Osteoplasty: Percutaneous Bone Cement Injection beyond the Spine

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ABSTRACT

Percutaneous osteoplasty, the injection of bone cement into a painful bone lesion refractory to conventional therapy (radiotherapy, chemotherapy, and narcotic analgesia), is performed to allow for immediate bone structure consolidation, reduce the risk of a pathological fracture, achieve pain regression, and improve mobility. In this article, the technique of this procedure and a review of the current literature including the author's personal large series will be described.

KEYWORDS: Osteoplasty, percutaneous, spine, cement

Objectives: Upon completion of this article, the reader should be able to list the correct indications for percutaneous osteoplasty, to recall minimally invasive techniques for percutaneous osteoplasty, and to manage bone pain refractory to conventional therapies.

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Bone is one of the most frequent sites of spread for many common cancers such as breast, prostate, lung, and kidney, and bone is usually affected in multiple myeloma. When appropriate systemic treatment for the underlying cancer fails (usually hormonal treatment or chemotherapy), patients are considered for specific treatment, the principal modalities being radiotherapy and bisphosphonates.¹ Radiotherapy reduces bone pain in ~60% of patients²; bisphosphonates, particularly zoledronic acid, are effective in breast cancer, multiple myeloma, and prostate cancer and most likely are active in a similar way in bone metastases from other sites, but the benefit may not be apparent because of shorter survival.³ On the whole, bone metastases and their skeletal related events are not controlled in ~20 to 40% of cancer patients,⁴⁻⁶ and the current therapeutic

regimens leave up to 45% of patients with inadequate or undermanaged pain control.^{7,8} This failure prompted the search for other treatment aimed at pain control through local tumor ablation such as percutaneous radiofrequency thermoablation (RFA), cryoablation,⁹⁻¹¹ microwaves,^{12,13} percutaneous osteoplasty (PO),¹⁴⁻¹⁶ and, more recently, magnetic resonance-guided focused ultrasound (MRgFUS).¹⁷ The results of the only large multicenter trial on RFA demonstrated a clinically significant reduction in pain in 95% of patients with a reduction of the usage of opioids,⁹ and ongoing studies about cryoablation as well as preliminary studies on microwaves and MRgFUS are promising. Unfortunately, these ablative procedures (RFA, cryoablation, microwaves, and MRgFUS) have a delayed effect on pain but they do not consolidate bone structure as early results; the

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consequence is that these ablative procedures are not the best choice when an impending fracture is treated. Since Galibert and colleagues first described that vertebroplasty was successful in the treatment of a painful vertebral body hemangioma,¹⁸ this procedure has been widely applied and is now frequently performed for the treatment of painful benign and malignant lesions of the spine.^{19–23} Although it is proven that the procedure has excellent and durable clinical results if performed in the vertebra,^{24,25} there are few studies showing a good clinical outcome on the same technique applied on other bones^{14,16,26} or performed in combination with RFA.^{27,28}

PO, the injection of bone cement into a painful bone lesion refractory to conventional therapy (radiotherapy, chemotherapy, and narcotic analgesia), could determine immediate bone structure consolidation, reduce the risk of a pathological fracture, achieve pain regression, and improve mobility.

MATERIALS AND METHODS

Indications

Inclusion criteria normally are:

- Patients with intense and focal pain associated with the evidence on plain X-ray films and computed tomography (CT) or magnetic resonance imaging of osteolytic bone lesion with or without impending bone fractures;
- Unsatisfactory response to conventional pain therapy;
- Life expectancy of more than 3 months;
- Age of more than 18 years and good mental conditions;
- Provided informed consent.

Exclusion criteria are:

- Noncorrectable coagulation disorders (platelets $\leq 90,000$, international normalized ratio ≥ 1.50);
- Systemic or local infection;
- Distance between the lesion and vessels or vital organ of less than 10 mm.

Lost integrity of the cortical bone is not an exclusion parameter.

Technique

Osteoplasty can be performed under digital fluoroscopy guidance or, in most cases, under combined CT and fluoroscopic guidance. Recently, state-of-the-art flat-panel angiography with rotational acquisition and two-dimensional reconstruction were successfully employed in this procedure.

