L. Alvarez
A. Pérez-Higueras
D. Quiñones
E. Calvo
R. E. Rossi

Vertebroplasty in the treatment of vertebral tumors: postprocedural outcome and quality of life

Received: 10 June 2002
Revised: 29 October 2002
Accepted: 27 December 2002
Published online: 22 March 2003
© Springer-Verlag 2003

L. Alvarez (✉) · E. Calvo
Department of Orthopaedic Surgery,
Fundación Jiménez Díaz,
Avda Reyes Católicos 2,
28040 Madrid, Spain
Tel.: +34-91-5495544,
Fax: +34-91-5499122,
e-mail: lalvarez@fjd.es

A. Pérez-Higueras · D. Quiñones
R. E. Rossi
Department of Neuroradiology,
Fundación Jiménez Díaz,
Madrid, Spain

Abstract The results of percutaneous vertebroplasty with polymethylmethacrylate (PMMA) of vertebral metastases were evaluated by a retrospective review of a consecutive series of 21 patients, with special reference to functional outcome. Patients complained of vertebral pain in all cases. Walking was impossible for 13 patients. Ten patients presented neurological deficit. Treatment included percutaneous vertebroplasty in all patients, radiotherapy in 15 patients and neural decompression surgery in 3 patients. Mean duration of hospitalization was 14.1 days (range 2–60 days) and the mean follow-up was 5.6 months (range 1–18 months). Preprocedural pain, measured by the visual analog scale (VAS), was 9.1, decreasing to 3.2 after the procedure and 2.8 at the last follow-up visit.

Morphinics were discontinued in 7 of 14 patients following discharge from hospital. Ten out of 13 (77%) patients recovered walking capacity. Neurological status improved in three out of five patients. No further vertebral compression occurred in the vertebrae treated. Overall, 81% of the patients in this study were satisfied or very satisfied with the procedure. One patient (5%) had transitory radicular neuritis after the procedure. No major complications were observed. In conclusion, percutaneous vertebroplasty with PMMA proved to be safe and beneficial, providing significant and early improvement in the functional status of patients with spinal metastasis.

Keywords Vertebroplasty · PMMA · Metastasis · Tumors · Augmentation

Introduction

The spine is the most common site for skeletal metastases, regardless of the primary tumor involved [12]. However, vertebral metastases are often asymptomatic and may be discovered only when a routine bone scan is performed. Symptoms may be the consequence of a pathologic fracture secondary to vertebral destruction, with development of spinal instability and compression of adjacent neurological elements. Chemotherapy, hormonal therapy, and radiation therapy have proven to be effective in halting the osteolytic process and reversing the neurological compromise. However, these modalities cannot provide stability to an unstable spinal column and cannot be expected to re-

lieve pain and cord compression [12]. In these cases, surgery can restore spinal canal support, which makes nursing care easier, restores neurological functions and helps to control pain [6]. However, because the risks involved in performing major surgery on severely ill patients are high, with reported complication rates ranging from 18.6% to 48% [17, 20], surgery is usually not recommended in patients whose expected survival is less than 6 months.

Percutaneous vertebroplasty (PV) has been used successfully since 1987 to treat patients with osteolytic metastasis, making it possible to reduce pain and strengthen bone [4, 8, 9, 13, 23]. The aim of this study was to report the author's experience with PV of spinal metastases and to evaluate procedural outcome and the quality of life of these patients.

Materials and methods

A retrospective analysis was performed in 21 consecutive patients in whom metastatic disease of the spine was managed with a percutaneous vertebroplasty at 27 different levels between April 1996 and February 2002 at our institution. Vertebroplasty was performed in patients with a vertebral collapse, with or without neurological deficit, and intractable pain unresponsive to conservative treatment. The presence of lytic lesions of the posterior wall did not exclude patients from this procedure. Myelomas were excluded from this series.

