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Anterior Microsurgical Approach to Ventral Lower Cervical Spine Meningiomas: Indications, Surgical Technique and Long Term Outcome

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Ventral lower cervical spinal meningiomas with posterior displacement of the spinal cord are rare and anterior approach has been rarely reported in the literature. The authors present their experience about eight patients operated through anterior microsurgical approach. Exposure of meningiomas was achieved through one or two corpectomies, according to meningioma extension. Tumour removal was performed thanks to the aid of a dedicated ultrasonic aspirator, and intraoperative evoked potentials were employed. Particular care was taken with the materials adopted for reconstruction of the anterior dural plane, to avoid postoperative cerebrospinal fluid leak. Vertebral fusion and stabilization were achieved by tantalum cage or titanium graft in case of one or two corpectomies respectively; anterior titanium plate fixed with screws was applied in all patients. Extent of tumour removal was related to the presence of a conserved arachnoidal plane between the tumour and the spinal cord: total removal was achieved in 2 patients, while gross total removal in the other six ones. Postoperative neurological outcome, which was favourable in all patients, was related mostly to preoperative neurologic status. No recurrence after total removal and no remnant growth after gross total removal occurred during an average follow-up period of 6, 7 years.

Key words: Anterior Approach; Dural Plane Reconstruction; Lower Cervical Spine Meningioma; Ventral Cervical Spine Meningioma.

Introduction

Cervical meningiomas are usually treated by posterior and posterolateral approaches, even in cases with anterior dural implant (1-3). Anterior approach for ventral spinal meningiomas has been rarely reported in the literature (1, 4-9) and, to our knowledge, papers treating exclusively lower cervical spine meningiomas operated on through microsurgical anterior route have been published very rarely (5, 6, 9). Upper cervical spine meningiomas (cranio-spinal junction, clival, C2) were not considered in this paper because surgical approaches for these tumours are usually posterior or postero-lateral, and anterior approach, when indicated, should be transoral, transfacial or transsphenoidal (10, 11). The presented approach can be required for tumours located anteriorly to the spinal cord without significant lateral extension and without significant lateral displacement of the spinal cord itself. We present our experience with eight patients affected by ventral lower spinal cervical meningiomas operated in our institute through an anterior microsurgical approach from 2004 to 2009. Surgical technique, intraoperative technology and clinical outcome are discussed.

Abbreviations: MR: Magnetic Resonance; MRI: Magnetic Resonance Image.

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Materials and Methods

Criteria if inclusion for patients in the study were represented by: anterior implant of meningioma with posterior displacement of the spinal cord (Figure 1), craniocaudal extension between C3 and C7, surgical approach performed by anterior cervical route. Patients were six women and two men, with an average age of 52, 3 years (range 41 to 72 years).

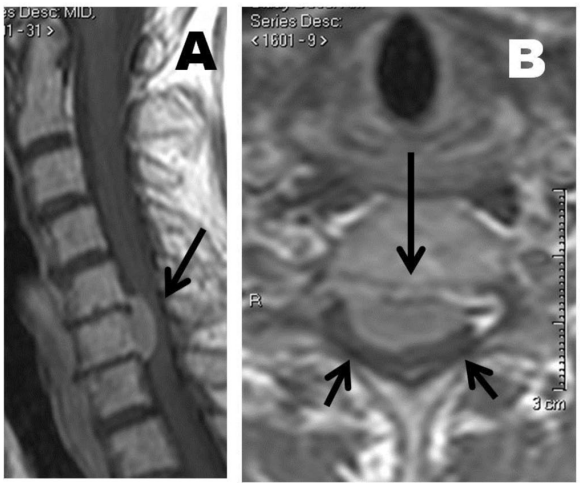

Figure 1: Preoperative post-contrast T1 weighted MRI showing one of our patients affected by a ventral cervical meningioma. (**A**) sagittal slice; the tumour (black arrow) is anterior to C6 (**B**) axial slice; ventral implant of the meningioma is evident (long black arrow). Spinal cord is compressed and its posterior dislocation (short black arrows), prevents any posterior or posterolateral safe approach.

Tumours were located anteriorly to C4, C5, C6 and C7; in five and three cases, cranio-caudal extension involved one and two vertebral bodies respectively. Meningiomas presented an average size of 2.52 cm in longitudinal axis and 1.16 cm in lateral one (Table I).

Intramedullary hyperintense signal in 1,5 tesla MR T2 weighted image, as well as T1 hypointense signal, suggestive for spinal cord damage, was evident in four patients.

Table I

Localization and extension of the 8 ventral cervical spine meningiomas.