Normally, the patients are positioned on a multi-slice CT scanner or onto the cradle in the angiographic

room either in the prone or supine position (according to the lesion site). Sterile conditions are mandatory and need to be respected; if combined CT-fluoro guidance is chosen, a digital mobile C-arm is normally placed in front of the CT gantry to allow fluoroscopic monitoring of acrylic cement injection. For osteoplasty, local anesthesia or mild sedation is necessary; otherwise, deep sedation is needed when a preliminary tumor ablation (RFA, etc.) is planned. Monitoring of heart rate, blood pressure, and pulse oximetry need to be performed continuously throughout the procedure.

After the target bone lesion is precisely localized on CT images, then the most adequate access point is identified (it could be done by placing a metallic radiopaque marker on the skin; Fig. 1). Angle and distance from skin to lesion can be easily calculated, and local anesthesia is administered along the tract using a 22-gauge spinal needle with 5 mL of 2% lidocaine hydrochloride. After performing a small skin incision at the puncture site, a dedicated vertebroplasty beveled needle of 15- to 10-gauge diameter is advanced into the bone lesion. The bevel tip is preferable as this feature allows easy repositioning and precise steer of the needle. In most cases, the simple pressure of the operator's hands on the needle is successful to correctly place the needle into the lesion; if an approach through a hard cortical bone (some cases when radiotherapy was previously performed) is necessary, gently hammering with a mallet on the needle can be useful. CT scans are then performed to assess the correct position of the needle tip inside the lesion (Fig. 2). Positioning the needle in the center of the lesion is recommended to avoid or reduce the potential risk of polymethyl methacrylate (PMMA) leakages.

Figure 1 The most adequate approach can be identified by placing a metallic radiopaque marker on the skin; distance from the entry point to the center of the lesion can be measured.

Figure 2 After needle insertion, computed tomography scan demonstrates the correct needle position inside the lesion.

During needle placement, it is possible to confirm the diagnosis by a core biopsy using an 18- to 16-gauge through-cut biopsy needle inserted coaxially through the vertebroplasty needle. Once the needle is in the correct position, it is possible to start bone cement injection.

For bone metastases, PMMA can be successfully used, whereas for benign lesions, a biological osteoconductive calcium-phosphate bone cement is preferable. Either a sterile 3-, 5-, or 10-mL luer-lock polypropylene syringe or a pressure injector can be used to inject the cement into the bone lesion. After PO, it is important to acquire CT scan of the treated region to assess the extent of lesion filling and to visualize possible PMMA leaks (Fig. 3). More than one lesion can be treated during the same session depending upon operator experience and patient compliance (Fig. 4). It is possible to treat small painful lesions as well as large lesions (more than 10 cm

Figure 3 After osteoplasty, a computed tomography scan of the treated region assesses the extent of lesion filling and visualizes possible polymethyl methacrylate leaks or complications.

Figure 4 More than one lesion (arrows) can be treated in the same session.

diameter); in large lesions, a combined ablative treatment (RFA, cryoablation, etc.) can be useful to reduce the tumoral bulk. Even if the best radiological (not clinical!) result seems to be the full cement replenishment of the lesion, a good clinical outcome can be achieved with partial lesion injection only. In our experience, partially injecting the normal surrounding bone also, to stabilize the bone cement into the lesion, is a prediction of a favorable clinical result. In our personal series, the mean volume of bone cement injected in each lesion was 6.1 ± 3.4 mL (range 1.5 to 20.0 mL).

After the procedure, all the patients are asked to remain at rest for 1 hour, then they are allowed to gradually increase mobility. Normally, hospital discharge can occur within the same procedural day, although an overnight stay is advised in patients who undergo PO plus ablation. A postoperative broad-spectrum prophylactic antibiotic treatment needs to be maintained for 5 days.

Personal Series

Since June 2002, 105 patients (59 women, of mean age 63.7 ± 12.2 years, range 33 to 92) were treated with PO

in our institute on 140 painful bone lesions (130 malignant and 10 benign). All the patients were referred to our institution because of pain resistant to conventional treatment, including opioids, chemotherapy, hormone therapy, and radiotherapy. Informed consent was obtained before study inclusion from all patients. Malignant lesions were metastases from: breast, lung, kidney, colon, thyroid, bladder, gastrointestinal stromal tumor, prostate, stomach, lymphoma, ovary, and myeloma. Benign lesions were aneurysmatic bone cyst (four patients), enchondroma (two), geodes in rheumatoid arthritis (one), and posttraumatic pseudarthrosis (two). The number of treated lesions varied from one to six; 82/105 patients had 1 lesion (78.1%), 15 had 2 (14.4%), 6 had 3 (5.7%), 1 had 4 (0.9%), and 1 had 6 (0.9%) for a total of 140 lesions. In malignancy, osteoplasty was performed with PMMA; for benignant lesions, we injected a biological calcium-phosphate bone cement. Patient data are detailed in Table 1.

