

Surgical Considerations for Maximal Safe Excision of Subaxial Cervical Dumbbell Schwannoma in a Single Approach

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BACKGROUND: Spinal dumbbell shaped tumors are tumors that grow over the constricted intervertebral foramen from the intraspinal canal to the extraspinal region. The best surgical approach for dumbbell tumors in the cervical spine is still debatable.

OBJECTIVE: To evaluate the clinical outcome, extent of resection and postoperative cervical spine stability following surgical resection of subaxial cervical dumbbell shaped tumors through the posterior approach.

METHODS: Patients with dumbbell shaped tumors in the subaxial cervical spine who were operated upon by the posterior approach in the department of neurosurgery at Cairo University hospitals between January 2019 and January 2021 were evaluated retrospectively. The preoperative and postoperative neurological conditions were assessed using the Japanese Orthopedic Association (JOA) score. Postoperative magnetic resonance imaging was performed for evaluation of the extent of resection.

RESULTS: Six patients with subaxial cervical dumbbell shaped tumors underwent surgery via a posterior approach for tumor excision and fusion in 2 years. We reported clinical improvement in 3 cases, 2 cases had a stationary course and only one case showed mild immediate postoperative deterioration that improved within a month after surgery. In five patients gross total resection was achieved, and in one patient subtotal resection was achieved. The pathology was schwannoma in all cases. We reported no vascular injury or mortality in our study.

CONCLUSION: For the excision of dumbbell shaped schwannomas in the subaxial cervical spine, one-stage posterior laminectomy with facetectomy appears to be a feasible and effective option. The tumor could be safely and fully excised in the majority of cases.

KEYWORDS: Cervical spine, Dumbbell tumors, Fixation, Laminectomy, Vertebral artery.

INTRODUCTION

Spinal dumbbell tumors are tumors that grow over the constricted intervertebral foramen from the intraspinal canal to the extraspinal region.^{1,2} Dumbbell shaped tumors are found in 14 to 18% of spinal cord tumors,^{3,4} with a higher prevalence in the cervical area.⁵ Schwannomas are the most common pathology in dumbbell cervical spinal tumors. Due to the anatomical differences between the atlas/axis and subaxial vertebrae, surgical approaches for addressing dumbbell tumors in the atlas/axis and subaxial levels differed. Attacking dumbbell tumors in the subaxial cervical spine is more difficult than attacking tumors in the atlas and axis because there is a large space between the lamina and no bony foramen between the atlas and axis, and because the lateral mass joints in subaxial levels make it difficult to attack these tumors from the back.³⁻⁵ The intimate relationship between subaxial cervical spine dumbbell tumors and the vertebral artery, which is frequently anteromedial to the tumors, is another barrier

for gross excision of subaxial cervical spine dumbbell tumors.⁶

So, while attacking these tumors through anterior or anterolateral approaches appears to be safer in terms of early identification of the artery and dissecting it through tumor, these approaches are less familiar among neurosurgeons for attacking cervical spine tumors, are narrower, and do not provide exposure for the intraspinal part of the tumor.⁷ This makes the posterior approach more versatile and familiar as a single approach for these tumors with creating a window, by doing facetectomy in addition to hemilaminectomy or full laminectomy. Subperineurial dissection of the extraforaminal part enables safe gross total dissection of the tumor from the vertebral artery as it provides an extra microscopic barrier between the operative bed and the artery.⁸ According to previously mentioned issues, a one-stage posterior approach involving hemilaminectomy or full laminectomy, facetectomy, and subperineurial dissection of the extraforaminal portion yields good outcomes.

The aim of the study is to evaluate the clinical outcome, extent of resection and postoperative cervical spine stability following surgical resection of subaxial cervical dumbbell shaped tumors through the posterior approach.

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PATIENTS AND METHODS

Patients with subaxial cervical spine dumbbell schwannomas who were admitted to Cairo University hospitals and had surgery through the posterior approach between January 2019 and January 2021 were evaluated retrospectively. Informed consents have been obtained from all the patients.

Radiculopathy, myelopathy, or myeloradiculopathy were present in all of the individuals. Based on the magnetic resonance imaging (MRI) and pathological investigation, the patients were diagnosed with dumbbell-shaped schwannomas in the subaxial cervical spine. Dumbbell schwannoma in the subaxial cervical spine with synchronous invasion into the intraspinal, foraminal, and paravertebral parts met the inclusion criteria. Computed tomography (CT) and MRI scans of the cervical spine with contrast were performed prior to surgery.