	Localization	Cranio-caudal axis	Latero-lateral axis	Consistency
Patient 1	C5	1.7 cm	0.8 cm	Soft
Patient 2	C4	1.9 cm	0.7 cm	Soft
Patient 3	C5-C6	2.9 cm	1.2 cm	Calcific
Patient 4	C7	2.1 cm	1.1 cm	Soft
Patient 5	C6-C7	3.5 cm	1.3 cm	Soft
Patient 6	C5	2.2 cm	1.5 cm	Calcific
Patient 7	C6	2.1 cm	1.9 cm	Calcific
Patient 8	C5-C6	3.8 cm	2.2 cm	Soft

Onset of clinical history started in all patients with a slowly worsening legs weakness, followed by a slowly progressive arms motor impairment, which lasted a period of 5 to 34 months before diagnosis. Three patients, after onset of symptoms and successive clinical examination by neurologist and/or neurosurgeon, were precociously submitted to cervical spinal MRI and early diagnosis was performed. In the other 5 patients, the diagnosis of cervical spinal cord compression due to meningioma was performed after a longer period of time ranging from 6 to 28 months. Come to our observation, all the patients suffered from various degrees of spastic tetraparesis. Supported ambulation was observed in 3 patients who needed monolateral and bilateral support in 2 and 1 case respectively, while the five others presented preservation of normal ambulation, which however was limited because of early onset of weakness. Two patients suffered from moderate impairment of fine hand movements. All the patients presented severe or moderate limitations in their daily life activities (Table II); condition of severe limitation was intended when the patient was not able to perform his work life activities, while moderate limitation was intended when the patient was able to perform only some of his work life activities. Relevant sensitivity disturbances were not present in any patient. Preoperative motor and sensory-evoked potentials of upper and lower limbs revealed various degrees of slowing of conduction velocity in all patients.

Surgical operation started in all cases with anterior exposure of cervical spine; the interested vertebral bodies were identified by fluoroscopic control. Corpectomy was performed, under microscopic view, by dedicated drill and kerrison rongeur until exposure of the dural plane. In five patients, at microscopic view, the external side of the dura mater turned out to be clearly infiltrated by the meningioma, while it revealed no alterations in the other three. In five patients, the consistency of the meningioma turned out to be soft: in three of them the arachnoidal plane between the tumour and the spinal cord was conserved and, after tumour debulking performed by dedicated ultrasonic aspirator provided with a tip for soft tissue, microdissection of the tumour from the spinal cord was possible, achieving total removal (Figure 2).

In the other two patients the arachnoidal plane was infiltrated and a very small tumoral remnant, after bipolar coagulation, was left *in situ* to avoid the risk of anterior spinal artery injury. In the three other patients, the meningioma was prevalently calcified and the arachnoidal plane was not conserved. The calcified part of the tumours was removed with the aid of the above mentioned dedicated ultrasonic aspirator, but in these cases equipped with a tip for calcified tissue, and a very limited remnant was left *in situ*, after bipolar coagulation, because of its adherence to the anterior spinal artery. Intraoperative motor and sensorial evoked potentials were used in all patients, and temporary alterations were registered

Table II
Preoperative clinical status in the eight patients affected by lower anterior cervical spine meningiomas.

	Age	Sex	Tetra-hyperreflexia	Supported ambulation	Severe limitations to life activities	Moderate limitations to life activities
Patient 1	43	F	Yes	No	–	Yes
Patient 2	67	M	Yes	Yes	Yes	–
Patient 3	53	F	Yes	No	–	Yes
Patient 4	39	F	Yes	Yes	Yes	–
Patient 5	61	F	Yes	Yes	Yes	–
Patient 6	55	M	Yes	No	–	Yes
Patient 7	49	F	Yes	No	Yes	–
Patient 8	52	F	Yes	No	–	Yes

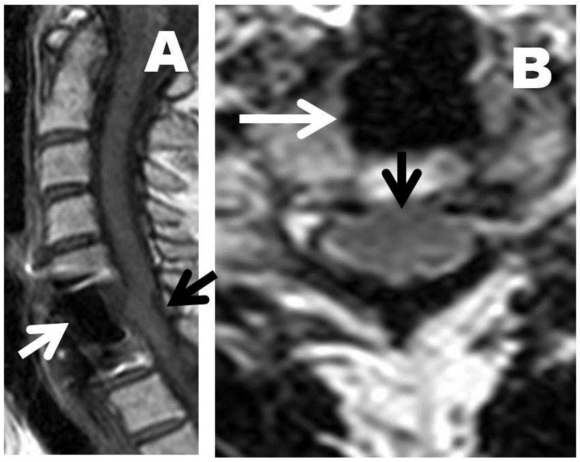

Figure 2: Postoperative MRI of Figure 1 patient. Spinal cord decompression and hypointense tantalum cage are evident in both slices. (**A**) post-contrast sagittal T1 weighted image, showing no evidence of tumour remnant and an optimal spinal cord decompression (black arrow); a tantalum cage was used for fusion (white arrow). (**B**) T2 weighted axial image, showing the important reexpansion of the spinal cord (black arrow); as in sagittal slice, the tantalum cage is visible (white arrow).

