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Outcome of Palliative Single Posterior Reconstruction Surgery for Metastatic Spinal Tumor

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Abstract

Study design: A retrospective single-center study

Objective: To report the clinical and radiological outcomes of palliative single posterior reconstruction surgery for the treatment of metastatic spinal tumor in different regions of the spine.

Summary of background data: The indications of surgical procedures, whether anterior, posterior or a combination of these, for patient with metastatic spinal tumor are still controversial, and all procedures have their pros and cons.

Methods: A retrospective analysis involving 53 patients (34 male, 19 female, 66.4 ± 9.8 years old) who underwent palliative single posterior reconstruction surgery for metastatic spinal tumor. 10 patients were affected in the cervical region (C2-7), 27 in the thoracic region (Th1-10), and 16 in the thoracolumbar/lumbosacral region (Th11-L5). Common primary tumors were prostate, lung, and thyroid cancers. Clinical evaluation of pain level, neurological function, ambulatory ability, and complications was carried out for the different sites, and correction angle and loss of correction were evaluated radiologically.

Results: 86% of the patients experienced pain relief, 70% improved by one or more Frankel grades, and 75% became ambulatory at follow-up, regardless of the affected region. The cervical group demonstrated a significantly greater correction angle (8.00 ± 4.84 degrees) compared to other groups (thoracic: 3.42 ± 4.97 degrees, thoracolumbar/lumbosacral: 3.62 ± 4.31 degrees) and also exhibited a smaller loss of correction (0.33 ± 3.31 degrees) compared to other groups (thoracic: 2.80 ± 2.46 degrees, thoracolumbar/lumbosacral: 2.85 ± 3.10 degrees).

Conclusion: Palliative single posterior reconstruction surgery provided good clinical and radiological outcomes at any region. Therefore, this procedure can be a choice of surgical treatment for metastatic spinal tumor, because of its lower invasiveness, for immunocompromised cancer patients.

Keywords: Metastatic spinal tumor; Palliative single posterior reconstruction surgery; Clinical outcome; Degree of correction; Loss of correction

Introduction

Metastatic spinal tumor has been reported to occur in approximately 30% of cancer patients. The distribution of lesions is 10% in cervical spine, 20% in lumbar spine and 70% in thoracic spine. Five percent of metastatic spinal tumor is reported to cause epidural compression, giving rise to clinical symptoms such as paralysis and pain. These symptoms can lead to deterioration of patients' daily activities. The therapeutic choice for these patients should be based on clinical information such as the extent of metastasis, degree of malignancy, general condition of the patient, and estimated life expectancy.

Tokuhashi et al. reported a scoring system for pre-operative evaluation of prognosis of metastatic spine tumor. In their paper, prognosis evaluation was based on the opinion of oncologist and the pre-operative prognostic score. They suggested that excisional procedures are indicated in patients with a total score from their scoring system of 12 or more (predicted survival period, 1 year or longer), while conservative or palliative procedures are indicated on patients with a total score of 8 or less (predicted survival period, less than 6 months) [1,2]. Tomita et al. also described a scoring system, with corresponding treatment proposals, for patients with spinal metastasis. It was based on three prognostic factors: (1) grade of malignancy, (2) presence of visceral metastasis, and (3) presence of bone metastases. Their strategy for each patient was decided along with treatment goal: a wide or marginal excision for long-term local control, marginal or intralesional excision for medium-term local control, palliative surgery for short-term palliation, and non-operative supportive care [3].

Palliative surgery, which consists of reconstruction of the spine and decompression of the neural elements, is reported to provide good clinical outcomes in terms of relief of pain and paralysis for patients with spinal metastasis. However, indications for surgical procedures, whether anterior, posterior or a combination of these, are still controversial, and all procedures have their pros and cons.

The anterior procedure offers the possibility of achieving anterior decompression by removing tumor tissue directly and for reconstruction of the anterior column [4-9]. However, its disadvantages are that it is highly invasive due to the necessity for an extra/trans-pleural or extra-peritoneal approach (for thoracic and thoracolumbar/lumbosacral regions). There is also occasional difficulty in managing bleeding from the tumor tissues (any sites), and weaker fixation force on anterior reconstruction, even using the cage and anterior instrumentations (any sites) [10-12].

