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Original Article

Vertebral body cemented stents combined with posterior stabilization in the surgical treatment of metastatic spinal cord compression of the thoracolumbar spine

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ABSTRACT

Background: Extensile interventions to provide anterior spinal column support in metastatic spinal cord compression (MSCC) surgery incur added morbidity in this surgically frail group of patients. We present our preliminary results of posterior spinal decompression and stabilization coupled with vertebral body cemented stents for anterior column support in MSCC.

Methods: Fourteen patients underwent posterior spinal decompression and pedicle screw construct along with vertebral body stenting (VBS) technique for reconstruction and augmentation of the vertebral body. The primary in all except one was solid organ malignancy and 10 patients (71%) were treatment naïve. The mean revised Tokuhashi score was 10.7 ± 2.7 and the mean spinal instability neoplastic score was 9.6 ± 1.9. All vertebral body lesions were purely lytic and were associated with a cortical defect in the posterior wall.

Results: A mean 5.3 ± 2.7 ml low-viscosity polymethyl methacrylate bone cement was injected within the stent at each compression level. No cement extrusion posteriorly was noted in any case from intraoperative fluoroscopy or postoperative radiographs. Five patients died at a mean 6.8 months (range 1–15 months), while the remaining patients have a mean survival of 18 months. Neither further revision surgical intervention nor any neurological deterioration was noted in any patient, who all continued to be ambulatory. The mean postoperative Core Outcome Measures Index score for 11 patients was 4.03 (standard deviation 3.11, 95% confidence interval (1.93–6.12).

Conclusion: In lytic vertebral body lesions with posterior wall erosions, cemented VBS technique adds to the surgical armamentarium in MSCC surgery showing promising early results without added complications.

Keywords: Bone cement, Metastatic spinal cord compression, Posterior stabilization, Vertebral augmentation, Vertebral body stent

INTRODUCTION

Standard surgical option in metastatic spinal cord compression (MSCC) involves decompression and spinal stabilization with the aims being to improve pain, restore stability, and address neurological dysfunction.[19] The primary goal is to improve the patient's quality of life rather than to prolong survival. Extensive surgery including anterior approaches incurs added morbidity and risks in this surgically frail group of patients.[20] In patients with significant pain, less invasive vertebral augmentation techniques such as vertebroplasty

(VP) and kyphoplasty are useful alternatives to open surgery.[12,17] They may also be the one option in metastatic disease causing extensive bone loss where instrumentation may be precluded due to poor bone quality. However, the technical complications of cement extravasation and tumor mass displacement[11] are compounded by the fact that these procedures on their own do not fully address spinal stability or the compression of neural elements.[22] Often, the vertebral body disease renders structural weakness that may affect the construct stability for posterior-only fixations. Vertebral body augmentation using acrylic bone cement not only addresses pain but, in the context of osteolytic body lesions, also contributes to the spinal stability. Cement insertion in spinal tumors aids in various means including reducing bone micromotion, exothermic effect, monomer toxicity, interfere with tumor tissue vascularity, and space-occupying effect.[26]

There are reports of tumor-induced spinal instability being stabilized by percutaneous pedicle screw-assisted cement augmentation of vertebral column.[2,18,25] However, when decompression of the neural elements is required in the context of MSCC, along with addressing spinal instability, we have used vertebral body cement stents to aid support of anterior column in extremely lytic body lesions. The technique allows for adequate neuraxis decompression and posterior spinal stabilization along with cement augmentation of the lytic vertebral body to support the posterior tension band construct. This report presents the technique and the preliminary results of this stabilization configuration which to our knowledge has not been reported before.

MATERIALS AND METHODS

A pathway and team exist where all patients with MSCC will be discussed with a surgical team which is coordinated through the regional oncology hospital as per the established guidelines.[13,14] Decision-making is aided by clinical history, examination, imaging, and hematological investigations, and incorporating the revised Tokuhashi scoring system[21] for patient prognosis and spinal instability neoplastic score (SINS) system[9] for spinal instability. Therapeutic decisions are made through a consultant spinal surgeon-led service at the surgical site in our tertiary referral spinal unit which is guided concurrently by discussions with the cancer service. Patients deemed suitable for surgical intervention are discussed in the "Urgency theatre list" meeting which is conducted every weekday and attended by the spinal surgeons in the unit. Appropriate treatment plans and operative technicalities are discussed in the meeting and finalized in the operating theater. The aim of surgical treatment in MSCC patients is palliative with the purpose to deliver better quality of life. Cases where there is extensive lytic or mixed lytic/sclerotic vertebral body lesion and a posterior cortical breach are selected for consideration of the vertebral body stent. Patients are counseled and an informed consent is obtained about risks of cement augmentation and stent application including (and not limited to) cardiovascular risks, cement leakage, neurological deficits, failure of procedure, and requirement of further revision surgery.

