

Is minimally-invasive spinal surgery a reliable treatment option in symptomatic spinal metastasis?

S. COLANGELI¹, R. CAPANNA¹, S. BANDIERA², R. GHERMANDI²,
M. GIROLAMI², P.D. PARCHI¹, V. PIPOLA², F. SACCHETTI¹, A. GASBARRINI²

¹Department of Orthopaedic and Trauma Surgery, University of Pisa, Pisa, Italy

²IRCCS Istituto Ortopedico Rizzoli, Bologna, Italy

Abstract. – **OBJECTIVE:** Up to 70% of patients with cancer are likely to develop spine metastasis. Radiation therapy is the standard of care for painful spinal metastases in absence of unstable or impending fractures. More frequently these patients require open palliative surgery for pain, vertebral collapse and neurological deficits. Minimally Invasive Spine Surgery (MISS) techniques using percutaneous pedicle screw fixation may be considered as an alternative to open surgery in selected cases. MISS techniques are thought to be associated with fewer tissues damages resulting in early pain relief, they also allow for early mobilization and optimization of function.

PATIENTS AND METHODS: From 2011 to 2018, 52 patients affected by spinal metastasis were treated with MISS techniques in Rizzoli Orthopaedic Institute of Bologna and in Cisanello Hospital of Pisa, Italy. All patients underwent percutaneous pedicle screw fixations (PPSF) coupled with mini-decompressions in case it was required by spinal cord compressions. All patients were evaluated pre and post-operatively by Frenkel classification and VAS scores.

RESULTS: Mean follow-up time was 19,4 months. Preoperatively, Frankel scores were E in 37 patients, D3 in 6 patients, D2 in 3 cases, D1 in 3 patients, B in one patient and C in two. The Frankel score improved in 10 patients, remained stable in 40 patients and worsened in two patients. Preoperatively, the mean VAS score in 29 patients treated with PPSF procedure with spinal decompression was 7, while postoperatively, it became 5. In 23 patients who underwent only PPSF procedure without spinal decompression mean VAS score was 5, postoperatively it became 3.

CONCLUSIONS: In selected cases, MISS surgeries may be considered as a valid alternative to open surgery. Although the efficacy of PPSF has been well documented in trauma or degenerative spine surgery, there is not sufficient literature about MISS techniques in spinal metas-

tasis and further studies are needed to elucidate the most appropriate patient in which this approach could represent the gold standard of treatment.

Key Words:

MISS surgery, Metastasis, Spine surgery, Minimally-invasive, Spinal metastasis, Orthopedic oncology.

Introduction

Up to 70% of patients with cancer are likely to develop spine metastasis¹. In fact, the three most frequently diagnosed tumors, such as lung, breast and prostate cancers, usually spread to bone, and indeed, the spine is the most frequently affected segment of the skeleton²⁻⁴. Decisions around care in this part of population must be shared between the patient his or her loved ones and a multidisciplinary team with an up-to-date knowledge of the currently used therapeutic interventions and the relative clinical evidence. Clinical presentations of spinal metastasis may vary but instability and neurologic deficits are usually present. Radiation therapy, when the tumor is sensitive, is the standard of care for painful spinal metastases in absence of unstable or impending fractures⁵. More frequently, however, these patients require open palliative surgery for pain, vertebral collapse and neurological deficits. Actually, in selected cases, Minimally Invasive Spine Surgery (MISS) techniques using percutaneous pedicle screw fixation (PPSF), coupled or not with mini-decompressions, may be considered as a valid alternative to open surgery when the latter is not safe due to patients' poor clinical conditions. MISS techniques are thought to be associated with fewer tissues damages resulting in earlier pain relief, also al-

lowing for early mobilization and optimization of function⁶. This is a retrospective case series study about the management of symptomatic metastatic spinal disease. Algorithm of Gasbarrini et al⁷ was applied to selected patient treated with MISS techniques using PPSF coupled or not with mini-decompressions. Functional outcomes, neurological status improvements or impairments, complication rates and Visual Analog Scale (VAS) have been evaluated.

