Posterior transpedicular corpectomy for malignant cervical spine tumors

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Abstract The goal of this study was to assess surgical clinical and radiographic outcomes of using a posterior transpedicular approach (posterolateral) for ventral malignant tumors of the cervical spine. Access to ventral lesions of the cervical spine can be challenging in patients with malignant tumors. Anterior approaches are the gold standard for ventral pathology in the cervical spine, however, there are cases, where a posterior approach is indicated due to multilevel disease, previous radiation, swallowing difficulty with difficulty in retraction of trachea and esophagus, and in cases where circumferential fusion cannot be done due to patients' poor medical condition. A single approach could provide spinal stabilization and removal of tumor. Eight cases of ventral cervical spine malignant tumors (7 metastatic and 1 chordoma) underwent corpectomy through a posterior transpedicular (posterolateral) approach. Tumors involved C2 (5), C3 (1), C5 (1), and C7 (1). Six cases had anterior reconstruction and three column fusion, and two cases had posterior fusion alone. Gross total resection was achieved in all cases. No hardware failure or worsening of neurological condition was seen (4 patient were neurologically intact and remained intact after surgery and 4 patients improved in their Frankel grade). Pain improved in all patients, mean visual analog scale preoperative was 86 and improved to 22 after surgery. In

two patients the vertebral artery was ligated without sequelae. We conclude that cervical spine transpedicular (posterolateral) approach is useful in cases where an anterior approach or a circumferential approach is not an option. It avoids the morbidity of anterior transcervical, transternal, and transoral procedures while providing decompression of neural elements and allowing three column stabilization when needed.

Keywords Transpedicular (posterolateral) approach · Malignant spine tumors · Cervical spine · Fusion · Ventral spine tumors

Introduction

Metastatic spine tumors involve the cervical spine in 15% of cases. Spinal cord compression due to malignant vertebral body tumors of the cervical spine is often a cause of pain, loss of mobility, and neurological deficit. It leads to significant compromise of the quality of life in those patients [7].

Oncological treatment of these tumors includes surgery, radiotherapy and chemotherapy. In particular, surgery is indicated in cases of spinal instability, cord compression, failure of previous radiotherapy and when the diagnosis is in doubt.

Malignant spine tumors typically involve the vertebral body in 70% of cases and spare the posterior elements [3–7].

The anterior approach in the subaxial cervical spine is the gold standard for management of ventrally located lesions. However, there are cases where a posterior approach is indicated due to multilevel disease, previous radiation that makes it hard to retract the trachea and esophagus, poor medical condition precluding circumferential approach,

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previous failed posterior instrumentation requiring revision, kyphosis and instability needing long segment dorsal fusion and high (C1, C2) or low (cervicothoracic) involvement where the anterior approach may be cumbersome [5, 8, 13].

In the cervical spine, the posterior column is responsible for more significant load sharing capacity in the lordotic cervical spine as the facet joint plays an integral part of the biomechanical stability of the cervical spine [5, 6], which differs from the thoracic and lumbar spine where 80% of the loads are supported by the anterior column. Biomechanical studies have shown that in the cervical spine, posterior instrumentation offers better strength and stiffness than anterior instrumentation.

The posterior transpedicular (posterolateral) approach has been extensively used in the thoracic spine for the treatment of tumors, disc herniations and fractures. In this report, we utilized a similar, posterior transpedicular (posterolateral) approach for the cervical spine. This approach can offer direct access to ventrally located lesions in the cervical spine and allows three column stabilization when needed, while avoiding the morbidity of transoral, anterior transcervical, and transmanubrium approaches [3, 5–7].

Materials and methods

All medical, surgical and radiographic records were retrospectively reviewed for patients who underwent posterior corpectomy for malignant lesion in the cervical spine at H. Lee Moffitt Cancer Center by the senior author (F. D. Vrionis). There were eight patients with average age of 61.8 (57–71) years. Mean follow up was 13 (range 6–18) months. Seven cases were metastatic tumors and one case

was a chordoma. Tumor involved C2 in five cases, C3 in one case, C5 one case, and C7 in one case.