The axial cuts of MRI cervical spine with contrast delineates the shift that occurs in the displaced vertebral artery in contrast to the normal side (**Fig. 1**).

Surgical procedures

Two surgeons with 5–10 years of relevant expertise performed the surgery. The patient was placed in the prone position after general anesthesia and intubation, with the three-pin head holder keeping the head in a neutral posture. Bilateral subperiosteal dissection was performed after a longitudinal midline incision. The muscle was dissected from the superior 1–2 vertebrae to the inferior 1–2 vertebrae, and laterally to the lateral section of the facet joint, in order to expose the distal part of the tumor. The muscle separation was performed as lateral as feasible to thoroughly expose the distal part of the tumor, with the intervertebral foramen tumor as the focal point of the exposure. It was decided to do adequate laminectomy with facetectomy. A longitudinal dural incision was created along the junction of the spinal cord and the tumor, then extending laterally along the long axis of the tumor for the paravertebral and foraminal parts of the tumor.

The intraspinal part was removed first with standard microsurgical techniques, disconnecting the foraminal and extraforaminal parts from the cord, avoiding more rocking of the cord upon manipulating foraminal and extraforaminal parts. Subperineurial dissection of the extraforaminal part was adopted in this study to provide gross total resection while preserving the vertebral artery and avoiding massive venous plexus bleeding. The dural defect was managed either by closing the root exit foramen or by using autologous fascia taken from the surgical incision. Following that, either unilaterally or bilaterally, lateral mass screws and rods were used to provide spinal internal fixation. Finally, the wound was closed in layers with or without submuscular drain.

Follow-up and evaluation of results

Clinical evaluation of the patients was done immediately after surgery, and periodically every week in the outpatient clinic for the first month after surgery. Immediate CT cervical spine was done after surgery for confirmation of the level and bony work of surgery, evaluation of the screws of the fixation system and exclusion of other neurosurgical emergencies as epidural hematomas. MRI cervical spine with contrast was done one month after surgery for confirmation of gross total resection. The preoperative and postoperative neurological conditions were assessed using the Japanese Orthopedic Association (JOA) score.⁹

Statistical analysis

A descriptive statistical analysis was done guaranteeing confidentiality of the clinical data. The level of statistical significance was set at $p < 0.05$.

RESULTS

Preoperative clinical data: In this study, six patients with subaxial cervical dumbbell schwannomas were operated upon in a single institute (Department of Neurosurgery, Cairo University hospitals) between January 2019 and January 2021. **Table 1** shows the summary of patient characteristics. The median age at diagnosis was 46 years (range 14–75 years), with a female predominance (female: male = 4: 2). None of the six patients had previous cervical spine surgery. All the cases were symptomatic. The clinical symptoms were neck pain (6 cases), radicular symptoms (5 cases), long tract symptoms (5 cases) and bladder or bowel dysfunction (2 cases). Patients were followed up for 1 year after the surgery both clinically and radiologically.

Surgical data

Gross total resection was achieved in 5 cases, while one case underwent subtotal resection of the dumbbell shaped tumor. All cases were intradural and extradural paravertebral (type 3B) according to Asazuma et al. classification for cervical schwannomas.¹⁰ One-stage posterior approach in the prone position using three-pin head holder in the neutral position was used to excise the tumor and to do the instrumentation as well. Full laminectomy and unilateral facetectomy was done to ensure adequate tumor visualization and excision with subsequent fusion to guard against progressive kyphosis that may develop later on. Three cases needed C2 pedicle screws in addition to the subaxial lateral mass screws that was performed in all cases to add strength to the fixation construct according to the operator's assessment intraoperatively. Unilateral fusion was done in 2 cases only while routine bilateral fusion was done in the remaining 4 cases. One or two nerve roots were sacrificed for better dealing with the tumor. Tumor site and distribution are summarized in (**Table 1**). The average surgical time was 240 ± 65 minutes and the average blood loss was 200 ± 130 mL. Two patients needed blood transfusion according

to the preoperative hemoglobin level.