On the other hand, the posterior approach is less invasive than the anterior approach (thoracic and thoracolumbar/lumbosacral

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region), and can still achieve partial removal of the tumor tissue which compresses the dura anterior at the pedicle level from the posterolateral aspect (thoracic and thoracolumbar/lumbosacral regions). It is also possible to achieve indirect decompression of the cord when performing posterior decompression with realignment of the cervical lordosis using posterior instrumentation (cervical region), and it provides a stronger fixation force using pedicle screw system than anterior fixation (any sites) [12-19]. The disadvantages of the posterior approach are that we cannot reconstruct the anterior column, although the biomechanically-insufficient part due to destructive change of the metastasis is mainly the anterior column (any sites), and also, we cannot achieve direct resection of the tumor (cervical region).

We have preferentially used the posterior approach for palliative surgery in metastatic spinal tumor cases because we believe this single procedure is less invasive for immunocompromised hosts and biomechanically reliable in unstable spine. The purpose of the present study, therefore, was to elucidate the efficacy of single posterior decompression and reconstruction surgery for metastatic spinal surgery. We also carried out, for the first time, a comparison of degree of kyphotic correction and loss of correction among the sites (cervical, thoracic, and thoracolumbar/lumbosacral regions).

Materials and Methods

Patient population

A retrospective analysis was performed in 53 patients who underwent palliative single posterior reconstruction surgery for metastatic spinal tumor at our institute between April 2000 and February 2013. There were 34 men and 19 women, and the average age at the surgery was 66.4 ± 9.8 years (range; 44-86 years). The sites of the primary tumors were; prostate (10 cases), lung (5), thyroid (5), malignant lymphoma (4), kidney (4), liver (3), breast (3), and multiple myeloma (3) (Table 1).

Affected levels were; cervical region (C2-7) in 10 patients, thoracic (Th1-10) in 27, and thoracolumbar/lumbosacral (Th11-L5) in 16 (Table 2). Single-level tumor involvement was seen in 32 (60%) patients and multi-level in 21 (40%) patients.

Site	No. of cases
Prostate	10
Lung	5
Thyroid	5
Malignant lymphoma	4
Kidney	4
Liver	3
Breast	3
Multiple myeloma	3
Esophagus	2
Stomach	2
Mediastinal tumor	1
Unknown	11

Table 1: Sites of primary tumor.

Palliative surgery was indicated for patients who had a life expectancy of less than 6 months according to the Tokuhashi score [1,2]. We consulted with the specialist for the primary cancer as well as the medical and radiation oncologists about the predicted prognosis and suitable treatment.

Fifty-two of 53 patients (98%) suffered pain referable to the metastatic lesion. Fifty-two patients (98%) had spinal cord compression resulting in motor deficit pre-operatively. Forty-four patients (83%) were not ambulatory due to pain or motor deficit. The diagnosis of metastasis was evaluated by plain radiography, computed tomography (CT), magnetic resonance imaging (MRI), bone scintigraphy, and histological evaluation of needle biopsy sample.

Surgical procedures

All patients underwent laminectomy at the affected level. For thoracic and thoracolumbar/lumbosacral regions, facetectomy and pediclectomy at the site were performed, and partial removal of the tumor from the posterolateral aspect was also carried out. Posterior stabilization was achieved using screw-rod system in 42 cases, segmental spinal instrumentation in 9 cases, and plate system in 2. Correction of kyphotic deformity was performed for all cases. The range of fusion was decided on the basis of deformity, bone quality and number of affected vertebrae. The average number of fused segments was 2.44 above and 2.44 below in the cervical region, 2.44 above and 2.40 below in thoracic region, and 2.60 above and 2.40 below in thoracolumbar/lumbosacral region (Table 2). Autologous bone was occasionally used for patients who were estimated to have longer life expectancy.