Surgical technique

All patients have the procedure under total intravenous anesthesia with antibiotic prophylaxis and intraoperative cell salvage. Patients are placed prone and all pressure areas are well padded, with measures taken to reduce intrathoracic and abdominal pressures.

Midline posterior subperiosteal release approach is performed and pedicle screws inserted at appropriate landmarks under fluoroscopy guidance as needed in the adjacent vertebral segments. Depending on the bone quality and preoperative imaging, we prefer to use fenestrated, cannulated pedicle screws to insert cement to aid the fixation. Posterior decompression is performed with laminectomy, flavectomy, and pedicle excision at the level of cord compression. A connecting rod is applied unilaterally to guard against causing thecal injury through movement before decompression.

At this point, the decision is made to proceed with vertebral body stent (VBS, DepuySynthes, Switzerland). A cannulated 4.7 mm access kit trocar is inserted through transpedicular route under fluoroscopy and seated approximately 3 mm into the vertebral body [Figure 1a]. A biopsy needle can be used if deemed necessary to obtain a tissue sample for histopathological analysis. An access channel is created using a drill and a plunger inserted to more than 5 mm from the anterior vertebral body cortex under fluoroscopy [Figure 1b]. Markings on the plunger allow the option to choose the correct length stent (13–20 mm). The VBS has a combined cobalt–chromium–molybdenum alloy stent and saline inflated balloon option of various sizes [Table 1].

The balloon catheter with the stent attachment is inserted under lateral fluoroscopy and should ideally be within 5 mm and parallel to the superior end plate of the vertebra [Figure 1c and d]. It is essential that the contralateral side stent be inserted, if deemed possible and necessary, at this point to enable near simultaneous dilatation of bilateral devices. In situations, where it is not been possible nor safe to insert contralateral stents, we aim to place the single stent into a more central position within the vertebral body. Gradual balloon inflation is then performed carefully, under the scrutiny of fluoroscopy imaging [Figure 1e

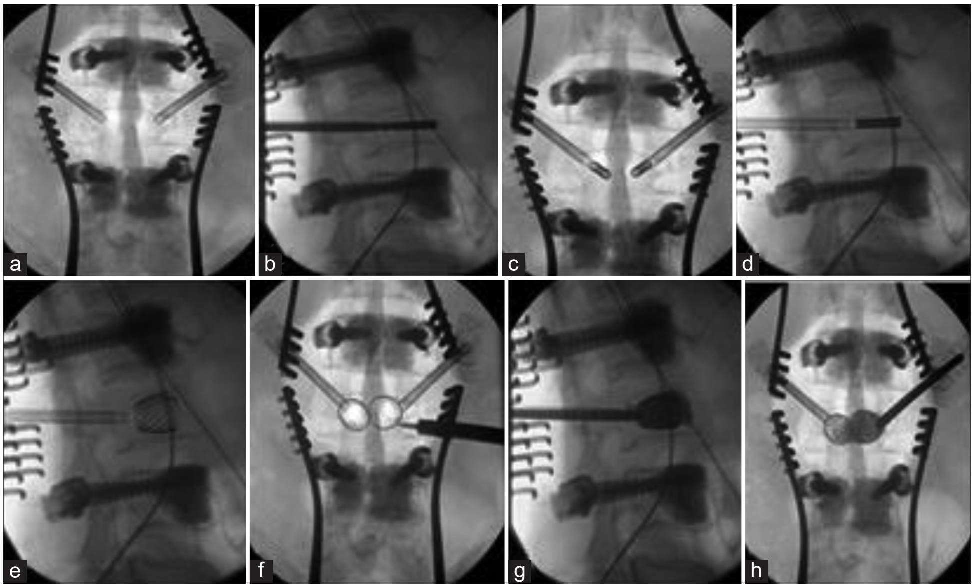

Figure 1: (a-h) Intraoperative fluoroscopy images of the various stages of surgical technique.

Table 1: Stent size options for vertebral body stenting and their characteristics.

