



## Original Article

# Percutaneous fixation for the treatment of metastatic spinal disease provides effective symptom palliation with low rates of hardware failure

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## ABSTRACT

**Background:** The incidence of survival from metastatic spinal disease (MSD) continues to rise. However, open surgery for MSD is associated with significant perioperative morbidity, while minimally invasive percutaneous pedicle screw fixation (MIPPSF) offers reduced tissue trauma, less blood loss, and a reduction in complications. Lytic bone disease plus perioperative radiation further increase risk for instrument failure, especially in long construct MIPPSF. Here, we compared 6 short construct and 14 long construct outcomes for MIPPSF performed in MSD patients, including multiple myeloma (MM).

**Methods:** For 20 patients undergoing MIPPSF for MSD, we evaluated disease type, location, the extent of surgery, outcomes, and survival rates. Statistical comparisons were performed between long-segment construct and short-segment construct patients utilizing Kaplan–Meier survival curves, Mann–Whitney U, and Chi-squared tests.

**Results:** No instrument failure and comparable symptomatic relief were observed for both short and long MIPPSF constructs. However, long construct patients experienced a higher incidence of postoperative complications, including screw loosening, but exhibited longer overall survivals (likely related to underlying type of MSD, with MM patients making up the largest portion of long construct patients).

**Conclusion:** Long construct MIPPSF in MSD did not have increased risk of construct failure and offered effective symptomatic relief, including for MM patients, without introducing a greater risk construct instability.

**Keywords:** Long construct, Metastatic spinal disease, Minimally invasive, Multiple myeloma, Percutaneous pedicle screw fixation, Spine

## INTRODUCTION

Metastatic spinal disease (MSD) is the most common type (60%) of bone metastases in cancer patients.<sup>[8]</sup> Immunotherapy along with other targeted therapies has increased the overall survival of these patients. Surgery for MSD patients aims to reduce pain, improve neurological function, and offer stability. In addition, minimally invasive percutaneous pedicle screw fixation (MIPPSF)

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for managing MSD appears to reduce perioperative morbidity, with reduced long-term instrumentation failure rates even in the setting of perioperative radiation.<sup>[3,5]</sup> Here, we present our experience with 20 consecutive patients who underwent MIPPSF for the treatment of MSD, including those with multiple myeloma (MM).

## MATERIALS AND METHODS

### Clinical, surgical data, and outcomes for 20 patients with MSD

We evaluated the demographic variables for 20 patients with MSD including; age, sex, comorbidities, primary cancer type, dates of diagnosis, and length of follow-up or time to death. Surgical data included; fused levels, location of metastases, estimated blood loss, adjuvant radiation treatment, and perioperative complications. The primary outcome measures included; implant failure (i.e., screw pull out, breakage, and angular deformity) and the reoperation/instrumentation revision rate. Secondary outcomes measures included follow-up duration and time to death. In addition, we defined long constructs as percutaneous screw fixation involving five or more levels.

### Metrics of analysis

The ASA Physical Status Classification (scaled I–VI), body mass index, visual analog scores (VAS) (scale 1–10) were used to classify patients' operative general health status and quantify pain both preoperatively and 2 weeks postoperatively. The spinal instability neoplastic score was used to determine the metastatic-related instability of the vertebral column. Finally, the American Spinal Cord Injury Association Impairment Scale (Graded A-E) was used for preoperative classification of impairment.

### Operative technique

Pedicle screws were percutaneously placed 5 mm lateral to the lateral border of the thoracic pedicles and 3 mm laterally for L2-L5 lumbar screw placement.

### Statistical analysis

Continuous variables were summarized with either means or medians. Standard deviation and range were included when appropriate. Continuous variables lacked normal distribution in our case series and intergroup comparisons were analyzed using the Mann–Whitney U-test. Discrete variables were analyzed by a Chi-squared test. Statistical significance was set to  $P \leq 0.05$ . All statistical analyses were performed using GraphPad Prism version 9.0 for Windows, GraphPad Software, San Diego, California, USA.

