

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