Postoperative clinical outcome and follow-up

All cases were proven to be schwannomas histopathologically. Neurological function was assessed

according to the JOA score. **Table 1** summarizes preoperative and postoperative JOA score, stating that 3 cases improved, 2 cases were stable, and 1 case showed mild deterioration. We reported no vascular injury or mortality in our study.

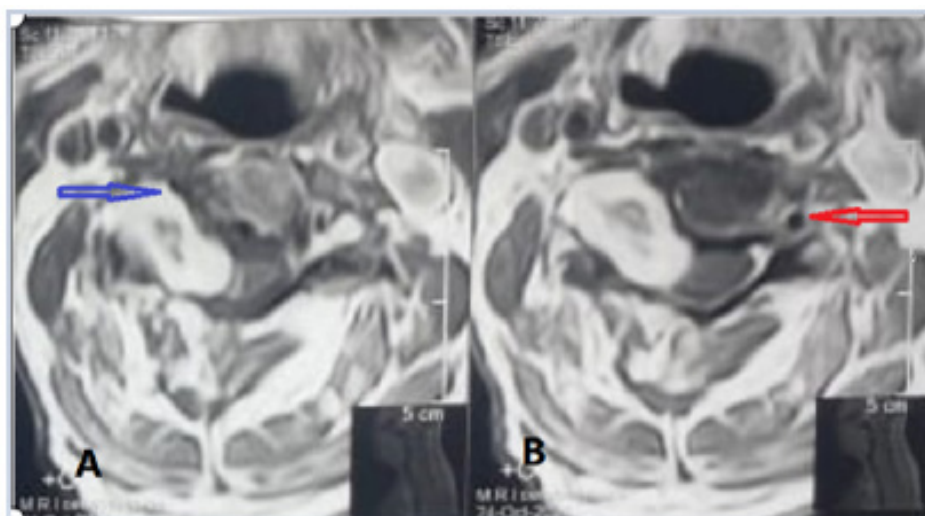


Fig 1: Axial cuts of MRI cervical spine with contrast of one of the study cases, (A) the blue arrow demarcating the displaced compressed vertebral artery, (B) the red arrow demarcating the position of vertebral artery at normal side.

Table 1: The demographic, clinical and operative data of the patients and JOA score (preoperative and postoperative)

Patient's characteristics	Number	Percentage %
Number of patients	6	100%
Sex		
Female	4	67%
Male	2	33%
Presenting symptoms		
Neck pain	6	100%
Radicular symptoms	5	83%
Long tract symptoms	5	83%
Sphincteric troubles	2	33%
Tumor location		
Cervical intradural extramedullary + extradural + extraforaminal	6	100%
Tumor location (subaxial)		
C3 – C4	3	50%
C4 – C5	1	17%
C4 – C6	1	17%
C5 – C6	1	17%
Surgical resection		
Gross total resection	5	83%
Subtotal resection	1	17%
JOA score	Preoperative	Postoperative
Case 1	12	13
Case 2	13	13
Case 3	12	13
Case 4	13	14
Case 5	11	11
Case 6	15	13

DISCUSSION

Although there is no disagreement about the surgical technique for the totally intraspinal or the totally paravertebral spinal cervical schwannoma excision, the best surgical method for resection of the dumbbell shaped tumors in the cervical spine is still debatable.⁴ The paravertebral extension of these tumors with their intimate relationship to the vertebral artery (VA) advocated the anterior approach by many surgeons to get control of the VA from the beginning of surgery, but this approach requires more the one level corpectomy of cervical vertebrae which will endanger the spinal stability. Moreover, the operative field is narrow, making full exposure of tumors in C2 and C3 challenging.^{2,7} The anterolateral technique offers the benefit of controlling VA, but it also has drawbacks, such as the risk of damaging the phrenic, vagus, accessory, and hypoglossal nerves.^{11,12} Although some skilled surgeons claim that the anterolateral technique alone can remove intradural tumor components, most surgeons believe it is more difficult than the posterior method. The intradural tumor is difficult to fully expose and resect, and the traction may harm the spinal cord.¹⁰ In fact, mixed anterior/posterior techniques are difficult for patients to accept and need extra surgery time. The spinal keyhole for dumbbell tumors in the cervical spine was described by Bobinski and his colleagues as an one stage transforaminal retro jugular method for addressing these lesions.⁶ In our point of view this approach will allow early dissection of the VA and preserve the bony stability of cervical spine, however it is not a familiar approach to neurosurgeons and will leave the intradural part to late steps of surgery, which will transfer rocking movements to the cord while manipulating the foraminal and extraforaminal parts, and finally the surgical view of the contents of the dural sac will not be as clear as the posterior approach. The posterior approach is the most common, and most surgeons are familiar with it; nonetheless, two factors prevent extensive complete removal of these lesions in these situations. The first element is the extension of these lesions beyond the foramen behind the facet joints and the second element is the intimate relation with vertebral artery at anteromedial surface of the lesion, which will be managed at later stages of tumor dissection.⁸ Our surgical strategy in these lesions depends on removal of the facet joint to get access to paravertebral part, in order to dissect this paravertebral part subperineurially, leaving the perineurial capsule as a barrier in between the dissection plane and the vertebral artery, which is usually displaced anteromedially, and not invaded by the schwannoma.^{8,13} Patience should be followed while removing of the paravertebral part as bleeding from the paravertebral venous plexus is usually encountered and managed with gentle tamponade with cottonoids and hemostatic agents.