Patients and Methods

From November 2011 to December 2018, 52 out of 1400 patients affected by spinal metastasis were selected according Gasbarrini et al⁷ algorithm and treated by MISS techniques in two referral centers with (29 cases) or without (23 cases) spinal decompressions. In 28 patients treated with spinal decompressions, pre-operative embolization was performed (Table I). The main indications to MISS surgery, according to Gasbarrini et al⁷, were spinal metastasis which caused pathological fractures, neurological deficits or uncontrollable pain. All patients underwent percutaneous pedicle screw fixations (PPSF) coupled with mini-decompressions if required by spinal cord compressions. All patients were evaluated pre and post-operatively and their neurological status was assessed by the Frenkel classification and VAS scores. All complications were recorded and classified as minor or major as McDonnell et al⁸ suggested. Pre-operative evaluation of all patients was performed using CT-scan or MRI images coupled with clinical examination and neurolog-

ical evaluation. All surgeries were carried out under fluoroscopic control using standard MISS approaches. In case of spinal cord compression, a preoperative embolization was performed, and a surgical curettage was associated (Figures 1-7).

Results

Fifty-two consecutive patients were treated with MISS in our institutions, respectively 26 males and 26 females, mean age of 59.3 years old (IC 95%: 55.8-62.7). Twenty-three patients underwent

Table I. Demographics.

Demographics	Number (%)
Gender	
Male	26 (50)
Female	26 (50)
Tumor pathology	
Breast	14 (27)
Renal	9 (17)
Lung	4 (8)
Prostate	2 (4)
Other	23 (44)
Level of pathology	
Thoracic	26 (50)
Lumbar	26 (50)
Need for mini-decompression	
Yes	29 (56)
No	23 (44)

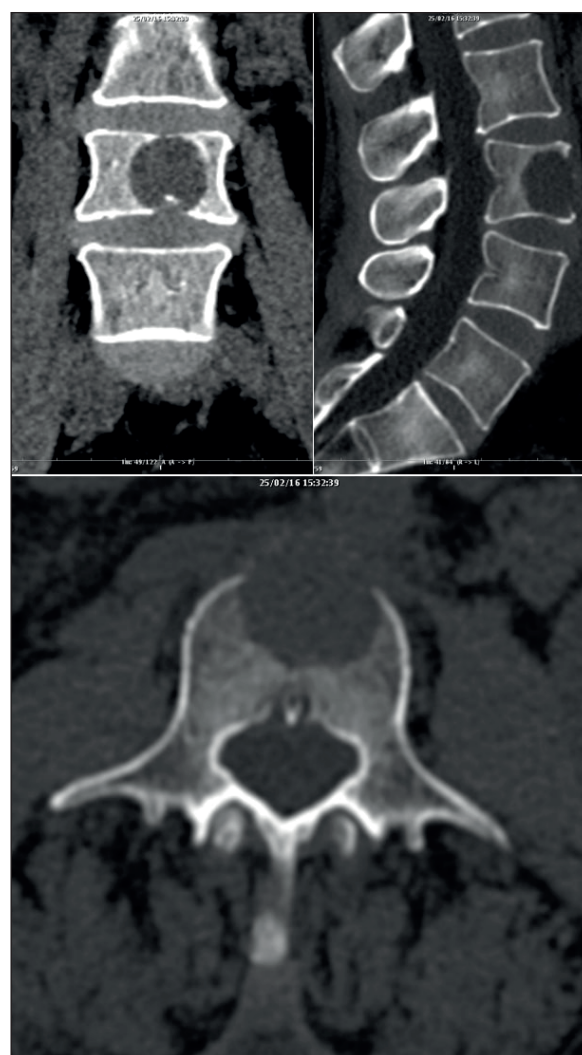


Figure 1. Hepatic carcinoma metastasis of L3. CT-Scan Images in coronal, sagittal and axial planes. The tumor is confined in the vertebral body. According to SINS score¹³, this is considered as unstable spine (TS: 8) so is advisable to perform a surgical posterior stabilization without decompression. In this tumor thermal-ablation is the gold standard treatment.

