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ORIGINAL ARTICLE

Surgical strategies for removal of intra- and extraforaminal dumbbell-shaped schwannomas in the subaxial cervical spine

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Abstract
Purpose Spinal dumbbell-shaped schwannoma is common neoplasm, usually occurring in the cervical spine. Posterior or anterolateral approaches are frequently used to remove this benign tumor. We analyzed how much amount of tumor could be possible to be totally removed with posterior approach.
Method Surgery was performed on 41 cases of cervical, dumbbell-shaped subaxial schwannomas with both intra- and extraforaminal involvement. The same surgeon performed all the procedures. Mean follow-up was 42.5 months (24–108 months). A combined anterolateral and posterior approach was used if the extraforaminal tumor was larger than 10 mm. A posterior approach and unilateral facet removal were used if it was smaller than 10 mm. We performed MRI and serial dynamic X-rays for postoperative 2 years.
Results We used the posterior approach with facetectomy in 35 cases and the combined approach in six. Complete removal was achieved with the combined approach in all six, and with the posterior approach in 28 of 35 cases. With the posterior approach, the extraforaminal dimension of totally resected tumors ranged from 3 to 5.4 mm. Subtotal resection was limited to extraforaminal tumors larger than 5.7 mm. On follow-up, instability on dynamic X-ray was not observed before 24 months in any patient after unilateral facetectomy.
Conclusion Total removal of intra- and extraforaminal cervical subaxial schwannomas could be possible using a posterior approach with facet removal if the size of extraforaminal tumor was less than 5.4 mm.

Keywords Cervical schwannoma · Dumbbell shaped · Posterior approach · Facetectomy · Instability

Introduction

Spinal dumbbell-shaped schwannoma is common neoplasm, usually occurring in the cervical spine [1, 2]. Several classification systems and appropriate surgical approaches have been developed in parallel with advances in imaging techniques [3–5]. Either posterior or anterolateral surgical approaches are used to remove this benign tumor [3–5]. However, choosing the most appropriate approach for subaxial schwannomas that are both intra- and extraforamenal is difficult for the surgeon. We analyzed how much amount of tumor could be possible to be totally removed with posterior approach with unilateral facet removal. In addition, we also analyzed whether unilateral facet removal might be related with significant cervical instability during follow-up.

Methods

Surgery was performed on 41 cases of cervical, dumbbell-shaped schwannomas that were subaxial and had both

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intra- and extraforaminal involvement. The same surgeon performed all these procedures from January 2001 to December 2011. We only included all cases which were histologically proven schwannoma and located in subaxial cervical spine in this study. Mean follow-up was 42.5 months (24–108 months). Mean patient age was 45.9 years (range 20–68). All cases with simultaneous extraforaminal and intracanal involvement were included.

According to the presence of intradural involvement, all tumors belonged to intracanal-extradural or intracanal–intradural tumors. All patients experienced myelopathy with or without radiculopathy.

We determined the surgical approach according to the size of the extraforaminal tumor. Preoperative maximal canal and extraforaminal tumor dimensions, CD and ED, respectively, were determined as shown in Fig. 1. Initially, we chose a combined anterolateral and posterior approach for tumors that were larger than 10 mm and a posterior approach and unilateral facet removal for those smaller than 10 mm. In the combined approach, a posterior approach was performed first. After identifying the index level, laminectomy was performed with a match head-type high-speed burr and a Kerrison punch. Although total facet removal was not necessary, facet resection, which amounted to less than half the total amount of facet, was performed. When the foraminal tumor was sufficiently exposed, proximal and distal ligations were performed and the tumor was cut. Thereafter, the dura was opened to remove the intradural tumor. After the entire intradural tumor had been removed, the dura and lamina were closed. In the second-stage surgery, gross removal of the entire tumor was easily achieved via the anterolateral approach.

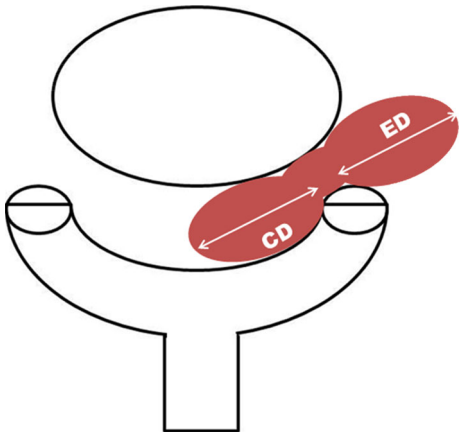

Fig. 1 Schematic diagram of dumbbell schwannoma in the cervical spine. Canal dimension (CD) and extraforaminal dimension (ED) are indicated

In the posterior approach alone, removal of the tumor in the spinal canal was followed by unilateral facet removal and maximal removal of the remaining tumor (Fig. 2).