All patients presented with neck pain, three patients had myeloradiculopathy, three patients have myelopathy, and two patients had swallowing difficulty with suboccipital headaches.

All patients were evaluated by visual analog scale (VAS) and Frankel grade pre and postoperative. Patient's characteristics are listed in Table 1.

Diagnostic evaluation

All patients were evaluated by cervical X-ray, MRI and CT scan of the cervical spine with sagittal and coronal reconstructions. MR angiography was done in three cases to evaluate patency of the vertebral arteries (Figs. 1, 2, 3).

Surgical technique

All patients had constant neuromonitoring of SSEPs and motor evoked potentials through out the procedure. All the patients were operated in a prone position, in Gardner Wells tongs with cervical traction through a midline skin incision.

For tumors located at C2 and C3, the C2 and/or C3 nerve roots were sacrificed to facilitate visualization and access to ventral pathology. While for tumors located from C4 down to C7 the nerve roots were preserved.

For tumor of the subaxial spine, the approach starts with a total facetectomy at the involved level. This exposes the ipsilateral pedicle, the exiting nerve roots above and below the pedicle and the lateral aspect of the thecal sac. The pedicle is then drilled under magnification and the vertebral

Table 1 Patients characteristics

Patient #	Age/sex	Pathology	Location	Clinical S&S	Previous treatment
1	57/M	Melanoma(Met)	C2	Neck pain, suboccipital headache, swallowing difficulty	Radiation and chemo, previous surgery
2	63/F	Renal(Met)	C2	Neck pain, radiculopathy	Previous biopsy
3	59/M	Colon(Met)	C2	Neck pain, suboccipital headache	Radio surgery
4	65/F	Lung(Met)	C2	Neck pain, myelopathy, paraparesis	Radiation
5	59/M	Chordoma ^a	C2	Neck pain, suboccipital headache, dysphagia, dysarthria, myelopathy	Previous surgery, proton beam radiation. This patient had already cage placed before many years prior to that from a lateral approach
6	71/M	Colon(Met)	C3	Neck pain, swallowing difficulty	Radiation and chemo
7	59/M	Melanoma(Met)	C5, T1	Neck pain, radiculomyelopathy	Chemo
8	62/M	Neuroendocrine(Met)	C7	Neck pain, myeloradiculopathy	Radiation, chemo, previous surgery

^a This case had already cage placed through a lateral approach. A preoperative biopsy showed signs of a malignant transformation. For these reasons it was not attempt to remove the tumor en bloc

Fig. 1 Illustrative case of patient No. 5, a 59-year-old man with C2 chordoma. A sagittal T2 weighted MRI of cervical spine shows the C2 tumor compressing the cord at the cervicomedullary junction (a). The axial contrast enhanced T1 weighted MRI demonstrates the tumor across the midline and significant cord compression (b). An additionally performed MRA shows the displacement of the right vertebral artery by the tumor (c). Postoperative plain lateral X-rays show the posterior instrumentation between the occiput and C5, corpectomy of C2 and the Harms cage between C1–C3 (d). The postoperative T2 weighted MRI (axial and coronal) show a complete removal of the tumor (e, f)

Fig. 2 Illustrative case of patient No. 6, a 71-year-old man with history of colon cancer. A sagittal T1 weighted MRI of cervical spine shows an extradural compression of the spinal cord from the lower border of C2–C4 (a). The axial computed tomography of cervical

body is entered. The vertebral artery is exposed lateral to the pedicle and ventral to the nerve roots. It is typically covered by a sheath and venous plexus (Figs. 4, 5a).

Vertebral artery mobilization at C1, C2

For tumor of C2, a wide laminectomy is performed and the C2 pedicle is skeletonized. The C2 nerve root is sacrificed.

spine demonstrates the destruction of the pedicle and foramen transversarium (b). The postoperative lateral plain X-rays show the instrumentation from C1 to C7, the corpectomy of C3 with anterior reconstruction with a titanium cage between C2–C4 (c)

The C1–C2 facet joint is exposed. The vertebral artery is first exposed at the sulcus arteriosus of C1 to obtain distant control. The foramen transversarium at C1 is dorsally opened with a 2 mm Kerrison. The vertebral artery is then followed laterally and inferior to the C1/C2 facet joint to obtain proximal control.