The implants which were used were; EXPEDIUM (Depuy spine, Raynham, MA, US) for 16 cases, U-shaped rod system (Medtronic Sofamor Danek, Memphis, TN, USA) for 9 cases, TSRH system (Medtronic Sofamor Danek, Memphis, TN, USA) for 6 cases, Synergy Spinal System (Interpore Cross International, Irvine, CA, USA) for 4 cases, ISOLA (Depuy spine, Raynham, MA, USA) for 3 cases, Mini ISOLA (Depuy spine, Raynham, MA, USA) for 3 cases, OASYS (Stryker Spine, Allendal, NJ, USA) for 3 cases, MOSS Miami (Depuy spine, Raynham, MA, USA) for 3 cases, COLORADO spinal system (Medtronic Sofamor Danek, Memphis, TN, USA) for 1 case, SOLERA spinal system (Medtronic Sofamor Danek, Memphis, TN, USA) for 1case, Axis (Medtronic Sofamor Danek, Memphis, TN, USA) for 1 case, Mountaineer OCT spinal system (Depuy spine, Raynham, MA, USA) for 1 case, MONARCH (Depuy spine, Raynham, MA, USA) for 1 case, and MESA (K2M, Leesburg, VA, USA) for 1 case.

Post-operatively, the patients were immobilized with a soft collar for the cervical region, and with thoracic-lumbar-sacral orthosis (TLSO) corset for thoracic and thoracolumbar/lumbosacral regions, for a period of 3 months. One patient who suffered renal cell carcinoma underwent pre-operative spinal angiography with tumor embolization in order to reduce intraoperative bleeding.

Clinical evaluation

Pain levels were evaluated using a scale which was graded as: 1. no pain, 2. mild pain (sometimes medication required), 3. moderate pain

Variables		Cervical	Thoracic	Thoracolumbar/Lumbosacral	P-value
No. of cases		10	27	16	
Average age at surgery (years)		68.6 ± 11.7	67.9 ± 9.11	62.7 ± 9.8	N.S
Average follow-up (month)		5.35	11.09	9.57	N.S
Average No. of fixed segment	Above	2.42 ± 0.72	2.44 ± 0.64	2.60 ± 0.82	N.S
	Below	2.42 ± 0.72	2.40 ± 0.57	2.40 ± 0.73	N.S
Average No. of decompression segment		4.11 ± 0.60*	2.54 ± 0.67	2.25 ± 0.93	*P<0.05

Table 2: Parameters with respective lesions of the spine.

(constant medication required), and 4. severe pain. Pre-operatively, 1 patient had grade 1, 11 had grade 2, 24 four had grade 3, and 17 had grade 4. Neurological status was graded using the Frankel classification of motor and sensory compromise. Post-operative clinical assessment was performed to document pain relief, neurological deficit, ambulatory ability, and complications at follow-up.

Radiological assessment

Kyphosis angle at pre-operation, correction angle between post-operation and pre-operation, loss of correction between follow-up and post-operation were measured on lateral radiographs, and they were compared between the different regions. The average follow-up period was 9.4 months (range 3 months -5 years).

Statistical analysis

One-way analysis of variance with Tukey-Kramer post hoc test was used to assess differences among the sites (cervical, thoracic, and thoracolumbar/lumbosacral regions). Statistical analyzed was carried out using IBM SPSS statistics 22 (IBM SPSS, Chicago, IL, US). Data were analyzed using. P values of <0.05 were regarded as statistically significance.

Results

Pain relief

Overall, pain was significantly relieved in 45 patients (87%). Of 41 patients with severe or moderate pain before surgery, 28 (68%) improved to no or mild pain. In the cervical region, all patients obtained pain relief. Only 1 patient (2%) worsened due to a local recurrence in 1 year after surgery (Figure 1).