## Study demographics

All 20 patients presented with generalized back pain, among which seven also had radiculopathy. Sixteen patients (80%) had a previously known diagnosis of primary malignancy. All 20 patients with a history of MSD underwent MIPPSF for spinal metastases. Patient average age was 58 years [Table 1]. The median survival for all patients was 624 days [Figure 1]. MM and breast cancer patients comprised 50% of the study cohort, followed by prostate cancer (10%), and eight various other cancers [Table 1]. Eighty-five percent ( $n = 17$ ) of patients had multiple major comorbidities [Table 1]. Majority of the patients 55% ( $n = 11$ ) had lumbosacral (L1-S1) MSD, while 30% ( $n = 6$ ) had lower thoracic (T7-T12) MSD. The remaining 15% ( $n = 3$ ) of patients presented with

**Table 1:** Patient demographics and disease characteristics.

Parameters	Total (n=20) (%)
Demographic variables	
Male	9 (45)
Female	11 (55)
Mean age at procedure	58 (years)
Median survival	624 (days)
Still alive	11 (55)
Primary cancer diagnosis	Total
Adenoid cystic carcinoma	1 (5)
Breast	4 (20)
Colon	1 (5)
Hodgkin's lymphoma	1 (5)
Leukemia	1 (5)
Melanoma	1 (5)
Multiple myeloma	6 (30)
NSCLC	1 (5)
Prostate	2 (10)
Renal	1 (5)
Urothelial	1 (5)
ASA physical status classification	
I	0
II	2 (10)
III	13 (65)
IV	5 (25)
V	0
VI	0
Comorbidities	
Hypertension	10 (50)
Diabetes	2 (10)
Coronary artery disease	1 (5)
Hyperlipidemia	7 (35)
Other	5 (25)
Location of diagnosed metastatic disease	
Lower thoracic	6 (30)
Lumbosacral	11 (55)
Entire spine	3 (15)

NSCLC: Nonsmall cell lung cancer

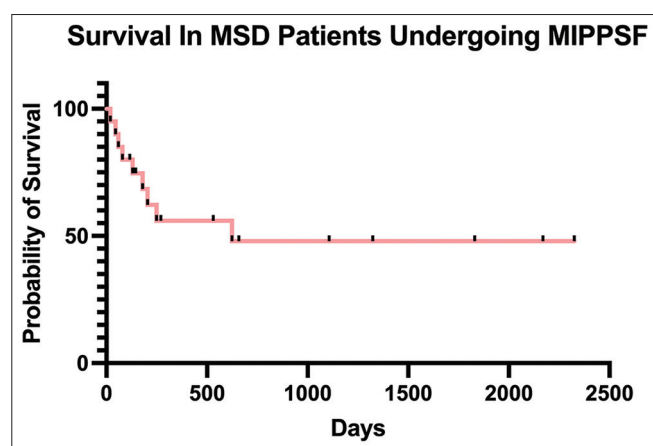
multifocal, diffuse spinal metastases. A small subset underwent focal separation surgery, and another 20% had kyphoplasty in addition to MIPPSF [Table 1]. Seven patients (35%) received radiation therapy preoperatively, 6 patients (30%) postoperatively, while 4 patients (20%) received both pre- and post-operative radiation [Table 2].

## RESULTS

### Surgical outcomes

Fourteen patients (70%) underwent long construct MIPPSF, with 6 (30%) undergoing short construct MIPPSF. Both groups exhibited comparable symptomatic relief/improvement (VAS reduction of 45.42% in long

constructs vs. 60.32% in short constructs,  $P = 0.43$ ). Those in the long construct group showed no greater blood loss from surgery, but three had postoperative complications requiring reoperations (i.e., superficial infection/dehiscence, radiculopathy due to medial placement of an S1 screw/revision, and reoperation 2 months later for epidural spinal cord compression with increased neurological deficits). Notably, no complications were observed in the short construct cohort, while 3 (21.4%) of the long construct patients exhibited instances of screw loosening versus 1 patient (16.7%) in the short construct group ( $P = 0.81$ ) [Table 3], and one patient in the long construct group experienced rod fracture following a traumatic fall [Figure 2]. Furthermore, long construct patients had longer median survivals [Figure 3 and Table 4].



**Figure 1:** Kaplan–Meier survival curve demonstrating overall survival of all 20 patients included in the study demonstrating a median survival of 624 days.