	Small balloon	Medium balloon	Large balloon
Stent length expanded	13 mm	15 mm	20 mm
Maximum diameter expanded	15 mm	17 mm	17 mm
Maximum volume expanded	4.0 ml	4.5 ml	5.0 ml
Maximum pressure	30 bar/atm	30 bar/atm	30 bar/atm

and f] at all times till one of the following is reached: (1) maximum stent pressure of 30 atmospheres, (2) maximal stent volume, or (3) desired vertebral body height. Once the anteroposterior and lateral fluoroscopy images show satisfactory stent expansion, the balloons are deflated and carefully extracted. Polymethyl methacrylate (PMMA) cement injection delivery system is attached to the cannula. High-viscosity PMMA cement (Confidence Spinal Cement System® DepuySynthes, USA) approved for use in VP/kyphoplasty procedures is then injected into the void created within the stent under close monitoring of the lateral fluoroscopy [Figure 1g and h]. Ideally, cement is injected until it infiltrates the surrounding cancellous bone in a controlled manner. In the absence of bony boundaries, an eggshell of cement is created and filled in slowly. This can be done in deficient posterior or lateral cortices at the level of cord and theca. Gradual filling of the stents is accomplished under increments and the filling pattern is observed to ensure no cement leakages.

Cement leakage is a significant complication that can result in paralysis or even death. If cement leakage is observed, it is essential to stop injection and attempt to reposition the needle direction; wait for cement to harden before injecting further; or to completely abandon further injection. We leave the injection syringes attached to the system to prevent any backfilling of the working sleeve. The working sleeve and the injection needle are then removed, preceded by an 180° turn to detach itself from any adherent cement, within the working time of the curing process of bone cement.

The posterior stabilization construct is then finally secured and the wound closed in layers. Patients are managed with early mobilization and discharged after satisfactory recovery for further treatment appropriate for their primary tumor.

RESULTS

We analyzed 14 patients who underwent posterior spinal decompression and pedicle screw construct along with VBS technique for reconstruction and augmentation of the vertebral body [Table 2]. The primary in all except one was solid organ malignancy and 10 patients (71%) were treatment naïve. The mean revised Tokuhashi score[24] was 10.7 ± 2.7 and the mean SINS was 9.6 ± 1.9. All vertebral body lesions were purely lytic and were associated with a cortical defect in the posterior wall. All patients except one were neurologically intact and ambulatory before surgery.

Table 2: Patient demographics for the study cohort.

	Age/sex	MSCC level	Primary tumor pathology	Revised Tokuhashi score	SINS score	Frankel grade	Ambulatory status	Sphincter function
1	66, F	T8	Breast	14	9	E	Yes	Normal
2	60, F	L3	Melanoma	11	9	E	Yes	Normal
3	71, F	L4	Renal	13	7	E	Yes	Normal
4	70, M	L4	Renal	9	8	E	Yes	Normal
5	72, M	L1	Myeloma	9	10	E	Yes	Normal
6	61, F	T9	Breast	12	12	D	Yes	Urinary dysfunction
7	50, M	L3	Lung	9	8	E	Yes	Normal
8	49, F	T12	Breast	14	10	E	Yes	Normal
9	54, F	T11	Gastric	5	14	E	No	Normal
10	63, F	L3	Oropharynx	13	10	E	Yes	Normal
11	53, F	T11	Breast	10	10	E	Yes	Normal
12	77, F	T5	Breast	12	10	E	Yes	Normal
13	73, M	T7	Prostate	13	7	E	Yes	Normal
14	61, M	L1	Esophageal	7	11	E	Yes	Normal

A mean 5.3 ±2.7 ml low-viscosity PMMA bone cement was injected within the stent at each compression level. No cement extrusion posteriorly was noted in any case from intraoperative fluoroscopy or postoperative radiographs. There were no procedural stent-related issues except in three cases were the stent failed to fully inflate. Eight patients also had cement insertion into adjacent level vertebral bodies through fenestrated pedicle screws for added construct stability. The fixation construct was kept within one segmental level on either side of the diseased vertebra in six patients, while the mean fixation level for the whole cohort was 3.3 segmental levels (range 2–6).

Five patients died at a mean 6.8 months (range 1–15 months), while the remaining patients have a mean survival of 18 months at the time of the study. Neither further revision surgical intervention nor any neurological deterioration was noted in any patient. All patients remained ambulatory after surgery and none had any neurological deterioration pertaining to the MSCC level at subsequent follow-up reviews [Figures 2 and 3]. Two superficial wound infections required oral antibiotics and one of these unfortunately had wound dehiscence that needed plastic surgery input. One patient had postoperative pulmonary embolism diagnosed 8 days postoperatively, which was unlikely due to the use of cement stent.