The C2 pedicle is then removed using a high speed drill. The pars interarticularis is completely removed into the

Fig. 3 Illustrative case of patient No. 8, a 62-year-old man with a neuroendocrine tumor. A sagittal T1 weighted image MRI of cervical spine shows destruction of C7 with kyphotic deformity and cord compression at the same level (a). The axial contrast enhanced T1 weighted MRI again reveals the significant cord compression by the tumor (b). Postoperative sagittal and axial computed tomography scans of the cervicothoracic spine shows the anterior reconstruction with Steinmann pins in C6 and T1 and PMMA at C7 and the additional posterior instrumentation with lateral mass/pedicle screw rod system (c, d)

body of C2. Working through the pedicular corridor, the soft tumor in the vertebral body is removed. The C2 superior articular process and C2–C3 disk are also removed.

Reconstruction

After removal of the ventral vertebral body tumor, anterior reconstruction was performed with Steinmann pins, PMMA, cage and allograft as illustrated. Six cases underwent circumferential fusion, four of these cases had anterior reconstruction by Steinmann pins and PMMA and the other two cases were anteriorly reconstructed by titanium mesh cages. All of these six cases had simultaneous posterior fusion and instrumentation. In some cases where more than 50% of the vertebral body remained intact, there was no need for anterior reconstruction (cases #1 and 4) (Fig. 5b).

Fig. 4 And intraoperative photograph shows the nerve root above (A) and below (B) the tumor (C) as well as the corridor of the transpedicular approach (D). The vertebral artery (E) is seen anterior to the nerve roots

Results

Gross total resection was achieved in all cases, and neck pain improved in all patients.

There were no hardware failures and none of the patients required additional surgery. Patients that presented with myelopathy improved in their neurological function. No patient had deterioration in Frankel grade, four patients had Frankel scale E and remained the same postoperative, two patients had Frankel scale of C and improved to D, and two patients had scale of D and improved to E (Table 2).

In VAS, all patients improved their pain level from preoperative, the mean preoperative VAS was 86 improved to the mean of 22 (Table 2). The vertebral artery was ligated in two cases without any neurological sequelae (case #1 patient had previous surgery and previous radiation. Case #4, patient had radiation before surgery and MR angiography showed the artery to be non patent). In both cases there was no change in motor and SSEP before and after ligation of artery. Table 2 summarizes the results.

Discussion

Surgical management of malignant cervical spine tumors can be challenging. The type of the approach depends on tumor location (ventral, dorsal or lateral C1, C2, subaxial or cervicothoracic), tumor consistency (vascular, soft, hard or necrotic), clinical necessity of gross total resection, bone quality for reconstruction, presence of instability, previous surgery and radiation and the medical condition and overall life expectancy of the patient [3–7, 12].

Management of ventrally located tumors in the upper cervical spine (C1, C2) includes the transoral approach, the

Fig. 5 Intraoperative photograph of patient No. 5. The intraoperative photograph **a** shows a tumor (chordoma) infiltrating the dura and compressing the spinal cord (A), the dural opening and infiltration (B) and the corridor of the transpedicular approach (C). Photograph

b shows the anterior reconstruction with a titanium cage (A), the nerve root above (B), the vertebral artery (C) and the dural repair after excision of the dura due to tumor infiltration (D)

Table 2 Surgical procedures and outcome

Patient #	Procedure	Post.fusion	Ant. reconstruction	Preop VAS	Postop VAS	Preop Frankel S	Postop Frankel S
1	C2 and C3 corpectomy	C1–C4	None	90	30	E	Intact
2	C2 corpectomy	C1–C6	Steinmann pins and MM	100	30	E	Intact
3	C2 corpectomy	O–T1	Steinmann pins and MM	100	20	E	Intact
4	C2 corpectomy	C1–C4	None	70	10	D	E
5	C2 corpectomy	O–C5	Harms cage	80	40	C	D
6	C3 corpectomy	C1–C7	Harms cage	90	20	E	E
7	C5 and T1 corpectomy	C2–T2	Steinmann pins and MM	80	20	D	E
8	C7 corpectomy	C2–T6	Steinmann pins and MM	80	10	C	D