Parameters	Total (n=20) (%)
Symptoms at presentation	
Lower back pain	12 (60)
General back pain	8 (40)
Radiculopathy	7 (35)
AISA impairment scale	
A	0
B	0
C	0
D	6 (30)
E	14 (70)
Median number of days between:	
Primary cancer DX to MSD SX	1065
Primary cancer DX to MSD DX	1129
MSD SX to DX	20
MSD SX to surgery	181
MSD DX to surgery	165
MSD: Metastatic spinal disease	

## DISCUSSION

Advancements in oncological treatment for MSD have led to increased survival rates and patients with MSD requiring surgical decompression/fusion of the spine. Minimally invasive spinal surgery for MSD now includes percutaneous pedicle screw fixation (MIPPSF). Here, we compared multiple clinical, radiographic, and outcome variables for patients with MSD undergoing short and long construct MIPPSF.

### Varying instrumentation failure rates using MIPPSF for MSD

Studies in the spine oncology literature demonstrate varying MIPPSF instrument failure particularly for longer constructs. Versteeg *et al.* conducted a retrospective study of 101 patients from which they observed  $n = 4$  patients experiencing construct failure (4%), with  $n = 6$  patients (5.9%) requiring revision surgery, bringing their instrument failure rate between 6% and 10%.<sup>[10]</sup> A study by Moussazadeh *et al.* looked at outcomes of short construct MIPPSF and reported an instrument failure rate of 2%.<sup>[7]</sup> This case series, however, includes all patients underwent cement augmentation in addition to MIPPSF. In a study of 318 patients treated with open surgical posterior fixation, Amankulor *et al.* observed an instrument failure rate (i.e., required reoperation for hardware revision) of 2.8%, with longer constructs having a greater risk of implant failure.<sup>[2]</sup> Patients undergoing fixation with six or less instrumented segments experienced 0 failures, while those undergoing fixation of 7 or more levels experienced 1- and 2-year failure rates of 3.5% and 6.6%, respectively. Mesfin *et al.* found an instrument failure rate in MSD of 2.9%.<sup>[6]</sup> In a meta-analysis by Aly, they concluded that they saw no differences in instrumentation failure rates for short and long constructs.<sup>[1]</sup>

**Table 3:** Characteristics of surgery and outcomes.

Parameters				
Surgical characteristics	All patients (%)	Long construct (%)	Short construct (%)	P-values
Total patients	20	14 (70)	6 (30)	-
Age (years)	58	59.5	54.7	0.2828
Preoperative VAS	7.4	7.86	6.33	0.0807
Postoperative VAS	3.75	4.29	2.5	0.4323
Preoperative SINS	11	11	10	0.2396
Average EBL (mL)	139	115	204	0.3529
Preoperative radiation	7 (35)	5 (35.7)	2 (33.3)	0.9186
Postoperative radiation	6 (30)	5 (35.7)	1 (16.7)	0.3943
Radiation pre- and post-operative	4 (20)	2 (14.3)	2 (33.3)	0.3291
Kyphoplasty	4 (20)	2 (14.3)	2 (33.3)	0.3291
Levels of instrumentation				
3	4 (20)	-	4	-
4	2 (10)	-	2	-
5	8 (40)	8	-	-
6	3 (15)	3	-	-
7	2 (10)	2	-	-
8	0 (0)	0	-	-
9	1 (5)	1	-	-
Outcomes				
Complications	2 (10)	2 (14.3)	0	-
Reoperation	3 (15)	3 (21.4)	0	-
Instrument failure	0	0	0	-
Screw loosening	4 (20)	3 (21.4)	1 (16.7)	0.8072

VAS: Visual analog scores, SINS: Spinal instability neoplastic score, EBL: Estimation of blood loss