Core Outcome Measures Index (COMI) scores evaluate the patient's pain, functionality, generic health status or well-being, disability, and satisfaction.[8,15] The summary score is a tallied average of these five dimensions and ranges from 0 to 10. The higher the score is, the worse is the patient's status. As part of our institution's prospective outcomes database for spinal surgery, COMI scores were collected at the 3 months postoperative period for these group of patients and were available for 11 patients in the study cohort. The mean postoperative COMI score was 4.03 (standard deviation 3.11, 95% confidence interval 1.93–6.12).

DISCUSSION

There are reports in the literature of pedicle screw fixation combined with cement augmentation for spinal metastasis causing instability[18,2] where a percutaneous technique was adopted. However, these techniques do not involve dealing with the spinal cord compression and are primarily designed to address stability. Weitao *et al*. reported on 18 patients who underwent posterior approach osteosynthesis, along with transpedicular VP for spinal metastases.[25] Decompressive laminectomy was then performed for patients with neural compromise, but this group was not elaborated.

There is paucity in the literature regarding cement augmentation techniques in spinal metastasis, as majority of evidence is in osteoporotic compression fractures. VP though has similar pain relief in spinal tumors as kyphoplasty,[22] has got higher reported complication rate of cement leakage.[10] A recent systematic review concluded that balloon kyphoplasty (BKP), in general, is reported to have better recovery of vertebral height in neoplastic spine lesions.[1] However, this effect may not be long maintained. As in osteoporotic compression fractures, BKP in malignant spinal fractures does not retain long-term benefit in restoring vertebral height and correcting kyphotic deformity.[4] The reason for this is probably due to loss of vertebral height restoration immediately after removing the balloon tamp, before filling the void with bone cement. VBS is a new concept to counter this problem, combining the principles of vascular stenting with BKP. The metal stent maintains the size of the void created by the balloon inflation even after balloon is deflated before the insertion of bone cement.[16,21] The stent also permits a more controlled delivery of cement into a contained void.

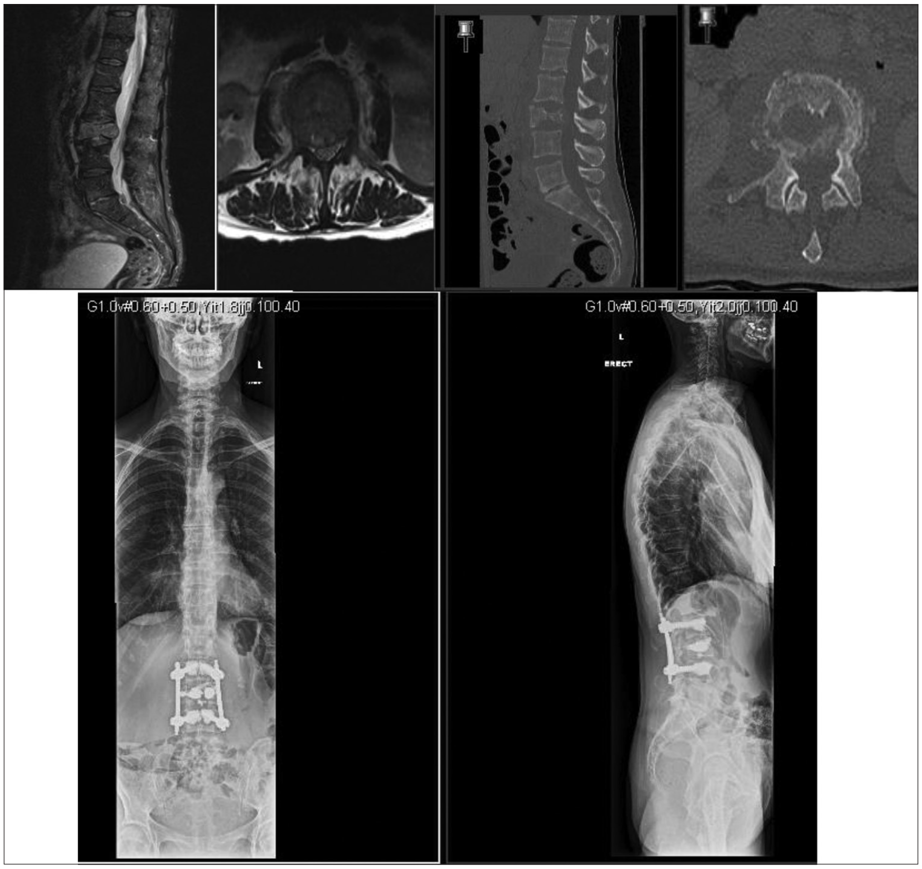

Figure 2: Images for a 63-year-old female with oropharyngeal cancer, L3 metastatic cord compression, magnetic resonance and computed tomography images show breach of the posterior cortex, underwent short posterior fixation with vertebral body stenting.