Neurological status

Neurological improvement in which an improvement of one or more Frankel grades was seen in 7 patients (70%) with cervical region lesions, 19 (70%) with thoracic region lesion, and 11 (68%) with thoracolumbar/lumbosacral lesions (Figure 2). Among 8 patients with Grade D pre-operatively, 1 patient (12%) improved to Grade E, and 7 patients (88%) remained unchanged including 1 patient with thoracic region lesions who deteriorated with bladder-bowel disturbance after surgery (Table 3). Of 37 patients with Grade C, 1 patient (3%) deteriorated to Frankel Grade A, whereas 1 (3%) improved to Grade E,

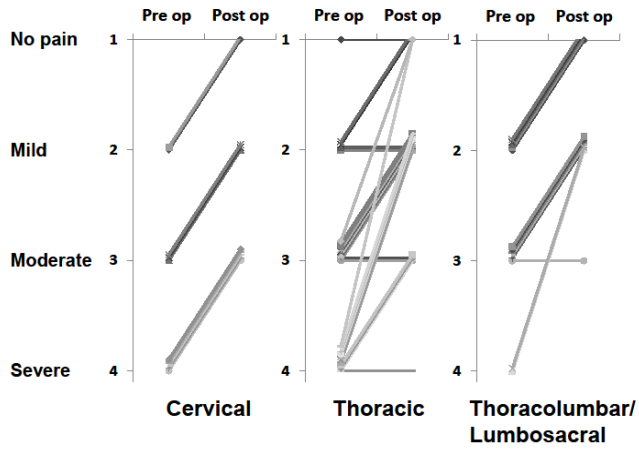

Figure 1: The change of pain level in different regions of the spine - Pain levels were evaluated using a scale which was graded as: 1) no pain, 2) mild pain (sometimes medication required), 3) moderate pain (constant medication required), and 4) severe pain.

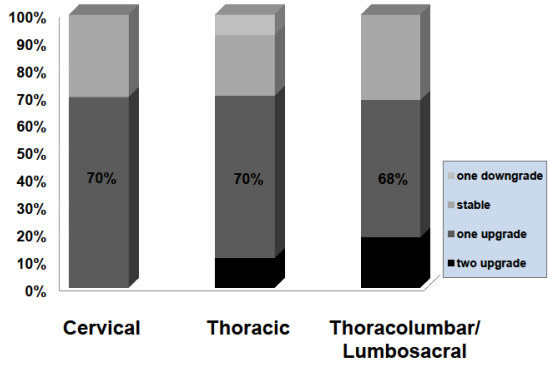

Figure 2: Post-operative neurological function - Neurological status was graded using the Frankel classification of motor and sensory compromise.

Pre-operative Frankel grade	Post-operative Frankel grade				
	A	B	C	D	E
A (N=0)	-	-	-	-	-
B (N=7)	-	-	3	4	-
C (N=37)	1	-	7	28	1
D (N=8)	-	-	-	7	1
E (N=1)	-	-	-	-	1

Table 3: Comparison of pre- and postoperative Frankel grade.

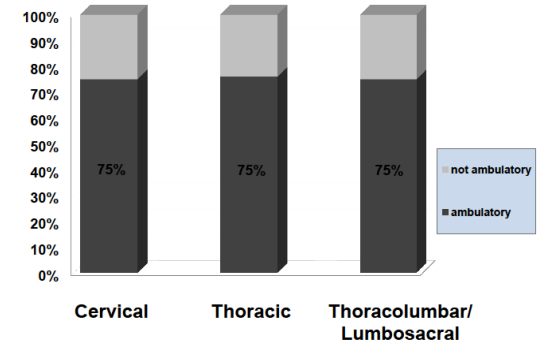

Figure 3: Post-operative ambulatory ability - Patients who had not been able to walk due to intractable pain or motor deficit (Frankel Grade A-C) were categorized as non-ambulatory.

28 (76%) to Grade D and 7 (18%) remained unchanged (Table 3). Seven patients with Grade B recovered their neurological function; 3 (43%) improved to Grade C and the other 4 (57%) to Grade D (Table 3).

Ambulatory ability

In total 33 of 44 (75%) patients who had not been able to walk due to intractable pain or motor deficit (Frankel Grade A-C) pre-operatively were ambulatory at follow-up (Frankel Grade D or E). Six patients (75%) with cervical region lesions, 18 (75%) with thoracic region, and 9 (75%) with thoracolumbar/lumbosacral regions became ambulatory at the final follow-up (Figure 3).