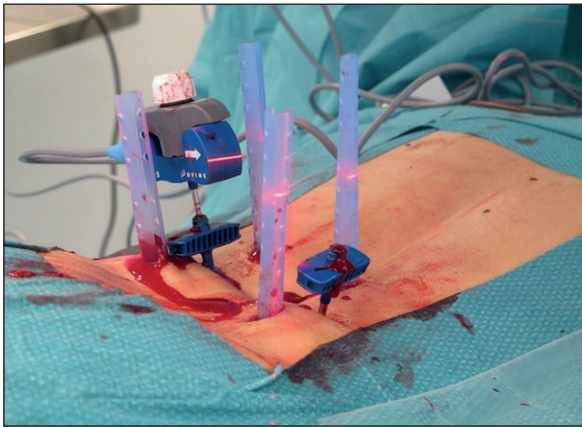


Figure 2. Surgical mini-invasive approach for the case showed in Figure 1.

only PPSF procedure without decompression, while 29 patients necessitated a surgical curettage procedure to relieve pressure on the spinal cord. Spinal metastases were as follows: 14 cases of breast carcinoma (26.9%), 9 cases of renal cell carcinoma (17.3%); and other of various carcinomas. Twenty-six patients (50%) had spinal metastasis in dorsal segment, 26 patients (50%). They were evaluated each month clinically and radiologically; MRI and Ct scan were performed in all patients preoperatively and a CT-scan was always performed after surgery. All patients underwent clinical and radiological (CT-scan or MRI) follow-up every 3 months in the first year after the intervention and then every six months. Mean follow-up time was 19.4 months (IC 95%: 14.3-25). Preoper-

Figure 3. Intraoperative X-rays of the case showed in Figures 1, 2.

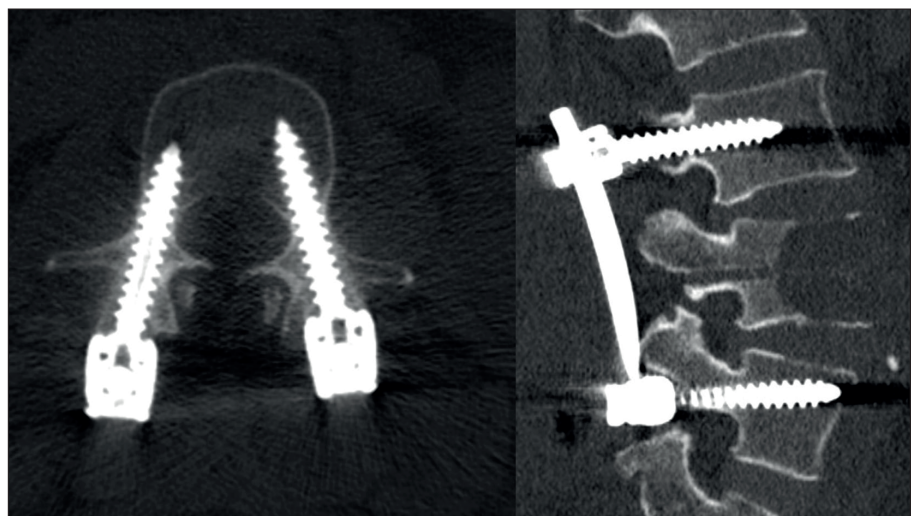
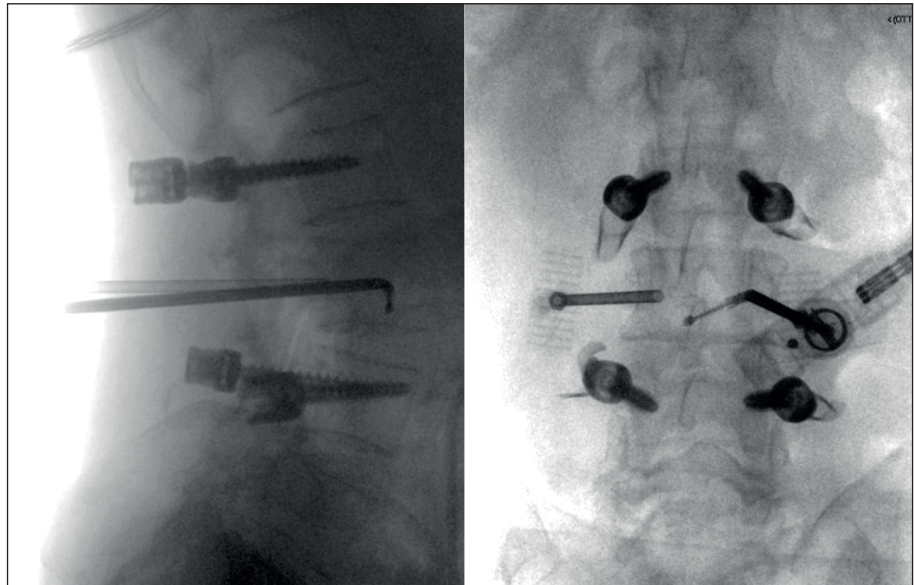


Figure 4. Post-operative imaging of the case showed in Figures 1, 2, 3. Ct Scan showing screws position.