In this study, we did not perform vertebral angiogram preoperatively, we relied on the axial cuts of MRI cervical spine with contrast which delineates the shift that occurs

in displaced vertebral artery in contrast to the normal side. Usually the displaced vertebral artery is present anteromedial to the tumor, and usually its parenchyma is not invaded, whilst displaced and compressed.¹³

In all cases of the study, the intradural part of the tumor was lateral or posterolateral to the cord, and we did not face the situation that the intradural part is ventral to the cord. Accordingly, our approach was more safe and anatomical as regards our cases. Cutting the dentate ligaments in these situations allows to mobilize the cord more away from the tumor, minimizing the transfer of the rocking movements from the tumor to the cord. In our study, five cases recovered well without new deficits and one case recovered with more weakness in motor power which recovered over one week. In our study, the paravertebral part of the tumor had not extended beyond the level of carotid sheath. So, if the intradural part is anterior to the cord, or the paravertebral part is extending too much anterior beyond the carotid sheath, it could be considered to approach the lesion via anterior or lateral transforaminal approach.^{2,14}

Our target in all the cases was safe gross total removal, with preservation of the vertebral artery and neurological functions, for the sake of reducing the risk of recurrence through a single approach. In only one elderly case (70 years) small residue was left due to significant bleeding from the paravertebral venous plexus. Throughout the duration of the study, no recurrences had occurred.

The incidence of cervical spine instability after unilateral facetectomy and various degrees of laminectomy is unknown. Cusick et al. discovered that when compared to an intact motion segment, isolated unilateral cervical facetectomy resulted in a 31.6 percent drop in strength in response to a continuous flexion/compression load. Although no immediate spinal instability was observed in this study, the significant loss of mechanical integrity associated with unilateral facetectomy raised the likelihood of delayed instability due to repetitive loading. This risk is most likely related to the severity of the laminar and ligamentous disruption. Independent factors such the patient's age, spinal mobility, specific loading patterns, and spinal level may all have a role.^{15,16}

After hemilaminectomy and unilateral facetectomy for cervical dumbbell shaped cervical lesion excision, McCormick et al. reached no results about the danger or prevention of delayed instability. In none of the eight cases that were not fused, overt clinical or radiological instability arose; nonetheless, two patients showed a loss of cervical lordosis over the follow-up period. Four patients had a single contralateral lateral mass plate fixation at the same time.¹³ In our study, we performed full laminectomy for our cases for the sake of better visualization of the intradural contents, added to this unilateral facetectomy, so we decided to do fusion to all of our cases, either unilateral or bilateral. To minimize delayed stabilization and sagittal balance disturbance, the choice to fuse these patients was customized depending

on the previously described considerations.

Drawbacks of our study include the small number of cases and the relatively short follow-up period.

CONCLUSION

For the excision of dumbbell schwannomas in the subaxial cervical spine, one-stage posterior laminectomy with facetectomy appears to be a feasible and effective option. The tumor could be safely and fully excised in the majority of cases.

List of abbreviations

CT: Computerized tomography.

JOA score: Japanese Orthopedic Association score.

MRI: Magnetic resonance imaging.

VA: Vertebral artery.

Disclosure

The authors report no conflict of interest in the materials or methods used in this study or the findings specified in this paper

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