Magnetic resonance imaging (MRI) was done immediately after surgery and postoperatively at 1 year if some tumor remained after surgery. Annual MRI for 3 years was scheduled in those patients even if their symptoms did not re-occur. If no tumor was observed immediately after surgery, then MRI follow-up was not done. Clinical follow-up of all patients to check postoperative improvement of myelopathy or radiculopathy was performed at 1, 3, 6, 12, and 24 months. X-Ray follow-up including flexion and extension images was done at 1, 3, 6 12, and 24 months in patients with the posterior approach and facetectomy. We assessed radiological subluxation or instability in dynamic views and clinically significant neck pain [Numeric Rating Scale (NRS) >5] occurred during follow-up in these

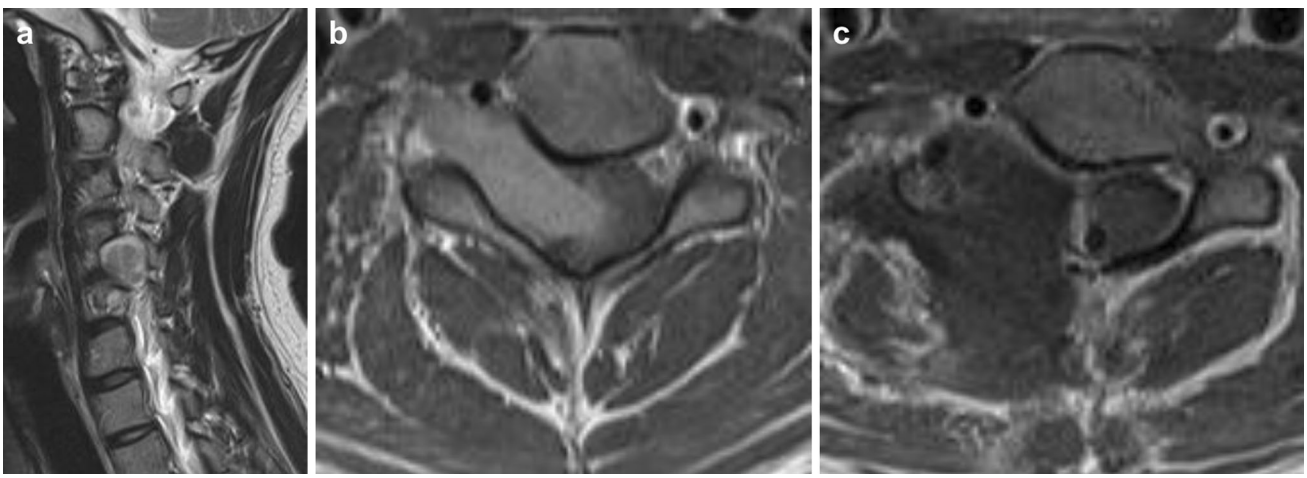

Fig. 2 A 25-year-old male patient complained of lower extremity weakness. **a** T2-weighted sagittal magnetic resonance imaging (MRI) shows an extraforaminal round shaped tumor at the C4–5 level. **b** T1-weighted axial MRI with enhancement shows a dumbbell-shaped tumor on the right side at the C4–5 level. **c** T1-weighted axial MRI with enhancement after surgery using the posterior approach shows complete removal of the tumor and fluid collection

patients who were performed unilateral cervical facetectomy. In addition, we also analyzed how much amount of removal of tumor was possible with posterior approach with facetectomy.

Results

No patient complained of any major preoperative symptoms following surgery. The anatomical locations of the tumors and their preoperative maximum canal and extraforaminal tumor dimensions are shown in Table 1. Of the 41 tumors, 34 tumors were totally resected as shown in Table 1. We used the posterior approach with facetectomy in 35 cases and the combined approach in 6 cases. All tumors were removed totally when the combined approach was used. Total removal was achieved in 28 of the 35 patients where the posterior approach was used (Table 2). The maximum extraforaminal dimension of tumors totally resected with the posterior approach ranged from 3 to 5.4 mm. In those cases where total resection was not achieved, the extraforaminal dimension was larger than 5.7 mm. The residual tumor ranged in size from 2.1 to 3.2 mm (Table 3). Follow-up MRI revealed that the size of the remaining tumors did not change until the third year in all six patients. Radiological subluxation or instability was not seen on dynamic X-ray until at least 24 months in any patient (Fig. 3). There was not any significant neck pain in all patients.

The extraforaminal tumor dimensions in the six patients with tumor removal by the combined approach are shown in Table 4.