Complications

Complications related to surgery were documented in 3 patients (6%): 1 patient with pulmonary embolus, 1 with wound infection leading to sepsis shock, and 1 with instrumentation failure. The pulmonary embolus was observed 2 weeks after spine surgery for metastatic lung cancer, and was reversible with thrombolityic treatment. One patient with prostate cancer presented surgical site infection post-

operatively was curable with surgical debridement and antimicrobial therapy. Reoperation was performed for 1 patient with radiculopathy due to displacement of the pedicle screw. On removing it, the symptom disappeared immediately.

Degree of correction

The pre-operative magnitude of local kyphosis due to vertebral collapse was 12.0 ± 11.4 degrees with cervical region lesions, 21.0 ± 11.0 degrees with thoracic region, and 8.6 ± 13.1 degrees with thoracolumbar/lumbosacral region. The average degree of correction gained by surgery was 8.00 ± 4.84 degrees with cervical region lesions, 3.42 ± 4.97 degrees with thoracic region, and 3.62 ± 4.31 degrees with thoracolumbar/lumbosacral regions. The cervical group demonstrated a significantly greater correction angle compared to other groups ($P<0.05$) (Figure 4).

Loss of correction

At the final follow-up, the average loss of correction was 0.33 ± 3.31 degrees with cervical region lesions, 2.80 ± 2.46 degrees with thoracic region, and 2.85 ± 3.10 degrees with thoracolumbar/lumbosacral regions. The cervical group also demonstrated a significantly smaller loss of correction compared to other groups ($P<0.05$) (Figure 5).

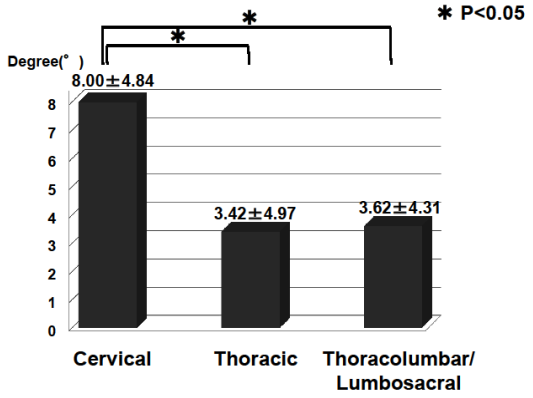

Figure 4: Post-operative degree of correction - Correction angle between post-operation and pre-operation was measured on lateral radiographs. P values of <0.05 were regarded as statistically significance. One-way analysis of variance with Tukey-Kramer post hoc test was used to assess differences among the sites (cervical, thoracic, and thoracolumbar/lumbosacral regions).

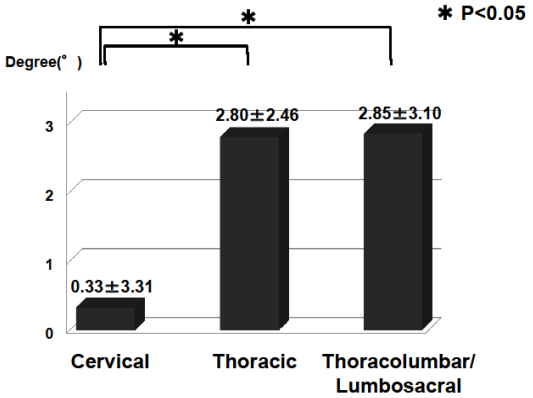

Figure 5: Loss of correction at final follow-up - Loss of correction between follow-up and post-operation was measured on lateral radiographs. P values of <0.05 were regarded as statistically significance. One-way analysis of variance with Tukey-Kramer post hoc test was used to assess differences among the sites (cervical, thoracic, and thoracolumbar/lumbosacral regions).

Figure 6: A 75-year-old man who suffered metastasis of Hepatocellular carcinoma at C5. (a. pre-operative lateral radiograph, b. pre-operative computed tomography, c, d. pre-operative T2-weighted magnetic resonance images). Lateral radiographs show correction and loss of correction of local kyphosis (angle between lines) at pre-operation (e), post-operation (f), and follow-up (g).