Follow-up

After the procedure, technical success and complications were recorded for all patients. Each subject was asked to prospectively quantify pain on an 11-point numeric visual analog scale (VAS) with values from 0 to 10 (where 10 indicates the strongest pain ever experienced and 0 absence of pain) before treatment, the day after treatment, after a week, and subsequently on a monthly basis by telephone interview.²⁹

A difference in VAS equal to or more than 2 points, meaning at least a 30% reduction of pain, was considered a clinically significant result, as reported in previous studies.³⁰ Pain medication (narcotic or nonsteroidal anti-inflammatory) before and after the intervention was also prospectively recorded in all patients.

Statistical Analysis

VAS score differences during follow-up were assessed using a two-tailed paired Student *t* test. Data, presented as mean $\pm$ standard deviation, were considered statistically significant at $P < 0.05$.

RESULTS

Treatment was technically successful in all cases. During the procedure, there were no significant changes in heart rate, blood pressure, and blood oxygen saturation. Six patients had minor periprocedural complications: two patients (1.9%) had transient nausea that resolved spontaneously after a few minutes and 11 patients (10.5%) had PMMA leakage in the soft tissues along the needle tract. Leakages were asymptomatic and did not require treatment. There were 2 (1.9%) delayed complications consisting in both cases of a femoral

diaphysis fracture after a month from PO, requiring open surgery.

Medium-term (9 months) follow-up results are presented in Table 2. Mean pre- and 9 months posttreatment VAS scores were respectively 8.7 ± 1.5 (range 4 to 10) and 1.9 ± 2.3 (range 0 to 9; $P < 0.0001$); mean difference was 6.8 ± 2.0 (range 1 to 10). Pain disappeared completely in 33 of 105 patients (31.4%). Administration of narcotics was suspended in 96/105 patients (91.4%) after PO treatment, whereas in 9/105 (8.6%), narcotic analgesia was continued because of pain persistence; in 36/105 patients (34.3%), residual pain was controlled by nonsteroidal anti-inflammatory drugs, and in the remaining 60 patients (57.1%), no analgesic therapy was necessary after the procedure.

DISCUSSION

Decreased mobility and pain are common symptoms in patients with advanced cancer with bone metastases. Combined treatment, including analgesics, systemic treatments such as hormonal therapy and chemotherapy, and specific treatments such as radiotherapy or bisphosphonates, can improve the performance status of patient with metastatic bone disease.³¹⁻³³ Nevertheless, these conventional treatments leave approximately one-third of cases with inadequate pain control.¹ Radiotherapy can reduce pain in $\sim 60\%$ of patients,² and bisphosphonates (particularly zoledronic acid) are effective in bone metastases but sometimes the benefit may not be achieved because of shorter survival.³ Conventional therapies leave up to 45% of patients with undermanaged pain control.^{7,8} Moreover, analgesics, frequently at the cost of unacceptable side effects, are often insufficient to improve mobility because of movement-induced pain.³⁴ Percutaneous ablation of symptomatic bone metastases have been proposed by several authors using different modalities, but these procedures cannot achieve immediate bone consolidation sometimes needed when an impending fracture is present. In few cases, conventional treatment of benign lesions are inadequate also, especially if the lesion is located in a weight-bearing bone. Good clinical outcome of percutaneous vertebroplasty in the treatment of vertebral malignant and osteoporotic lesions has encouraged us to use the same procedure in other bone districts.

This large case summary of PO performed on bones other than the spine seems to show the same good clinical outcome regarding analgesic therapy management, pain control, and mobility improvement.