Table 1 Location and dimensions of 41 dumbbell-shaped schwannomas resected in this surgical series

Anatomical location	Number of cases (total resection)	Mean CD mm (range)	Mean ED mm (range)
C2–3	5 (4)	8.7 (6.2–9.1)	4.6 (3–6.2)
C3–4	6 (5)	7.7 (5.8–8.9)	6.6 (3.5–12.7)
C4–5	11 (8)	8.0 (5.2–12.1)	9.5 (3.2–35)
C5–6	11 (10)	8.5 (6.3–11.2)	7.5 (3.1–21)
C6–7	8 (7)	8.7 (7.1–12.1)	6.4 (3.3–18)
Total	41 (34)		

CD canal tumor dimension, *ED* extraforaminal tumor dimension

Table 2 Anatomical location and surgical approach for 41 dumbbell-shaped schwannomas resected in this surgical series

Anatomical location	Posterior approach (total resection)	Combined approach (total resection)	Total cases (total resection)
C2–3	5 (4)	0	5 (4)
C3–4	5 (4)	1 (1)	6 (5)
C4–5	9 (6)	2 (2)	11 (8)
C5–6	9 (8)	2 (2)	11 (10)
C6–7	7 (6)	1 (1)	8 (7)
Total	35 (28)	6 (6)	41 (34)

Table 3 Pre-operative extraforaminal tumor dimension (ED) and size of residual tumor in 35 cases where the posterior approach was used to remove dumbbell-shaped schwannomas

Anatomical location	Patients	Maximum ED (mm) of totally resected cases (range)	Maximum ED (mm) of subtotally resected cases (range)	Mean size of remaining tumor (mm)
C2–3	5	4.2 (3–4.7)	6.2	2.1
C3–4	5	4.3 (3.5–5.2)	7.3	2.5
C4–5	9	4.7 (3.2–5.4)	8.75 (8–9.5)	2.9 (2.5–3.2)
C5–6	9	4.7 (3.1–5.4)	8.7	2.9
C6–7	7	4.2 (3.3–4.5)	5.7	2.1
Total	35	28	7	7

Discussion

Overall, dumbbell-shaped tumors comprise from 13.7 to 17.5 % of spinal cord tumors; and of those, 44 % occur in the cervical spine. They also occur more frequently in the cervical than in the thoracic and lumbar spine [6]. We report on 41 cases of surgical resection of cervical, subaxial dumbbell-shaped schwannomas. We included only cases that had simultaneous intaracanal, extraforaminal, and foraminal involvement, classified as Type 2 and 3 with Eden classification [6, 7]. Those tumors were also classified as Type 2a, 2b, 3a, and 3b by Asazuma and colleagues [4]. It is easy to choose an approach for a pure intracanal or extraforaminal tumor, which is classified as Eden type 1 or 4 [6–8]. One study reported that a combined approach should be applied to huge tumors that extend inside and outside the foramen. However, they also described that the choice of an appropriate surgical approach for a small or medium-sized tumor extending inside and outside foramen, which is classified as Eden type 2 or 3, remains controversial [3, 6, 7]. Although many surgeons select the posterior approach for such tumors, several surgeons have advocated the anterolateral approach and reported good results. They explained that the portion of the tumor located within the foramen can be explored through the enlarged foramen [3, 5, 8–10]. However, it is difficult to know exactly whether a tumor inside the canal has any intradural components only with MRI prior to surgery. Sometimes, the absence of any tumor intradural

Fig. 3 Postoperative X-rays of a 25-year-old patient. There is no radiological instability or subluxation at 2 years after surgery using the posterior approach with right-side facetectomy

Table 4 Pre-operative extraforaminal tumor dimension (ED) in six patients with surgical resection by the combined approach

Anatomical location	Combined approach	Maximum ED (mm)
C2–3	0	
C3–4	1 (1)	12.7
C4–5	2 (2)	24.5 (14–35)
C5–6	2 (2)	16.5 (12–21)
C6–7	1 (1)	18
Total	6 (6)	

components can only be confirmed after opening the dura. Extradural tumors (Eden type 3), in which it can be confirmed there are no intradural components prior to surgery, can be removed by the anterolateral approach alone. Although some experienced surgeons reported that intradural tumor components can be removed by the anterior approach alone, surgeons often feel that this is more difficult than the posterior approach [5, 11]. Therefore, we believe that most surgeons use the posterior approach to remove a medium-sized tumor extending inside and outside the foramen. Consequently, this study only included medium-sized tumors extending inside and outside the foramen and aimed to determine how much of an extraforaminal tumor can be removed by the posterior approach alone.