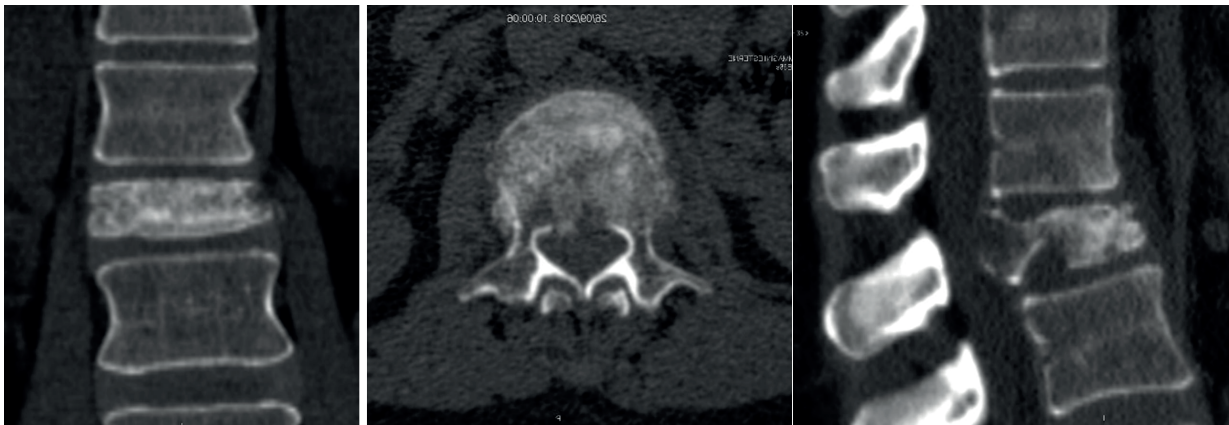


Figure 5. Pre-operative CT-Scan in coronal, axial and sagittal planes showing adenocarcinoma metastasis of L2 with collapse of vertebral body. This patient was treated by thermal-ablation and stabilization using CARBON/PEEK materials.

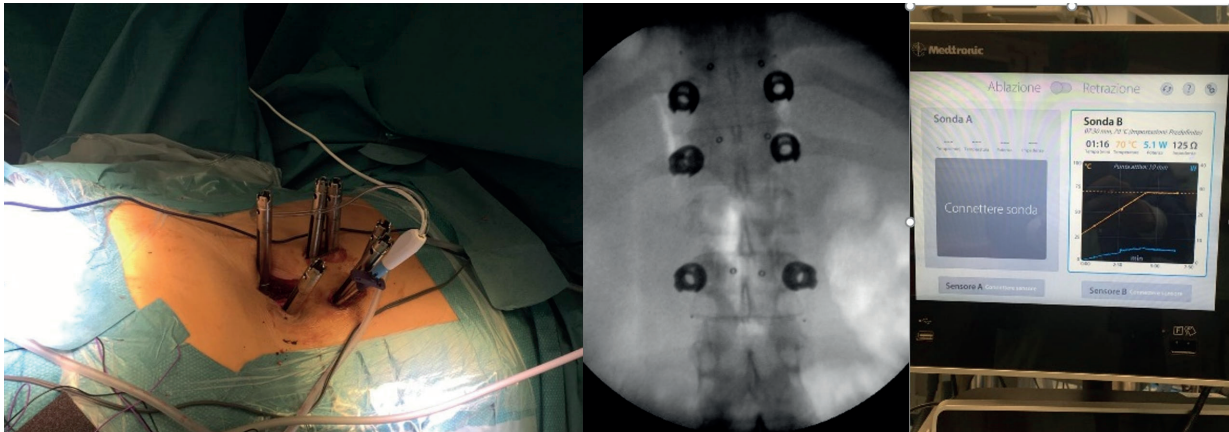


Figure 6. Intra-operative images showing surgical approach, intraoperative X-rays and thermal ablation management of the case in Figure 6.