Representative Cases

A 75-year-old man who suffered severe neck pain and was unable to walk due to myelopathy (Frankel grade C). Pre-operative radiographs and computed tomography (CT) showed pathological vertebral collapse at C5 due to the metastasis of Hepatocellular carcinoma with kyphotic deformity (Figures 6a and 6b). Pre-operative magnetic resonance imaging (MRI) showed a C5 lesion involving the spinal cord compression. (Figures 6c and 6d). Pre-operatively, the magnitude of C4-6 local kyphosis was 13 degrees. (Figure 6e). Posterior decompression and reconstruction using pedicle screw fixation on C3-7 were performed (Figure 6f). As the result, his neck pain was relieved, and he became ambulatory at follow-up. Moreover, local kyphosis was corrected to 0 degrees. At the final follow-up, loss of correction was 3 degrees (Figure 6g).

A 64-year-old man suffered intractable back pain and was unable to walk due to myelopathy (Frankel grade C). Pre-operative radiographs and computed tomography (CT) showed the osteosclerotic change of Th9 vertebral body (Figures 7a and 7b). magnetic resonance imaging (MRI) revealed metastatic involvement of Th9 with tumorous tissue protruding into the spinal canal (Figures 7c and 7d). The diagnosis was metastasis of prostate cancer. He underwent posterior decompression and fusion including laminectomy of T8 and 9, pediclectomy of Th9, partial removal of the metastatic tumor, and posterior instrumentation with pedicle screw and lamina hook from Th6 to Th12. Seven degrees of Th8-10 kyphosis before surgery was maintained after surgery, and loss of correction was 3 degrees. His Frankel grade improved from C to D, and his back pain was dramatically relieved at the follow-up (Figures 7e, 7f and 7g).

Discussion

This study has indicated that the outcome of palliative single posterior reconstruction surgery for metastatic spinal tumor will be acceptable because 86% of the patients benefited from pain relief, 70%

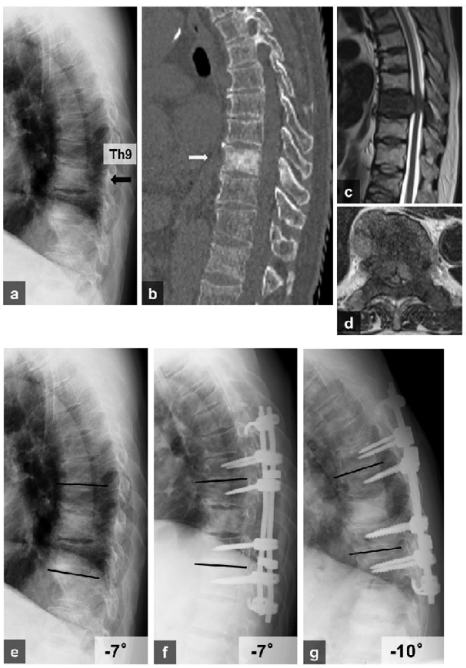

Figure 7: A 64-year-old man who suffered metastasis of prostate cancer.at Th9. (a. pre-operative lateral radiograph, b. pre-operative computed tomography, c, d. pre-operative T2-weighted magnetic resonance images). Lateral radiographs show correction and loss of correction of local kyphosis (angle between lines) at pre-operation (e), post-operation (f), and follow-up (g).

of them with neurological deficits had improved neurological function, and 75% of them who were not able to walk pre-operatively became ambulatory at follow-up. In particular, the patients with cervical lesions exhibited the best radiological outcome regarding realignment and loss of correction in addition to good clinical outcome.

For cervical lesions, anterior resection of the tumor and reconstruction of the anterior column with a cage or plate has long been considered the gold standard [4-9,16-19]. Thalgott et al. reported that 21of 26 patients (81%) with anterior cervical reconstruction with titanium mesh cages and anterior plating had a good or excellent clinical outcome, and 23 of 26 patients (88%) achieved a good or excellent restoration of lordosis [20].