We attempted to remove extraforaminal tumors smaller than 10 mm via the posterior approach. Similarly, posterior approaches to remove extraforaminal tumors less than 40 mm away from the dural margin or extraforaminal tumors smaller than 25 mm have been previously attempted [3, 8]. Our results showed that extraforaminal tumors smaller than 5.4 mm could be to be completely removed with a posterior approach and facetectomy. We agree that the maximum amount of an extraforaminal tumor that can be removed may depend on the experience or skill of the surgeon to some extent, as has been previously reported [3, 8].

Many reports have shown that cervical facetectomy is associated with mechanical instability and may necessitate subsequent reconstruction. It was reported that more than 20 % of patients exhibit instability following surgery using the posterior approach. In addition, postoperative deformities have been reported in 50 % of patients [3, 4, 6, 12–15]. Although our results showed that unilateral facetectomy was not related with significant instability during the 2-year follow-up, the follow-up period was short and the number of patients was quite small. Reconstruction might be needed for longer stability and better clinical outcomes. Longer follow-up of our patients is required for a more definitive answer.

In addition, asymptomatic, small residual extraforaminal tumors should be followed up by performing serial MRI scans. If there is evidence of postsurgical tumor growth or symptoms related to the remaining tumor, additional treatment such as radiosurgery is required.

Conclusion

Total removal of cervical intra- and extraforaminal cervical subaxial schwannomas was achieved using a posterior approach with facet removal if the size of extraforaminal tumor was less than 5.4 mm in this series. Although our results showed that unilateral facetectomy was not related with significant instability during the short follow-up period, the necessity of a spinal reconstruction should be considered for longer stability and better clinical outcomes.

Conflict of interest We do not have any financial interest or ethical conflict for this article.

References

1. Conti P, Pansini G, Mouchaty H, Capuano C, Conti R (2004) Spinal neurinomas: retrospective analysis and long-term outcome of 179 consecutively operated cases and review of the literature. Surg Neurol 61:34–43 (discussion 44)
2. Seppala MT, Haltia MJ, Sankila RJ, Jaaskelainen JE, Heiskanen O (1995) Long-term outcome after removal of spinal schwannoma: a clinicopathological study of 187 cases. J Neurosurg 83:621–626
3. Jiang L, Lv Y, Liu XG, Ma QJ, Wei F, Dang GT, Liu ZJ (2009) Results of surgical treatment of cervical dumbbell tumors: surgical approach and development of an anatomic classification system. Spine (Phila Pa 1976) 34:1307–1314
4. Asazuma T, Toyama Y, Maruiwa H, Fujimura Y, Hirabayashi K (2004) Surgical strategy for cervical dumbbell tumors based on a three-dimensional classification. Spine 29:E10–E14
5. Iwasaki Y, Hida K, Koyanagi I, Yoshimoto T, Abe H (1999) Anterior approach for dumbbell type cervical neurinoma. Neurol Med Chir (Tokyo) 39:835–839 (discussion 839–840)
6. Ozawa H, Kokubun S, Aizawa T, Hoshikawa T, Kawahara C (2007) Spinal dumbbell tumors: an analysis of a series of 118 cases. J Neurosurg Spine 7:587–593
7. Eden K (1941) The dumb-bell tumours of the spine. Br J Surg 28:549–570
8. Raysi Dehcordi S, Marzi S, Ricci A, Di Cola F, Galzio RJ (2012) Less invasive approaches for the treatment of cervical schwannomas: our experience. Eur Spine J 21:887–896
9. Lot G, George B (1997) Cervical neuromas with extradural components: surgical management in a series of 57 patients. Neurosurgery 41:813–820 (discussion 820–812)
10. McCormick PC (1996) Surgical management of dumbbell tumors of the cervical spine. Neurosurgery 38:294–300
11. Yasuda M, Bresson D, Cornelius JF, George B (2009) Anterolateral approach without fixation for resection of an intradural schwannoma of the cervical spinal canal: technical note. Neurosurgery 65:1178–1181 (discussion 1181)
12. Voo LM, Kumaresan S, Yoganandan N, Pintar FA, Cusick JF (1997) Finite element analysis of cervical facetectomy. Spine (Phila Pa 1976) 22:964–969
13. Hong-Wan N, Ee-Chon T, Qing-Hang Z (2004) Biomechanical effects of C2-C7 intersegmental stability due to laminectomy with unilateral and bilateral facetectomy. Spine (Phila Pa 1976) 29:1737–1745 (discussion 1746)
14. Cusick JF, Yoganandan N, Pintar F, Myklebust J, Hussain H (1988) Biomechanics of cervical spine facetectomy and fixation techniques. Spine (Phila Pa 1976) 13:808–812
15. Katsumi Y, Honma T, Nakamura T (1989) Analysis of cervical instability resulting from laminectomies for removal of spinal cord tumor. Spine (Phila Pa 1976) 14:1171–1176