All the vertebroplasties were performed by neuroradiologists with the technique previously reported [2]. A posterolateral or transpedicular approach was made, according to the level treated under fluoroscopic guidance. Computed tomography (CT) guidance was used for an anterior approach in the cervical spine. A double-side transpedicular approach was used for thoracic vertebrae and L5, while a posterolateral route was chosen for the rest of the lumbar spine. Neuroleptoanalgesia and local anesthesia (2% lidocaine) were used in all cases. The polymethylmethacrylate (PMMA) used was CMW3 Gentamicin (DePuy International Ltd, Blackpool, UK) mixed with 1 g Tungsten powder (Balt, Monmency, France) to increase its radio-opacity. The cement was injected using a screw-system syringe with a 14-G needle, which allows a controlled procedure and decreases the effort needed to inject the cement. Injection was stopped if a leak of methylmethacrylate into the spinal canal was detected, even when the complete lesion filling had not been achieved. The amount of cement injected was 4.2 cc (range 2–5 cc). CT was performed after the procedure to assess the distribution of the PMMA and the presence of leaks.

Clinical outcome was assessed by evaluating ability to walk and severity of pain, using a visual analog scale (VAS) and changes in analgesic treatment before and after the procedure. Ambulation was graded as follows: gait without support, gait with a cane, or non-

ambulatory because of severe spinal pain or motor weakness of the lower extremities. The Frankel score [10] was used for neurological function. The Tokuhashi score [21] was used to assess the patient's general health and estimation of life expectancy. For subjective assessment of the overall result of the procedure, the patient was asked to select one of the following options: (1) very satisfied, (2) satisfied, (3) acceptable, (4) dissatisfied, or (5) very dissatisfied. Radiographic follow-up evaluation was done at 3-month intervals.

Statistical analysis was performed using SPSS 9.0 software package (SPSS Inc., Chicago, Ill.) for Windows. The Wilcoxon paired test was used to assess significance in pre- and postprocedural differences in pain and functional status, and the McNemar test was used to assess improvement in the gait.

Results

Fourteen women and seven men with a mean age of 58 years (range 27–78 years) were studied. The primary tumors were lung carcinoma (four patients), gastrointestinal tract carcinoma (three patients), renal cell carcinoma (three patients), breast carcinoma (three patients), prostate carcinoma (two patients), carcinoma of the uterus (one patient), malignant tumors at other different sites (two patients), and adenocarcinoma of unknown primary origin (three patients).

The lumbar spine was the most common site for metastatic deposits, which were present in 20 patients (95%). Eleven patients (52%) had multiple levels of spinal involvement. Sixteen patients (76%) had concomitant bone

Table 1 Demographic and outcome data pre- and postvertebroplasty (VAS visual analog scale, PV percutaneous vertebroplasty)

Case	Sex	Age	Levels	VAS			Gait ^a		Frankel		Tokuhashi score		Days in hospital	Survival (months)
				Pre-PV	Post-PV	3 mths	Pre-PV	Post-PV	Pre-PV	Post-PV	Pre-PV	Post-PV		
1	M	77	L2,3	10	8	7	A	A	E	E	7	7	10	6
2	M	57	C6,L4	8	1	1	A	A	E	E	5	5	3	5
3	M	27	L3	10	3	3	C	A	E	E	8	8	12	10
4	M	77	L2,L3	10	7	7	A	A	E	E	8	8	5	5
5	F	70	L1	10	1	0	C	A	E	E	9	9	7	18
6	F	52	L4	8	3	1	C	A	D	E	4	5	5	3
7	F	52	L4	8	2	3	B	A	D	E	5	5	5	6
8	M	45	L2	10	0	0	B	A	E	E	8	8	12	10
9	F	70	L1	10	2	2	C	A	E	E	8	8	12	11
10	M	57	T6	8	1	1	A	A	E	E	5	5	3	5
11	M	33	T12,L3	10	3	3	C	A	D	E	3	3	7	7
12	F	49	L3,L5	10	3	3	A	A	E	E	8	8	2	6
13	M	51	L2	8	5	4	A	A	E	E	6	6	4	5
14	M	33	T12,L3	8	2	2	C	A	D	E	2	2	8	3
15	M	68	L3	10	5	5	C	C	A ^b	A	5	5	60	2
16	F	70	L5	9	4	3	A	A	E	E	5	5	2	4
17	M	69	L3	10	5	5	C	B	C ^b	D	5	5	15	5
18	F	67	L5	9	4	3	A	A	D	E	4	5	2	3
19	M	57	L3	10	3	3	C	C	A	A	3	3	30	1
20	M	78	L5	9	3	3	C	C	A	A	3	3	40	1
21	M	69	L1	8	3	3	C	B	B ^b	D	4	4	50	2

^a A: gait without support; B: gait with a cane; C: nonambulatory

^b Decompression surgery associated

metastases elsewhere than in the spine, and all patients presented nonskeletal metastases.