PO, as well vertebroplasty, seems to be a safe procedure, also: It was technically successful in all cases, and no immediate severe complications were reported. Lesions with lost integrity of the cortical bone were also treated; an asymptomatic leakage of PMMA in the soft tissues was reported in only 11 of 105 patients (10.5%)

Table 1 Case Summary

Patient	Sex	Age (y)	Disease	No. of Lesion(s)	Lesion(s) Site and Average Diameter (mm)	Previous Analgesic Therapy	VAS Before	VAS after 9 mo	Analgesic Therapy after Treatment
M.A.	M	61	GIST	2	Femur, pelvic bone (93 mm)	Oral narcotic	10	0	None
G.M.	F	62	Breast Ca	2	Femur, pelvic bone (76 mm)	Oral narcotic	10	0	None
C.R.	M	63	Colon Ca	1	Sacrum (34 mm)	Transdermal narcotic	9	7	NSAID
R.B.	F	69	Breast Ca	1	Pelvic bone (32 mm)	Oral narcotic	8	1	None
O.C.	M	76	Colon Ca	1	Sacrum (34 mm)	Oral narcotic	10	2	NSAID
P.V.	F	43	Breast Ca	1	Femur (26 mm)	Oral narcotic	9	1	NSAID
R.C.	M	82	Lung Ca	1	Femur (72 mm)	Intravenous narcotic	9	1	None
G.E.	M	69	Colon Ca	1	Pelvic bone (35 mm)	Oral narcotic	9	3	NSAID
V.C.	M	57	Kidney Ca	1	Femur (73 mm)	Intravenous narcotic	10	2	None
F.M.	F	71	Kidney Ca	1	Knee (75 mm)	Oral narcotic	10	9	Oral narcotic
B.L.	M	59	Lung Ca	2	8th and 9th ribs (19 mm)	Intravenous narcotic	10	7	NSAID
B.L.	M	54	Kidney Ca	2	Femur, pelvic bone (55 mm)	Oral narcotic	10	4	NSAID
S.G.	F	55	Colon Ca	1	Sacrum (65 mm)	Intravenous narcotic	8	2	NSAID
P.M.	F	92	Breast Ca	1	Femur (20 mm)	Transdermal narcotic	10	2	None
R.A.	F	66	Breast Ca	3	Omerus, ribs (2) (19 mm)	Transdermal narcotic	10	2	None
B.S.	M	69	Kidney Ca	1	Tibia (30 mm)	Intravenous narcotic	8	2	NSAID
F.G.	M	73	NH lymphoma	1	Tibia (18 mm)	Oral narcotic	9	3	NSAID
B.V.	F	67	Ovarian Ca	1	Pelvic bone (34 mm)	Transdermal narcotic	8	2	NSAID
P.M.	M	55	Colon Ca	1	Pelvic bone (76 mm)	Transdermal narcotic	10	9	Oral narcotic
S.G.	M	79	Lung Ca	1	Pelvic bone (33 mm)	Intravenous narcotic	10	2	None
Z.M.	F	62	Thyroid Ca	1	Pelvic bone (34 mm)	Transdermal narcotic	8	0	None
B.L.	M	77	Lung Ca	3	Omerus, femur, knee (31 mm)	Intravenous narcotic	10	5	NSAID
R.V.	M	50	Kidney Ca	6	2 sacrum, 2 femur, pelvic bone, knee (33 mm)	Transdermal narcotic	8	0	None
P.G.	M	77	Lung Ca	1	Pelvic bone (35 mm)	Transdermal narcotic	8	1	None
M.V.	F	58	Breast Ca	1	Sacrum (33 mm)	Oral narcotic	8	0	None
S.T.	M	62	GIST	1	Scapula (31 mm)	Transdermal narcotic	10	2	NSAID
R.C.	M	54	Myeloma	1	Pelvic bone (35 mm)	Transdermal narcotic	6	0	None
B.R.	F	46	Lung Ca	1	Pubis (32 mm)	Oral narcotic	10	1	None
Z.A.	F	66	Lung Ca	2	Femurs (24 mm)	Transdermal narcotic	7	1	NSAID
S.N.	M	67	Prostate Ca	1	Pubis (19 mm)	Transdermal narcotic	9	0	None
F.V.	F	63	Breast Ca	3	Pelvic bone (2), femur (31 mm)	Transdermal narcotic	10	0	NSAID
G.M.	F	75	Thyroid Ca	2	Pelvic bone (33 mm)	Transdermal narcotic	10	2	NSAID
S.A.	F	78	Breast Ca	1	Sacrum (32 mm)	Oral narcotic	10	6	NSAID