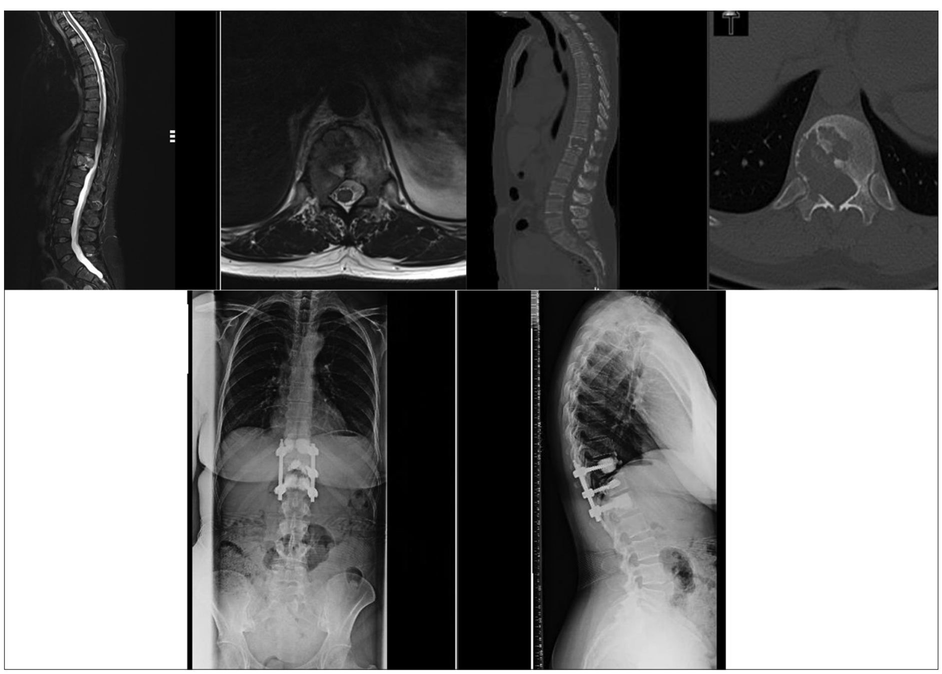

Figure 3: Magnetic resonance imaging and computed tomography images of 49 years old with breast cancer and Bilsky 1b metastatic spinal cord compression at cord level T12, treated with vertebral body stenting stent.

Despite the use in the past decade for osteoporotic spinal fractures, VBS has not been indicated for use in spinal tumors. The potential advantage of a reliable cement filled stent that restores vertebral body height aids in anterior column stability and lesser potential for cement leakages while avoiding the extensile anterior surgery in this frail MSCC, patient group has prompted us in using VBS-assisted posterior spinal decompression and stabilization. Our indications are lytic or mixed pattern of spinal metastasis and careful surgical planning is crucial for good surgical outcomes. Posterior cortical breach is not a contraindication and by extension neither is involvement of the vertebral end plates. To prevent stent from protruding back, peroperative imaging is used to position and size the stent as per the space available. As the stent is filled up with cement in a controlled manner, the cement infiltrates the surrounding cancellous bone, forming a micro-interlock at the bone-cement interface. The resultant fixation aids to anchor the stent in its inserted position. We have not come across stent migration in postoperative radiographs in our study [Figure 4].