Back pain was the main symptom in all cases, with radiculopathy in four cases (19%). Pyramidal irritation (Babinski sign, hyper-reflectivity, spasticity) was present in eight patients (38%). The VAS showed significant improvement after treatment. As shown in Table 1, the average pain VAS revealed a significant reduction in pain intensity after the intervention ($P < 0.001$), which was maintained at 3-months' follow-up. Pain medication was suppressed in 7 out of 14 patients who had been preoperatively treated with high doses of morphinics. Eight patients could walk without support before and after the procedure. Of the remaining 13 patients, ten (77%) showed improvement in ambulation immediately after the procedure. These data were statistically significant, with $P < 0.01$ on a McNemar test. Postprocedural mobilization was initiated with no additional external stabilization in 13 patients. Five patients presented neurological compromise of at least Frankel grade C, and decompressive surgery was associated in three of these patients. The other two patients had a long-term neurological deficit with a very short life expectancy. Fifteen patients received radiation therapy. Neurological improvement was observed in three patients, two with a decompressive laminectomy and one with radiotherapy alone. None of the patients treated developed neurological deterioration.

The Tokuhashi score was 5.5 (range 2–9). Seven patients (33%) had presented a preprocedural Tokuhashi score of 4 or less, 13 patients (62%) a Tokuhashi score of between 5 and 8, and one patient a Tokuhashi score of 9. After the PV these scores improved by one point in only two cases, and were maintained in the rest. The patients were discharged from hospital after 14.2 days (range 2–60 days). Excluding four patients who died during hospitalization after the PV because of their disease, the average number of hospitalization days was 6.6 (range 2–15).

Mean postprocedural survival time was 5.6 months (range 1–18 months). The longest survival time was in a patient with a prostatic metastasis and a Tokuhashi score of 9, in whom the cemented vertebrae remained stable during follow-up.

Leakage of the cement outside the vertebral body was noted in 12 of 27 vertebrae (44%). The leakage was in the disk in one case, in the entry site in another case and in the epidural veins in ten cases (37%). Despite the high number of leaks of PMMA detected with CT in our patients, only one patient had a transitory radicular neuritis after the procedure. The presence of these leaks did not affect the functional result. We also did not find any relationship between the amount of cement injected and the functional result or the presence of leaks. No other major complications were related with the procedure. The post procedure and last follow-up visit plain X-ray films obtained in patients demonstrated no further collapse of the vertebrae treated.

The subjective assessment showed that seven patients (33%) were very satisfied with the result of the PV, ten (48%) were satisfied, two patients (10%) found them acceptable and only two patients (10%) were dissatisfied.

Discussion

The spinal column is the most frequent site of metastatic tumors [12]. Vertebral metastases are often asymptomatic; however, the presence of a pathologic fracture secondary to vertebral destruction, or the development of spinal instability from such a fracture, may be the origin of pain and neurological symptoms. The treatment of these patients is controversial and must be integrated into the overall management of the cancer patient.

Conventional therapy for painful spinal metastasis consists of bedrest, bracing, radiation therapy and pain medication. The analgesic effect of radiation therapy can be complete or almost complete in 83% of cases [18]. However, radiotherapy does not correct spinal instability [19], and its efficacy is delayed, as the mean time for maximum analgesic effect is 35 days (range 0–150 days) [18], and the bone strengthening effect is delayed 2–4 months after the start of irradiation, which increases the risk of vertebral collapse [11].

Indications for surgery are generally: intractable pain unresponsive to conservative treatment, deformity, biomechanical impairment, and neural deficits [3, 16]. However, the surgical options require significant postprocedural recovery and have associated morbidity and mortality in 19–48% of the cases [17, 20], in patients who often have limited life expectancies. Survival time is a factor that must be considered and, although no absolute value has been established, in general, a minimum life expectancy of 3–6 months has been accepted as a prerequisite for surgery [5], which is a problem for the management of terminal patients with intractable pain associated with instability. Furthermore, surgery in vertebral metastasis without neural deficit results in substantial functional improvement, but does not increase the duration of life [6]. In conclusion, pain relief and maintaining quality of life must be balanced with the patient's life expectancy, comorbidities and functional status.