Table 1 (Continued)

Patient	Sex	Age (y)	Disease	No. of Lesion(s)	Lesion(s) Site and Average Diameter (mm)	Previous Analgesic Therapy	VAS Before	VAS after 9 mo	Analgesic Therapy after Treatment
L.A.	M	69	Thyroid Ca	2	Sacrum, pelvic bone (13 mm)	Oral narcotic	10	2	NSAID
A.D.	M	83	Lung Ca	1	Pubis (35 mm)	Transdermal narcotic	10	1	None
Y.E.	F	43	Gastric Ca	1	Pelvic bone (76 mm)	Oral narcotic	10	5	NSAID
C.V.	M	60	Bladder Ca	1	Scapula (31 mm)	Transdermal narcotic	10	1	NSAID
M.S.	M	77	Lung Ca	1	Tibia (29 mm)	Transdermal narcotic	10	1	None
B.P.	M	71	Bladder Ca	1	Pelvic bone (35 mm)	Oral narcotic	10	1	None
R.G.	M	66	Lung Ca	1	Femur (21 mm)	Transdermal narcotic	9	0	None
B.P.	F	52	Breast Ca	1	Pelvic bone (33 mm)	Intravenous narcotic	10	9	Oral narcotic
B.G.	F	45	Breast Ca	1	Femur (19 mm)	Transdermal narcotic	8	1	None
B.M.	F	65	Thyroid Ca	1	Pelvic bone (34 mm)	Oral narcotic	7	0	None
G.M.	F	75	Thyroid Ca	1	Tibia (32 mm)	Oral narcotic	10	1	NSAID
O.M.	F	52	Breast Ca	1	Pubis (21 mm)	Oral narcotic	8	0	None
C.R.	F	55	Breast Ca	1	Pelvic bone (33 mm)	Oral narcotic	6	0	None
S.E.	F	62	Breast Ca	2	Femurs (19 mm)	Transdermal narcotic	9	1	NSAID
G.A.	M	70	Lung Ca	1	Femur (21 mm)	Transdermal narcotic	7	0	None
E.M.	F	53	Breast Ca	2	Sacrum, pelvic bone (34 mm)	Transdermal narcotic	10	2	NSAID
V.A.	F	80	Breast Ca	1	Femur (22 mm)	Transdermal narcotic	9	1	None
S.M.	F	41	Breast Ca	1	Pelvic bone (30 mm)	Transdermal narcotic	9	6	Oral narcotic
S.M.	F	78	Breast Ca	1	Sacrum (25 mm)	Transdermal narcotic	10	2	NSAID
I.C.	F	67	Colon Ca	1	Sacrum (28 mm)	Transdermal narcotic	10	9	Transdermal narcotic
M.S.	M	78	Lung Ca	1	Tibia (32 mm)	Transdermal narcotic	10	1	None
S.G.	M	69	Colon Ca	3	Acetabulum left and right (22, 19 mm), pelvic bone (15 mm)	Transdermal narcotic	10	2	None
M.A.	F	75	Kidney Ca	1	Femur (26 mm)	Transdermal narcotic	9	0	None
T.P.	F	60	Colon Ca	1	Iliac bone (30 mm)	Transdermal narcotic	10	5	Oral narcotic
G.R.	M	59	Lung Ca	1	Tibia (21 mm)	Transdermal narcotic	10	2	NSAID
R.G.	M	72	Kidney Ca	1	Sacrum (23 mm)	Intravenous narcotic	9	2	NSAID
S.F.	F	63	Breast Ca	1	Iliac bone (27 mm)	Transdermal narcotic	8	0	None
S.G.	F	53	Breast Ca	1	Iliac bone (31 mm)	Transdermal narcotic	7	1	None
D.S.	F	43	Breast Ca	1	Scapula (26 mm)	Transdermal narcotic	9	1	None
F.O.	F	66	Breast Ca	1	Iliac bone (32 mm)	Transdermal narcotic	7	0	None
T.G.	M	77	Thyroid Ca	1	Iliac bone (24 mm)	Transdermal narcotic	8	1	None

Table 1 (Continued)