However, in recent years there have been many reports on posterior procedures that provide stronger fixation force using pedicle screw system than anterior devices. Huch et al. have shown that posterior instrumentation using pedicle screw for the cervical and cervico-thoracic metastatic regions provided good stabilization, and showed no loosening or failure of instrumentation [21]. Oda et al. also reported that the advantages of posterior reconstruction using pedicle screw fixation for metastasis of the cervical spine are biomechanical superiority and capability of deformity correction without any need for anterior support. They demonstrated that spinal stability was restored and maintained throughout the survival period in 94% of the patients [22]. Other biomechanical studies have also shown that, in the cervical spine, posterior reconstruction surgery alone with posterior instrumentation offered better stability than anterior reconstruction [10,13]. Additionally, the facet joint is an integral participant in the stability of the cervical vertebral columns, therefore the posterior column is responsible for more significant load sharing capacity in the lordotic cervical spine than other regions [23].

In the thoracic and thoracolumbar/lumbosacral regions, approximately 80% to 90% of the axial load bearing is reportedly absorbed by the vertebral bodies, in contrast with approximately 10% to 20% through the posterior facet joints. Therefore, a posterior-alone procedure without any anterior augmentation, may carry the risk of worse clinical and radiological outcome through the follow-up [24]. Sundaresan et al. described 101 consecutive patients suffering from cervical, thoracic, and lumbar metastasis with anterior vertebral body resection and stabilization with methyl methacrylate and Steinmann pins, and they reported that additional augmentation using posterior instrumentation was required for 10% of them [16,17]. Most of the metastatic tumors involve the middle and anterior columns, therefore single anterior reconstruction surgery may be insufficient for restoring torsional stability or tensile strength because the pedicles and facet joints may be invaded by the metastasis. Therefore, in some cases, combined anterior and posterior surgery is held to be the only method of maintaining spinal stability [16-19,25,26]. Later, Sundaresan et al. reported on 110 patients with metastatic spinal tumor treated by anterior, posterior, or combined anterior-posterior decompression and stabilization with instrumentation. The incidence of stabilization failure in patients undergoing either anterior or posterior instrumentation alone was higher than in patients undergoing combined anterior-posterior instrumentation (anterior or posterior: 18%, combined: 7%), while a higher incidence of complications, such as infection, wound breakdown, or excessive bleeding, was seen in patients undergoing combined anterior-posterior instrumentation [19]. Jansson et al. reported on 282 patients with thoracic or lumbar metastatic spinal tumor treated by anterior or posterior decompression and stabilization with instrumentation. They showed that both anterior and posterior procedures provided important improvement of clinical outcome, but they could not draw any conclusion as to whether there is a difference in clinical outcome between anterior or posterior procedures regarding pain and neurological function because of selection bias. Additionally, they did not refer to radiological outcome such as degree of correction or loss of correction [14].

Similarly, to the results of our series, Rompe JD et al. reported that, even though the affected vertebrae were not reconstructed, posterior decompression and stabilization with the Cotrel-Dubousset instrumentation in patients suffering from cervical, thoracic, and lumbar metastases was sufficient to retain improvement throughout the follow up. They reported that 6 of 106 patients (5%) required additional operation for local tumor recurrence [12,15]. However, they made no reference to radiological outcomes.

In the present study, it has been shown that patients with metastasis in the thoracic and thoracolumbar/lumbosacral regions exhibited acceptable clinical and radiological outcomes (no breakage of rod and small loss of correction). Such good results may be explained by the low activity of the patients and “not so long” prognosis of cancer patients. We do believe that this result can be advantageous for immunocompromised patients, who can avoid the major invasiveness of extra/trans-pleural or extra-peritoneal approaches.

The present study has several limitations. This is only a single institutional experience and our results have not been duplicated at other centers. Small number of patients at each region, and the usage of various types of implants were also limitations of the present study.

Conclusion

In conclusion, we report the clinical and radiological outcomes of palliative single posterior reconstruction surgery for metastatic spinal tumor. Posterior procedures provided an acceptable degree of correction, loss of correction, and clinical recovery for involvement

in any region. Therefore, single posterior reconstruction surgery can be the first choice of the surgical treatment for metastatic spinal tumor because of the lower invasiveness of a single procedure for immunocompromised cancer patients.

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