Percutaneous vertebroplasty consists in percutaneous injection under fluoroscopy guidance of PMMA through a needle into a weakened vertebral body. This procedure tries to solve the problem in the management of a selected group of patients with a metastatic disease that lacks a clear treatment option at this moment. In most patients in our group, surgery was not considered because of the extension of the disease and a short life expectancy. The procedure allowed the patients to stand without pain, to decrease the dose of morphinics and to leave hospital promptly. PV has demonstrated an immediate analgesic efficacy in 90% of the patients in our series. An excellent result (with

a VAS of 3 or less) was obtained in 67% of the cases. The results were stable over time. These data are similar to other previously reported results [4, 7, 8, 9, 13, 14, 23]. From our point of view, the most important finding is that 69% of nonambulatory patients became ambulatory after the PV procedure. These results are very similar to those reported in the literature for patients treated with radiotherapy [18] or surgery [12, 22]; however, complication rate and in-hospital days compare favorably with other surgical reports [17, 20, 22]. The presence of multiple skeletal and other metastases, as potential sources of pain, made these results worse than those obtained with this technique in the management of pain from osteoporotic compression fractures [1].

Presence of neurological deficit is an indication for emergency salvaging surgery, with a higher risk of morbidity after surgery [20]. In our patients, neurological deficit was managed by the combined use of PV, radiotherapy and, in three cases with posterior neural decompression, without instrumentation. Use of bone cement ensures immediate stability, it is bioinert, and its solidity is not affected by irradiation [15].

The key to safe performance of PV is recognizing that therapeutic response is not related to the degree of filling, but is related to the risk of complications. It is important to understand that there is no relationship between the degree of vertebral body filling and the likelihood of achieving pain relief in these patients [7, 8]. Procedural complications are related mostly to leakage of PMMA into adjacent structures because of vertebral cortical destruction or injection into the vertebral plexus. Several authors [8, 9, 23] have stated that clinically significant complications with PV occur predominantly in patients with spinal metastatic disease. These complications occur in patients with a lytic lesion affecting the posterior wall, and can result in

cord compression. However, the presence of leakages in the epidural plexus in these patients (37%) was lower than our experience in the treatment of osteoporotic vertebral fractures, where the presence of cement in the epidural venous plexus was observed in 47% of the patients [1]. This may be related to the technique, as the cement is injected very slowly with a screw-type syringe that allows a controlled procedure, and the epidural plexus may be partially infiltrated from the metastatic disease.

Overall, 81% of the patients in this study were satisfied or very satisfied with the procedure, indicating a high level of acceptance. These data are similar to those reported for surgical treatment [22].

Conclusions

The current results have demonstrated that PV in vertebral metastasis leads to substantial functional improvement in patients with expected survival of less than 6 months, with a very low rate of complications. In our opinion, PV should be included in the therapeutic arsenal for patients with a Tokuhashi score of 4 or less, with intractable pain from a spinal instability, where surgery is not considered. In patients with a Tokuhashi score of between 5 and 8, PV should be considered as an alternative to surgical stabilization. Patients with a neurological deficit can be effectively treated for pain relief with a PV, while radiotherapy allows a neurological recovery. We recommend further multidisciplinary, prospective studies to help define more clearly which patients are suitable candidates for PV treatment.

Acknowledgements The authors thank JJ Granizo, MD (clinical epidemiologist), for performing the statistical analysis and L Guliksen for his assistance in correcting the text.