Patient	Sex	Age (y)	Disease	No. of Lesion(s)	Lesion(s) Site and Average Diameter (mm)	Previous Analgesic Therapy	VAS Before	VAS after 9 mo	Analgesic Therapy after Treatment
V.V.	F	34	Breast Ca	1	Acetabulum (24 mm)	Oral narcotic	6	0	None
G.G.	M	70	Myeloma	1	Pubis (18 mm)	Oral narcotic	8	1	None
B.G.	M	65	Lung Ca	1	Iliac bone (32 mm)	Transdermal narcotic	4	0	None
B.M.	F	65	Bladder Ca	3	Iliac bone (32 mm), peroneal bone (34 mm), calcaneus (28 mm)	Transdermal narcotic	10	3	NSAID
C.E.	M	57	Lung Ca	1	Iliac bone (38 mm)	Intravenous narcotic	10	1	None
V.M.	F	58	Breast Ca	1	Acetabulum (42 mm)	Intravenous narcotic	10	3	NSAID
R.G.	M	53	Kidney Ca	1	Femur (48 mm)	Intravenous narcotic	10	1	NSAID
C.M.	F	70	Breast Ca	1	Calcaneus (35 mm)	Intravenous narcotic	10	1	None
L.D.	F	58	Breast Ca	1	Femur (50 mm)	Intravenous narcotic	6	0	NSAID
A.N.	F	60	Breast Ca	1	Knee (42 mm)	Intravenous narcotic	9	2	NSAID
U.F.	M	67	Prostatic Ca	1	Femur (38 mm)	Intravenous narcotic	9	0	None
N.C.	F	50	Myeloma	4	Omerus (28 mm), iliac bone (35 mm), femur (42 mm), acetabulum (31 mm)	Transdermal narcotic	8	0	None
G.C.	F	58	Breast Ca	1	Scapula (23 mm)	Transdermal narcotic	7	1	None
C.A.	F	66	Lung Ca	1	Acetabulum (26 mm)	Transdermal narcotic	10	1	None
P.S.	F	66	Breast Ca	2	Rib (11 mm), sternum (27 mm)	Oral narcotic	6	0	None
P.T.	F	61	Myeloma	2	Sacrum (50 mm), femur (43 mm)	Intravenous narcotic	8	3	NSAID
V.D.	M	70	Lung Ca	1	Femur (46 mm)	Intravenous narcotic	8	0	None
Z.M.	M	60	Kidney Ca	1	Femur (38 mm)	Transdermal narcotic	7	1	None
C.C.	M	50	Lung Ca	1	Acetabulum (61 mm)	Intravenous narcotic	10	6	NSAID
N.G.	M	70	Bladder Ca	1	Iliac bone (38 mm)	Transdermal narcotic	8	1	None
G.L.	F	54	Oropharyngeal Ca	1	Tibia (48 mm)	Intravenous narcotic	10	4	NSAID
L.G.	F	58	Breast Ca	2	Iliac bone (40 mm), acetabulum (32 mm)	Transdermal narcotic	5	0	None
N.M.	F	33	Chondrosarcoma	3	Iliac bone (45 mm), pubis (38 mm), acetabulum (25 mm)	Intravenous narcotic	8	2	NSAID
D.G.	F	44	Breast Ca	2	Acetabulum left and right (30, 25 mm)	Intravenous narcotic	10	9	Intravenous narcotic
P.F.	M	63	Lung Ca	1	Femur (55 mm)	Intravenous narcotic	10	5	Oral narcotic
M.V.	M	76	Lung Ca	1	Femur (42 mm)	Intravenous narcotic	10	4	Oral narcotic
B.M.	F	87	Breast Ca	1	Acetabulum (33 mm)	Intravenous narcotic	10	3	NSAID
A.R.	F	64	Breast Ca	1	Radius (25 mm)	Intravenous narcotic	7	0	None
P.E.	F	81	Breast Ca	1	Omerus (32 mm)	Intravenous narcotic	10	3	NSAID

Table 1 (Continued)