Figure 7. Post-operative X-rays in sagittal and coronal planes. Ct scan showing screws position. The CARBON/ PEEK system allows a post radiotherapy treatment more effective compared to the one after positioning of standard metallic instrumentation. The case showed is the same of the Figures 6 and 7.

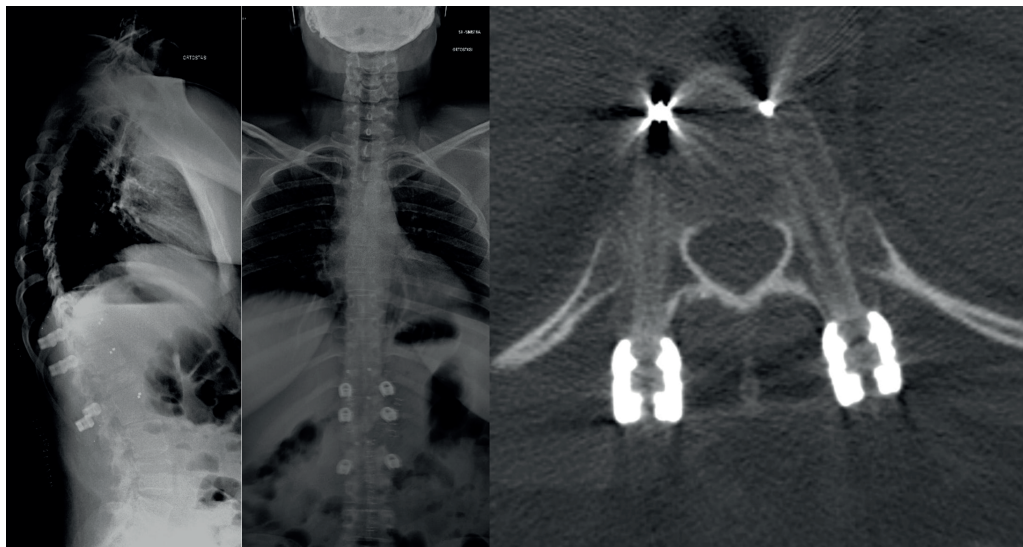


Table II. Functional outcomes.

Functional category analyzed	Number (%)
Neurological assessment (Frenkel Score)	
Improved	10 (19)
Unchanged	40 (77)
Worsened	2 (4)
Status at last follow-up	
Alive with disease (AWD)	36 (70)
No evidence of disease (NED)	0
Dead for causes directly linked to spinal met (DUD)	0
Dead for other causes (DOC)	16 (30)
Need for mini-decompression	
Yes	29 (56)
No	23 (44)

actively, Frankel scores were E in 37 patients, D3 in 6 patients, D2 in 3 cases, D1 in 3 patients, B in one patient and C in two of them. The Frankel score improved in 10 patients, remained stable in 40 patients and worsened only in two patients. According to the latest available follow-up, 44 patients were evaluated as E, 4 as D3, 1 as D2, 2 as D1 and one patient as B. Preoperatively, the VAS score in 29 patients treated with PPSF procedure with spinal decompression was 7 on average, while postoperatively, the VAS score became 5 on average. In 23 patients who underwent only PPSF procedure without spinal decompression VAS score was 5 on average, postoperatively VAS score became 3 on average. According to the latest available follow-up, 36 patients were classified as alive with disease (AWD), 16 dead for disease progression or other causes but not related to the spinal metastasis (DOC) and no patient died for a cause directly related to the spinal metastasis (DUD) (Table II). In our series, 3 minor and 3 major complications were reported. In one case an aseptic screw mobilization was detected without clinical consequences, while two patients had wound dehiscence healed without additional surgeries. As to the three major complications, in two cases an intraoperative lesion of the dural sac during mini-decompression procedure was reported without consequences, and finally, in

one case a hematoma was reported with neurological compression symptoms which required a new surgery of spinal decompression with symptom regression (this last patient affected by metastases of hepatic carcinoma in D8 had not performed preoperative embolization) (Table III).