References

1. Alvarez L, Perez-Higueras A, Rossi RE, Calvo E (2001) Vertebroplasty in osteoporotic fractures: clinical and radiological results after 5 years. *Eur Spine J* 10 [Suppl 1]:8
2. Alvarez L, Pérez-Higueras A (2002) Vertebroplasty: indications and technique (in Spanish). *Rev Ortop Traumatol* 46:175–182
3. Argenson C, Cordonnier D, Enkaoua E, Laredo JD, Onimus M, Resbeut M, Saillant G, Viens P, Vital JM (1997) Place de la chirurgie dans le traitement des métastases du rachis. *Rev Chir Orthop* 83 [Suppl III]:109–174
4. Barr JD, Barr MS, Lemley TJ, McCann RM (2000) Percutaneous vertebroplasty for pain relief and spinal stabilization. *Spine* 25:923–928
5. Bünger C, Laursen M, Hansen ES, Neumann P, Christensen FB, Hoy K, Helming P (1999) A new algorithm for the surgical treatment of spinal metastases. *Curr Opin Orthop* 10:101–105
6. Chataigner H, Onimus M (2000) Surgery in spinal metastasis without spinal cord compression: indications and strategy related to the risk of recurrence. *Eur Spine J* 9:523–527
7. Cortet B, Cotten A, Boutry N, Dewatre F, Flipo RM, Duquesnoy B, Chastanet P, Decalmbre B (1997). Percutaneous vertebroplasty in patients with multiple metastases or multiple myeloma. *Rev Rhum Engl Ed* 64:177–183
8. Cotten A, Dewatre F, Cortet B, Assaker R, Leblond D, Duquesnoy B, Chastanet P, Clarisse J (1996) Percutaneous vertebroplasty for osteolytic metastases and myeloma: effects of the percentage of lesion filling and the leakage of methylmethacrylate at clinical follow-up. *Radiology* 200:525–530
9. Deramond H, Depriester C, Galibert P, Le Gars D (1998) Percutaneous vertebroplasty with polymethylmethacrylate. Technique, indications and results. *Radiol Clin North Am* 36:533–546
10. Frankel HL, Hancock DO, Hyslop G, Melzak J, Michaelis LS, Ungar GH, Vernon JD, Walsh JJ (1969) The value of postural reduction in the initial management of closed injuries of the spine with paraplegia and tetraplegia. *Paraplegia* 7:179–192

11. Gilbert HA, Kagan AR, Nussbaum H, Rao AR, Satzman J, Chan P, Allen Brent, Forsythe A (1977) Evaluation of radiation therapy for bone metastases: pain relief and quality of life. *Am J Roentgenol* 129:1095–1096
12. Hammerberg KW (1992) Surgical treatment of metastatic spine disease. *Spine* 17:1148–1153
13. Kaemmerlen P, Thiesse P, Bouvard H, Biron P, Mornex F, Jonas P (1989) Percutaneous vertebroplasty in the treatment of metastases. Technique and results. *J Radiol* 70:557–562
14. Martin JB, Sugi JK, San Millan D, Piotin M, Murphy K, Rüfenacht B, Muster M, Rüfenacht DA (1999) Vertebroplasty: clinical experience and follow-up results. *Bone* 25:11S–15S
15. Murray JA, Bruels MC, Lindberg RD (1974) Irradiation of poly-methyl-methacrylate: in vitro gamma radiation effect. *J Bone Joint Surg Am* 56:311–312
16. Onimus M, Schraub S, Bertin D, Bosset JF, Guidet M (1986) Surgical treatment of vertebral metastases. *Spine* 11:883–891
17. Pasca-Moussellard H, Broc G, Pointillart V, Siméon F, Vital JM, Sénégas J (1998) Complications of vertebral metastasis surgery. *Eur Spine J* 7:438–444
18. Prié L, Lagarde P, Palussière J, El Ayoubi S, Dilhuydy JM, Durand M, Vital JM, Kantor G (1997) Radiothérapie des métastases vertébrales du cancer du sein. A propos d'une série de 108 patientes. *Cancer Radiother* 1:234–239
19. Resbeut M, Alzieu C, Hannoun-Levi JM, Noirclerc M, Cowen D (1997) Place de la chirurgie dans le traitement des métastases du rachis. Radiothérapie des métastases vertébrales. *Rev Chir Orthop* 83 [Suppl III]:127–130
20. Sundaresan N, Sachdev VP, Holland JF, Moore F, Sung M, Paciucci PA, Wu LT, Kelligher K, Hough L (1995) Surgical treatment of spinal cord compression from epidural metastasis. *J Clin Oncol* 13:2330–2335
21. Tokuhashi Y, Matsuzaki H, Toriyama S, Kawano H, Ohsaka S (1990) Scoring system for the operative evaluation of metastatic spine tumor prognosis. *Spine* 15:1110–1113
22. Weigel B, Maghsudi M, Neumann C, Kretschmer R, Müller FJ, Nerlich M (1999). Surgical management of symptomatic spinal metastases. *Spine* 24:2240–2246
23. Weill A, Chiras J, Simon JM, Rose M, Sola-Martinez T, Enkaoua E (1996). Spinal metastases: indications for and result of percutaneous injection of acrylic surgical cement. *Radiology* 199:241–247