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Clinical Study

Unilateral multilevel interlaminar fenestration: A minimally invasive approach for cervical intramedullary lesions

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ABSTRACT

The traditional approach for cervical intramedullary lesions is laminectomy, but the procedure may result in spinal instability and spinal deformity. Unilateral multilevel interlaminar fenestration (UMIF) is an alternative minimally invasive approach that may have great advantages in preserving spinal stability. However its use in cervical intramedullary lesions is rare, and the indications, safety and limitations of this approach for cervical intramedullary lesions are still under investigation. We report five patients (three males, two females, age range 12–46 years) who were treated between 2010 and 2011 for cervical intramedullary lesions. The lesions included three ependymomas, one astrocytoma and one ependymal cyst, and the locations of the lesions were at the medulla–T2, C4–T1, C5–C7, C4–C7 and C6–C7. All of these lesions were completely removed through UMIF, and all patients had stable or improved neurological status after surgery. No recurrences or spinal deformities were detected during the follow-up period which ranged from 24 to 35 months (mean = 27.4 months). UMIF is a feasible approach for selected cervical intramedullary lesions. This approach allows complete resection of multilevel lesions without increasing the risk of injury to the spinal cord, and minimizing the risk of postoperative spinal instability. The indications for and limitations of UMIF are discussed.

1. Introduction

The traditional surgical approach to a cervical intramedullary lesion is laminectomy, because it provides adequate exposure of the spinal cord and the tumor. Laminectomy involves dissection of bilateral paraspinal muscle and removal of the vertebral laminae, the spinous processes and the attached ligaments. However, these structures are important for stability of the spine, and laminectomy has been repeatedly reported to lead to spinal instability and spinal deformities [1–7]. Laminectomy in the cervical spine, multilevel laminectomy and intramedullary lesions are all thought to be risk factors for postlaminectomy deformity [8,9], and the reported rates of postlaminectomy deformity range from 24% to 100% in series of cervical intramedullary tumors [1,3,8,10,11]. Thus, postlaminectomy spinal instability should receive special attention in the treatment of multilevel cervical intramedullary lesions.

To reduce the risk of spinal deformity after laminectomy, hemilaminectomy was developed to preserve spinal stability, and the procedure is generally considered to have great advantages in preserving spinal stability [12–15]. Unilateral multilevel interlaminar fenestration (UMIF) is an alternative minimally invasive approach that may have more advantages in preserving spinal stability than hemilaminectomy. Koch-Wiewrodt et al. first reported its use for spinal tumors and it was reported to be a feasible, safe, and effective approach for intraspinal lesions [16]. However, its use in cervical intramedullary lesions is rare, and the indications, safety and limitations of this approach in the treatment of cervical intramedullary lesions are still under investigation. The challenge of UMIF for treating cervical intramedullary lesions is to preserve the function of the spinal cord while achieving total resection of the lesion. In this paper, we describe our experiences with five cervical intramedullary lesions that were safely and totally removed using UMIF. This report aimed to validate the feasibility of this approach for selected cervical intramedullary lesions and to describe operative nuances based on our experiences.

2. Materials and methods

From 2010 to 2011, five patients (three males and two females, age range 12–46 years) with cervical intramedullary lesions underwent UMIF surgery. All patients presented with slowly progressive

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symptoms. Numbness of the extremities or trunk occurred in three patients. Weakness of the extremities and muscle atrophy of the hands were present in two patients. One patient also suffered from dizziness, vomiting and ataxia (see Section 4.1. Patient 1). All patients underwent preoperative MRI scanning of the spine. The locations of the lesions were at the medulla–T2, C4–T1, C5–C7, C4–C7 and C6–C7. The lesions were three ependymomas, one astrocytoma and one ependymal cyst, which were confirmed by histological examination. The McCormick classification was used to assess neurological function [17].

2.1. Operative technique

After induction of anesthesia and endotracheal intubation, the patients were positioned prone on the surgical table, and a Mayfield cranial clamp was used to fix the head. Continuous somatosensory and motor-evoked potentials were monitored in all patients.