Patient	Sex	Age (y)	Disease	No. of Lesion(s)	Lesion(s) Site and Average Diameter (mm)	Previous Analgesic Therapy	VAS Before	VAS after 9 mo	Analgesic Therapy after Treatment
C.G.	M	76	Prostatic Ca	1	Acetabulum (47 mm)	Transdermal narcotic	10	1	None
C.L.	F	70	Colon Ca	2	Iliac bone left and right (30, 41 mm)	Transdermal narcotic	6	0	None
U.B.	M	77	Kidney Ca	1	Iliac bone (70 mm)	Intravenous narcotic	10	2	None
R.S.	F	45	Enchondroma	1	Metacarpal bone (13 mm)	Oral narcotic	5	0	None
N.L.	F	62	Enchondroma	1	Knee (32 mm)	Oral narcotic	7	0	None
A.C.	F	83	Rheumatoid geodes	2	Acetabulum (10 mm), femur (12 mm)	Oral narcotic	10	1	None
F.A.	M	67	Traumatic pseudarthrosis	1	Calcaneus (32 mm)	Oral narcotics	8	0	None
M.D.	F	82	Traumatic pseudarthrosis	1	Femur (27 mm)	Oral narcotic	8	1	None
D.D.	M	34	Aneurysmatic bone cyst	1	Sacrum (75 mm)	Oral narcotic	6	0	None
M.A.	F	81	Aneurysmatic bone cyst	1	Sacrum (80 mm)	Oral narcotic	8	0	None
M.R.	F	67	Aneurysmatic bone cyst	1	Metatarsal bone (22 mm)	Oral narcotic	5	0	None
O.A.	M	41	Aneurysmatic bone cyst	1	Iliac bone (55 mm)	Oral narcotic	7	0	None

Ca, cancer; GIST, gastrointestinal stromal tumor; NH, non-Hodgkin's; NSAID, nonsteroidal anti-inflammatory drugs.

Table 2 Preprocedural and Postprocedural VAS Score

VAS Score	Number of Cases	
	Preprocedure	9 mo Postprocedure
10	48	0
9	15	5
8	21	0
7	10	2
6	7	3
5	3	4
4	1	3
3	0	7
2	0	19
1	0	29
0	0	33
Mean VAS $\pm$ SD	8.7 $\pm$ 1.5	1.9 $\pm$ 2.3*

* $P < 0.0001$ compared with preprocedure (paired t test, two-tailed P). VAS, visual analog score; SD, standard deviation.

but did not require treatment. These results are similar to another small series by other authors, who reported no major early complications.²⁷ If a good-quality radiological imaging guiding system is employed, PO can be virtually performed in any bone where a needle can be placed.

Delayed complications are rare also. In our experience, two patients (1.9%) with metastases of the femoral diaphysis had a fracture 1 month after treatment. A similar case was reported by Toyota et al²⁷; this did not occur when osteoplasty was applied to the tibial or peroneal bone in our experience. We think that lytic lesions of the femoral diaphysis can be treated with osteoplasty to achieve pain regression, but further surgery has to be considered to reduce the risk of fracture during ambulation; probably in these cases, regaining mobility and putting pressure on weight-bearing bones could play a role in bone fracture occurrence.

Considering the poor general conditions of the treated patients with malignancy, pain relief represents a sensible and simple index about mobility and quality of life, which is why the clinical outcome was evaluated only by means of VAS; in the patients treated for a benign lesion, the clinical outcome was measured with Oswestry Disability Questionnaire also, but data are still preliminary.

After PO, pain disappeared completely in 33 of 105 patients (31.4%), and analgesic requirements dropped significantly. Pain relief was significant already in the first 24 hours after treatment; this result parallels that reported for PV.³⁵ Conversely, according to what was previously reported,⁹ pain relief after RFA alone is gradual, and opioid requirements actually increased 1 week after treatment. This rebound effect was previously experienced in some patients treated in our

institution according to the Mayo Clinic Study protocol. This is due to the fact that RFA alone does not provide immediate support to the bone structure. In our experience, pain relief, when it occurred, was achieved in all cases within 72 hours from treatment. This result is consistent with the theory that stabilization of bone matrix prevents microfractures and may be the single most important factor influencing pain scores; the fact that pain relief was achieved in benign lesions also where a biological bone cement (that has no exothermic reaction during polymerization as well no toxicity) was injected leads to the conclusion that thermal nerve injuries and monomer-related toxicity can be ruled out as a mechanism for pain treatment.

The results of this series should offer to all patients with painful bone lesions that do not respond to conventional therapy a new option for successful treatment with minimally invasive interventional radiology procedure.

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