Discussion

Spinal metastasis is a very frequent disease; the bone is one of the most targeted tissues and the spine is the most frequently involved site in the skeleton. It is important to maintain proper oncological perspective when managing this patient population. Many of these patients do not have long to live, and, therefore, the goal must be to improve or maintain their quality of life during the remaining life-time. Management of spinal metastasis is a trending topic as the newest surgical techniques have been lately developed in order to palliate pain related and neurological symptoms to reduce surgery-related complications. It is intuitive to say that open posterior surgery has been employed for palliative reason, but complication rates have been shown to approach 25%⁹, related to extensive blood loss and postoperative wound infections associated with

Table III. Medical and surgical complications.

Complications	N	Treatment/consequences
Minor complications		
Aseptic screw mobilizations	1	No/no clinical consequences
wound dehiscence	2	Antibiotics/healed
Major complications		
Intraoperative lesion of dural sac	3	Intraoperative suture/no clinical consequences

muscle dissection and denervation. MISS techniques, using PPSF only or mini-decompression with a small central incision, are thought to be less invasive procedures, allowing early mobilization and maintaining or improving functional and neurological outcomes. Moreover, MISS or open surgery in spinal metastases treatment, is to be used alongside other adjuvant therapies, such as radiation or chemotherapy. This last aspect is very important. In fact, in patients treated with MISS surgery the healing of the surgical wounds is faster and therefore allows a radiotherapy treatment already after 2 weeks from the surgical treatment (in open surgery radiotherapy treatments can be performed after 30-40 days). Recently, MISS techniques using carbon\PEEK devices to facilitate post-operative radiotherapy treatments have been suggested with encouraging results¹⁰. In our series, only 2 cases were treated with this system. Hamad et al¹¹, report a prospective study of 51 consecutive patients with metastatic spinal disease treated with PPSF. Out of the 51 patients, 49 could be successfully treated with MISS (26 females and 23 males). Twenty-six patients (55%) required a mini-decompression, while 27 patients (55%) had improvement in the Karnofsky's performance status (KPS) by at least 10 points ($p < 0.0005$). Only 2 patients (4%) had a worsening of KPS, due to other coexisting problems. Six of the 13 patients improved their neurology by one Frankel grade following surgery and 95% reported improvement in pain. Mean blood loss was 92 mls only for the fixation group and 222 mls for those requiring mini-decompression, with no other differences between these two surgical groups. Screw positioning was excellent in 91%, with 98% having uncompromised bony hold. Only two patients required revision surgery for aseptic loosening. They concluded that MISS using PPSF is a safe and reproducible technique that maintains or improves functional outcome in the vast majority of patients presenting spinal metastases. Furthermore, Schwab et al¹² report the successful short-term treatment of 24 patients with a minimally invasive approach for malignancies in the spine without spinal decompression. They concluded that pain and ambulatory status had both improved after this minimally invasive approach. Recently, Pennington et al⁹ report a review of literature about MISS vs. conventional spine surgery for vertebral metastases. The authors reported the results of nine studies by an immediate comparison of the achieved results from both MISS and

open techniques for the treatment of symptomatic vertebral metastases. All in all, these studies compared 183 patients treated with MISS techniques to 163 patients treated with conventional approaches to decompression and fusion. Six of the studies referred significantly lower blood loss in the MISS group, three reported significantly shorter operative times, four outlined significantly shorter recovery times, two reported a lower complication rate, and four referred similar or superior improvements in pain post-operatively. Additionally, five studies indicated the MISS techniques to provide clinically similar improvements in neurological function. The conclusion of the review was that MISS may provide similar improvements in neurological function and pain relief, while decreasing the morbidity of surgery, including blood loss, operative time, complication rate, and in-patient length of stay. The overall quality of evidence currently available is low since all evidence is currently class either III or IV. Since a strong evidence-based recommendation cannot be made, the decision to use MISS techniques should be made on the basis of patient preference and surgeon familiarity.

Conclusions

A multidisciplinary approach is an important care component in these cases. Local radiation is often an important adjuvant therapy in the setting of spinal metastases, and this is particularly true when a minimally invasive approach is to be considered. The surgery goals are to stabilize and/or decompress the spine. Debulking of tumor is possible in a minimally invasive fashion, but if tumor debulking is a central part of the local control plan, then an open procedure may be more suitable. MISS either with or without spinal decompression in the treatment of patient affected by spinal metastases in selected cases, according to Gasbarrini et al⁷ algorithm, may be considered as a valid alternative surgical approach to open surgery. In our series, the patients had an improvement of neurological status and pain with relative low complications rate. Although the efficacy of PPSF has been well documented in trauma or degenerative spine surgery, there is not sufficient literature about MISS techniques in spinal metastasis and further studies are needed to elucidate the most appropriate patient in which this approach could represent the gold standard of treatment.