A midline incision of the skin was made, and the length of the incision was based on the number of operated levels. Then one side of the paravertebral muscles was elevated off the spinous process and the laminae. The interspinous ligaments and the contralateral paravertebral muscles were kept intact. With the aid of a high-speed air drill, the unilateral interlaminar fenestrations were made depending on the location of the lesion. For example, the tumor was located at C4–T1 in Patient 2 so the fenestrations were prepared between C4–C5, C5–C6, C6–C7, and C7–T1, and four bone windows and three bone bridges were created (see Section 4.2. Patient 2). The lateral border of the bone windows was the boundary of the facet. For the medial border, the base of the spinous process was drilled until the contralateral roots were seen. The median part of the unilateral lamina was preserved as a bone bridge between the facet and the spinous process. The ligamentum flavum under the fenestrations was excised.

The operating microscope provided a good view of the dura mater in its lateral extension, and the dura was incised in the midline. The spinal cord was well exposed in the surgical view after incision of the dura. The dorsal midline could be accurately estimated by noting the midpoint between the dorsal nerve root entry zones bilaterally. Small veins exiting from the septum also assisted in establishing the midline. Thus, a midline myelotomy could be easily made under microscopy. The lesion could be identified after myelotomy. Piecemeal resection was used for removal of the lesion. The lesion beneath the bone windows could be resected in the traditional fashion, but the dissection around the bone bridges required special surgical instruments and procedures. Angled and right-angled dissectors were used to develop the boundary of the lesion beneath the bone bridges, and angled microforceps were used to remove it. The lesion beneath the bone bridges was dissected in small visual angles through the two neighboring bone windows. The procedures were a little more difficult than usual, but total removal was achieved in all five patients. The normal cord anatomy was restored through pial and arachnoid welding, and the dura was closed with uninterrupted absorbable sutures under microscopic view.

3. Results

The clinical data of the patients is shown in Table 1. Lesion removal was considered to be complete when the intraoperative view confirmed no residual lesion, and the postoperative MRI also revealed no residual lesion during more than 2 years follow-up. One patient endured transient neurological deterioration after surgery, and one patient had transient proprioceptive sensory disorder, which did not cause McCormick grade deterioration. Both of these patients recovered in the follow-up period. There were no other intraoperative or postoperative complications in this series.

The average follow-up period was 27.4 months. No spinal instabilities or spinal deformities developed on MRI or plain radiograph films at the last follow-up. Before surgery, all patients were independent and did not require walking aids; one patient was McCormick grade II and four patients grade I. After surgery, one patient deteriorated from McCormick grade I to II immediately after surgery and returned to McCormick grade I at their 3 month follow-up. Three patients maintained their McCormick grade I functional status immediately after surgery. The patient with a preoperative McCormick grade II status maintained functional status immediately after surgery and improved to McCormick grade I at 3 weeks after surgery. The excellent postoperative functional status allowed early postoperative mobilization. The patients were mobilized on postoperative day 1 or 2, and the mean length of hospital stay was 8.4 days after the surgical procedure. All patients could walk without aid when they were discharged home. No patient suffered further functional deterioration at the last follow-up.

4. Illustrative patients

4.1. Patient 1

A 12-year-old boy complained of dizziness, vomiting, ataxia and weakness of the left hand for 1.5 months. Neurologic examination revealed gait ataxia, and the left heel-knee-tibia test and the left finger-to-nose test were positive. Muscular atrophy of the left hand was also detected during the clinical examination. The muscle strength of the left hand was grade 5. Trunk sensation was normal. The patient was classified as McCormick grade II. MRI demonstrated a cystic solitary heterogeneously enhancing intramedullary lesion that extended from the medulla to T2 (Fig. 1A, B). The tumor was slightly hypointense on T1 and T2-weighted images. The upper extremity of the tumor extended to the fourth ventricle, with compression of the medulla and cerebellum (Fig. 1C). Total

Table 1
Clinical characteristics of patients with cervical intramedullary lesions managed by unilateral multilevel interlaminar fenestration

Patient	Age, years	Sex	Presentation	Preoperative McCormick grade	Lesion location	Lesion pathology	Postoperative McCormick grade	Follow-up, months
1	12	Male	Dizziness, vomiting, gait ataxia, muscle atrophy of the left hand	II	Medulla–T2	Ependymoma	I	26
2	46	Male	Numbness of the left trunk	I	C4–T1	Ependymoma	I	24
3	40	Female	Numbness of the hands	I	C5–C7	Ependymal cyst	I	27
4	22	Male	Weakness of the extremities, muscle atrophy of the hands	I	C4–C7	Ependymoma	I	35
5	46	Female	Numbness in both upper extremities	I	C6–C7	Astrocytoma	I	25