transcervical retropharyngeal approach and the transmandibular approach. All of these approaches require posterior stabilization, and the exposure is deep and narrow and cannot be used for lesions with significant lateral extension. Postoperatively, there are significant risks of dysphagia, aspiration, and infection with oral flora especially in patients with cancer who will typically need postoperative radiotherapy [2, 5, 13]. Some of those procedures (transmandibular) require concurrent tracheostomy.

The anterior transcervical approach is substantially easier in the subaxial spine but is still limited if the tumor involves the posterior elements or if there is presence of kyphosis/subluxation and instability that typically require a circumferential approach.

In our opinion the impact of typical complications of the anterior cervical approaches on the quality of life especially in conjunction with radiation is much higher than that of typical complications of posterior approaches.

At the cervicothoracic junction, the high stress imposed from moving from a mobile cervical spine to immobile thoracic spine has led to many clinical failures for the anterior approach alone with most authors recommending circumferential fusion for tumors involving the cervicothoracic

junction [2, 11, 12]. In addition, transmanubrial approaches for access to the C–T junction carry significant morbidity and require additional surgical expertise. A partial manubriectomy is often sufficient to expose the cervicothoracic junction, however, it also carries the typical risks of anterior cervical approaches and sometimes it is not possible to burden oncological patients with a combined anterior/posterior surgery for medical reasons.

Lesions of the C2 and C3 vertebral body are more accessible for resection by a transpedicular (posterolateral) approach because the C2 or C3 nerve roots can be sacrificed without motor function loss, and the vertebral artery is located more laterally resulting in additional working room. However, in the cervical spine the pedicles are very small, and it is difficult to talk about a pure transpedicular approach. Therefore we added the term “posterolateral” in brackets. In addition, the spinal cord occupies a smaller component of the intradural volume at the C2 level. In the subaxial cervical spine, the nerve roots have a critical motor function and are not typically sacrificed [1, 2, 9].

In patients with malignant tumors of the spine solid fusion is not always the goal, as life expectancy is limited and radiotherapy and chemotherapy play an important role

in inhibiting bone growth. Anterior column reconstruction with methylmethacrylate and Steinmann pins can provide immediate stability and can be used as alternative to bone fusion [4, 10].

The risks of the posterior transpedicular (posterolateral) approach include injury to the vertebral artery from mobilization and retraction, injury to the spinal cord and cervical nerve roots [1, 2, 4]. However, in our series we did not have any such injuries and, in fact, patients improved in their neurological status. Regarding the vertebral artery, two cases had ligation of the vertebral artery. One of them was a planned one as the preoperative MRA showed severe stenosis, but in the other case the artery was injured and was ligated without sequelae. Obtaining information on the vertebral artery preoperatively by means of CT angiography, MR angiography or even by conventional angiography is important for two reasons: First to minimize the risk of a vertebral artery injury caused by failure to appreciate anatomic variants or severely displaced or compressed vessels within or adjacent to the tumor. Furthermore in case of a vertebral artery injury it is important to know about a possible side dominance or congenital absence of the artery. If there is any doubt, an occlusion test is recommended in high risk surgeries with respect to vertebral artery injury.

Our experience with this technique is limited and the follow up period is relatively short. Long-term clinical complications and outcomes are not yet known, but our results are encouraging. We do not advocate this technique in cases where the tumor location is purely ventral or the tumor is firm or calcified rendering it unfavorable for piecemeal resection.

Cervical spine transpedicular approach is useful in cases where an anterior approach or a circumferential approach is not an option. It avoids morbidity of anterior transcervical and transoral procedures while providing decompression of neural elements and allows three column stabilization if needed. Postoperative instability is prevented by immediate posterior spinal reconstruction by lateral mass, pedicle screws and rod fixation. Steinmann pins with methylmethacrylate or cages provide immediate stability of spine when used as anterior reconstruction.

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