Conflict of Interest

The Authors declare that they have no conflict of interests.

References

- 1) GASBARRINI A, BEISSE R, FISHER C, RHINES L. Spine Metastasis. *Int J Surg Oncol* 2011; 2011: 375097.
- 2) HARRINGTON KD. Metastatic disease of the spine. *J Bone Joint Surg Am* 1986; 68: 1110-1115.
- 3) HORN SR, DHILLON ES, POORMAN GW, TISHELMAN JC, SEGRETO FA, BORTZ CA, MOON JY, BEHERY O, SHEPARD N, DIEBO BG, VIRA S, PASSIAS PG. Epidemiology and national trends in prevalence and surgical management of metastatic spinal disease. *J Clin Neurosci* 2018; 53: 183-187.
- 4) BARZILAI O, VERSTEEG AL, SAHGAL A, RHINES LD, BILSKY MH, SCIUBBA DM, SCHUSTER JM, WEBER MH, PAL VARGA P, BORIANI S, BETTEGOWDA C, FEHLINGS MG, YAMADA Y, CLARKE MJ, ARNOLD PM, GOKASLAN ZL, FISHER CG, LAUFER I, THE AO SPINE KNOWLEDGE FORUM TUMOR. Survival, local control, and health-related quality of life in patients with oligometastatic and polymetastatic spinal tumors: a multicenter, international study. *Cancer* 2019; 125: 770-778.
- 5) GERSZTEN PC, MENDEL E, YAMADA Y. Radiotherapy and radiosurgery for metastatic spine disease what are the options, indications, and outcomes? *Spine (Phila Pa 1976)* 2009; 34: S78-S92.
- 6) MOLINA CA, GOKASLAN ZL, SCIUBBA DM. A systematic review of the current role of minimally invasive spine surgery in the management of metastatic spine disease. *Int J Surg Oncol* 2011; 2011: 598148.
- 7) GASBARRINI A, LI H, CAPPUCCIO M, MIRABILE L, PADERNI S, TERZI S, BORIANI S. Efficacy evaluation of a new treatment algorithm for spinal metastases. *Spine (Phila Pa 1976)* 2010; 35: 1466-1470.
- 8) McDONNELL MF, GLASSMAN SD, DIMAR JR 2ND, PUNO RM, JOHNSON JR. Perioperative complications of anterior procedures on the spine. *J Bone Joint Surg Am* 1996; 78: 839-847.
- 9) PENNINGTON Z, AHMED AK, MOLINA CA, EHRESMAN J, LAUFER I, SCIUBBA DM. Minimally invasive versus conventional spine surgery for vertebral metastases: a systematic review of the evidence. *Ann Transl Med* 2018; 6: 103.
- 10) TEDESCO G, GASBARRINI A, BANDIERA S, GHERMANDI R, BORIANI S. Composite PEEK/Carbon fiber implants can increase the effectiveness of radiotherapy in the management of spine tumors. *J Spine Surg* 2017; 3: 323-329.
- 11) HAMAD A, VACHTSEVANOS L, CATTELL A, OCKENDON M, BALAIN B. Minimally invasive spinal surgery for the management of symptomatic spinal metastasis. *Br J Neurosurg* 2017; 31: 526-530.
- 12) SCHWAB JH, GASBARRINI A, CAPPUCCIO M, BORIANI L, DE IURE F, COLANGELI S, BORIANI S. Minimally invasive posterior stabilization improved ambulation and pain scores in patients with plasmacytomas and/or metastases of the spine. *Int J Surg Oncol* 2011; 2011: 239230.
- 13) FISHER CG, VERSTEEG AL, SCHOUTEN R, BORIANI S, VARGA PP, RHINES LD, HERAN MK, KAWAHARA N, FOURNEY D, REYN-OLDS JJ, FEHLINGS MG, GOKASLAN ZL. Reliability of the spinal instability neoplastic scale among radiologists: an assessment of instability secondary to spinal metastases. *AJR Am J Roentgenol* 2014; 203: 869-874.