**Table 4:** Cancer types by construct

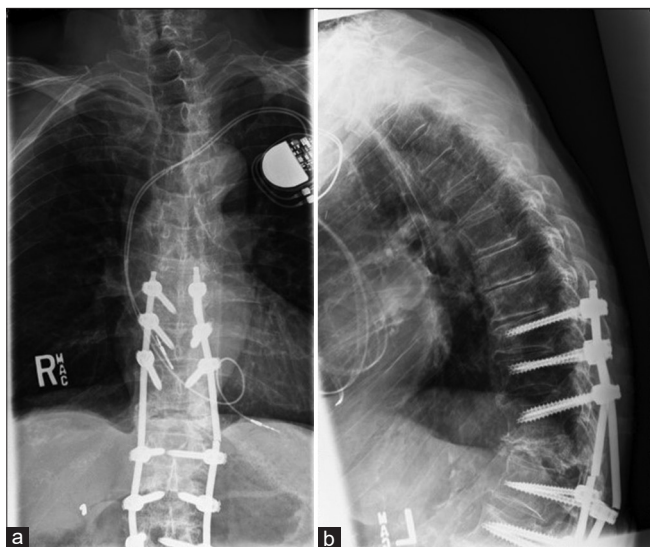
Parameters	Total (n=20)		
	Long construct (n=14) (%)	Short construct (n=6) (%)	Average FU/survival
Adenoid cystic carcinoma	0	1 (16.7)	130
Breast	4 (28.6)	0	248
Colon	0	1 (16.7)	204
Hodgkin's lymphoma	0	1 (16.7)	2325
Leukemia	1 (7.1)	0	1107
Melanoma	1 (7.1)	0	180
Multiple myeloma	6 (42.9)	0	1123
NSCLC	0	1 (16.7)	19
Prostate	1 (7.1)	1 (16.7)	88
Renal	0	1 (16.7)	249
Urothelial	1 (7.1)	0	80

NSCLC: Nonsmall cell lung cancer

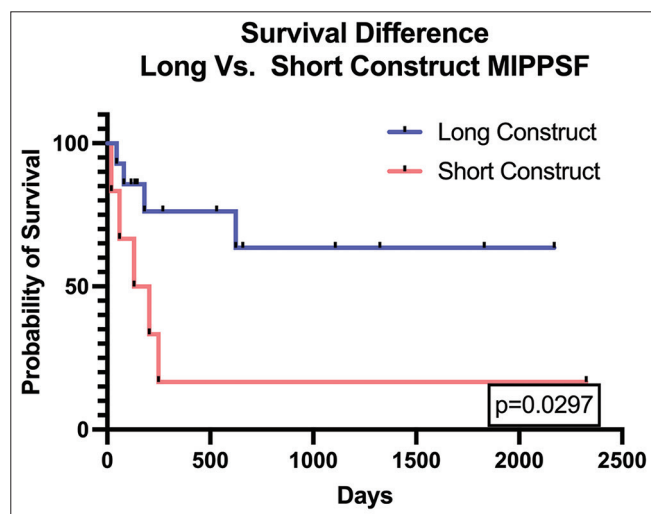
**Differences in survival**

We observed a higher median survival in the patients undergoing long construct PSFS versus short constructs. This was likely attributed to the types of the primary underlying cancers. The literature shows that survival for MSD patients primarily depends on the tumor type with 2-year survival rates ranging from 9% in lung cancer to

44% in breast and prostate cancer, with only 10–20% of MSD patients still alive 2 years following diagnosis the time of their original diagnosis.<sup>[4,9]</sup> Nearly half of the primary malignancies, 42.9% (n = 6) in the long construct group were diagnoses of MM, a disease with a 5-year survival rate of nearly 50%. Notably, the data for MM significantly skew the overall survival data in this series. Therefore,



**Figure 2:** (a) Anteroposterior and (b) lateral X-ray demonstrating left-sided rod breakage in a patient suffering from a fall.



**Figure 3:** Kaplan–Meier survival curve comparing overall survival between patients in the short construct and long construct groups. Patients undergoing long construct minimally invasive percutaneous pedicle screw fixation demonstrated a statistically significant longer overall survival ( $P = 0.0297$ ).

the majority of patients with MSD have poor prognoses, regardless of construct length.

## CONCLUSION

In our retrospective cohort of 20 patients who underwent MIPPSF for MSD, we found that long-segment constructs were safe and did not increase the risk of instrumentation failure requiring reoperation. Notably, the inability to perform MIPPSF fusions did not correlate with poorer outcomes.

## Declaration of patient consent

Institutional Review Board (IRB) permission obtained for the study.

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Nil.

## Conflicts of interest

There are no conflicts of interest.

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