The procedure is not without pitfalls, primarily associated with cement leakages, number of stents used, and incomplete stent deployment. The cement augmentation of the stent is performed with utmost care under fluoroscopy guidance, so as to avoid cement leakages. Cement can still leak if one is not careful in timing it. It is essential to meticulously use the stent to form a shell with the cement as far as possible. Compared to VP group (42.1%), the frequency of cement leakage after VBS was reported to be 25.5% in a series of patients with vertebral osteoporotic fractures without neurological deficit.[23] In a cohort of 35 patients with extensive lytic vertebral lesions due to tumor, VBS screw-assisted internal fixation had cement leakage in only 1 (2.7%) case.[7]

Although bilateral stents may support the anterior column symmetrically, in tumor surgery, this is neither always needed nor feasible. Unilateral stents are advisable in vertebral lytic lesions that involve only one half of the vertebral body, in small-sized vertebral bodies or operative technicalities preclude bilateral stent insertion. The stent is directed more across the midline in these cases [Figure 5]. In our series, we had incomplete opening of the stent in three cases. This could be attributable to surgical technique or the presence of sclerotic bone areas that prevent the expansion of the stent fully. Opening the stent can sometimes be tricky as the bone density is variable when affected by tumor and there might be a differential deployment due to differing density within a single vertebra. In this situation, cement insertion within the stent can still be carried out and we have managed to instill 3 ml of high-viscosity bone cement in each case. Two of these levels were in the upper half of thoracic spine where we feel that the cement volume would be reasonable. The 4 ml cement volume proposed by Boszczyk for restoration of vertebral strength is applicable to the larger volume thoracolumbar junctional vertebrae.[3]

Recent literature has shown promising results of VBS in spinal metastasis. Cianfoni *et al*. have shown VBS use as anterior augment in neoplastic osteolysis[6] and have subsequently reported on a stent screw-assisted technique where after inflation of the VBS, cannulated fenestrated pedicle screws are inserted and cement instillation through the screws is performed.[5] Their most recent work on combining this technique along with posterior spinal decompression and stabilization in four cases is promising.[7]

Our preliminary report on VBS for anterior column support in spinal metastasis with posterior cortical breach along posterior decompression and stabilization is the largest report of this application. We rely on careful surgical technique for stent and cement insertion in vertebral body lesions destroyed by tumor that otherwise would need a longer construct or a massive surgical trauma. Extensile surgical interventions are fraught with significant complications that can impair the remaining life of the patient. The aim is to keep the fixation short, as a means to decompress and stabilize the spine to improve the patient's quality of life.

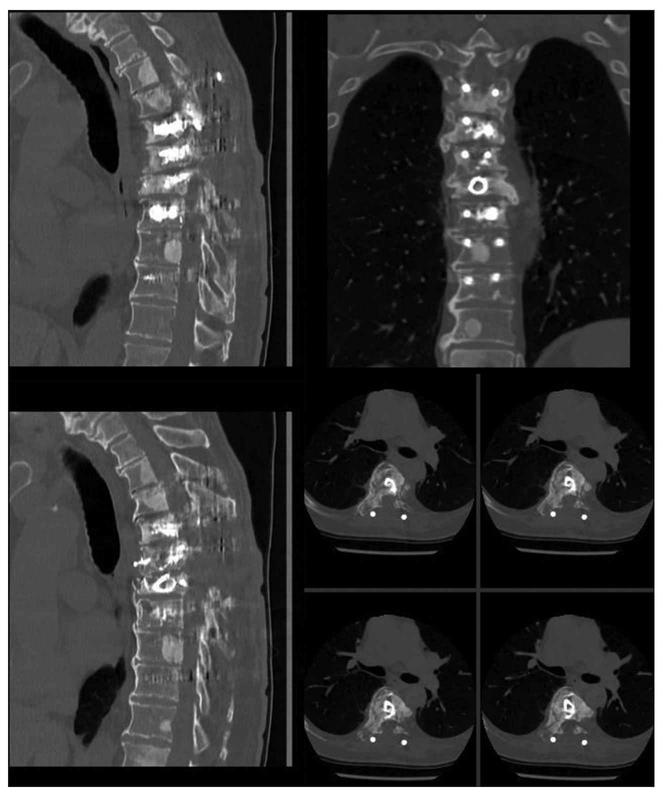

Figure 4: Computed tomography images at 6 months postoperative period in 73 years old with T7 metastatic spinal cord compression showing stent well incorporated in the vertebral body.

Figure 5: Pre- and postoperative images for a 60-year-old female with L3 metastatic cord compression from malignant melanoma, and imaging showing destruction in the left half of the body and posterior elements, underwent short posterior fixation with single vertebral body stenting stent application.

CONCLUSION

The addition of VBS during posterior decompression and stabilization surgery for MSCC achieved a stable fixation construct without the need for extensive anterior surgery to support the anterior spinal column. Stent expansion was seen fairly consistently allowing cement insertion and no cement leakages were noted with careful technique. We believe this preliminary report of VBS in MSCC surgery adds to the surgical armamentarium with promising early results and without major complications.

Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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