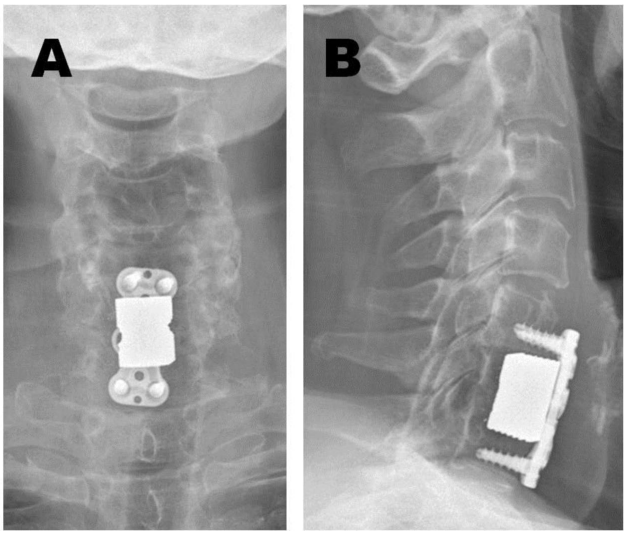

Figure 3: Postoperative cervical x-ray of the same patient showing the stabilization system. (**A**) antero-posterior x-ray showing the tantalum cage and the anterior titanium plate (**B**) lateral x-ray showing tantalum cage, anterior plate and screws.

in one patient affected by calcified meningioma during the use of ultrasonic aspirator. Because the external and/or internal side of the dura mater turned out to be infiltrated by the tumour in all patients, it was removed. Hence, before cervical stabilization, a meticulous reconstruction of the anterior dural plane was performed with selected materials: a single layer of absorbable haemostat (surgicel) to cover the spinal cord and then a single layer of absorbable synthetic dura mater substitute ("Seamdura", manufactured by Gunze Limited and distributed by Codman) covered by synthetic glue (Duraseal) were placed; at the end, a Valsalva manoeuvre was performed by the anaesthetist, and in no patient cerebrospinal fluid (CSF) leak was observed. Vertebral fusion was achieved in all patients with a tantalum cage of adequate size in the case of one corpectomy, while titanium graft was used in the three patients submitted to two corpectomies; anterior titanium plate fixed with screws to the upper and lower vertebral body was placed in all patients (Figure 3).

Postoperative neurological outcome was evaluated by clinical examination performed in four different stages: immediate postoperative period, one week, one month and 5 months after surgery; postoperative evoked potentials were performed one and six months after surgery. Postoperative radiologic controls were represented by: cervical x-ray performed 2 months and one year from surgery; MRI performed 6 months after the operation and, afterwards, MRI once at year.

Results

Histological examination revealed, in all patients, grade 1 WHO meningioma. Total removal was achieved in the three patients affected by soft consistency meningioma and presence of conserved arachnoid plane between the tumour and the spinal cord. In the other two soft tumours, which infiltrated the arachnoid plane with direct contact and adherence

to the spinal cord parenchyma and vessels, a millimetric remnant was coagulated and left *in situ*. Concerning the three patients affected by prevalently calcified meningiomas, gross total removal was accomplished to don't run the risks of surgical morbidity, as other Authors reported (12), with very small tumoral remnants remaining adherent to the anterior spinal artery. Optimal spinal cord decompression and medullary reexpansion was achieved in all patients (Figure 2); presence of tumoral remnants, because of their very limited size, did not affect, in any case, the postoperative clinical outcome.

Postoperative clinical results were very satisfactory: all the patients were put out of bed on the second postoperative day, and they were discharged from the hospital 5 and 7 days after surgery in 4 and 2 cases respectively. Two patients turned out to have a subcutaneous anterior cervical fluid collection, in absence of clinical symptoms, during postoperative course; apposition of a lumbar drainage, draining 100 ml/day for 4 days, was effective in resolving this occurrence in these two patients, as other authors reported in their experience (1); so that these two patients were discharged 9 and 10 days after surgery respectively. Out of the four patients who experienced moderate limitations in their preoperative daily life activities, all recovered valid ambulation during an average follow-up period of 3 to 11 months, and three of them were able to resume all work life activities performed before the onset of clinical symptoms. The two patients who presented moderate impairment of fine hand movements, recovered completely. Out of the four patients who experienced severe limitations in their daily life activities, three reacquired autonomy for simple daily life activities and for the majority of work life activities, while the last one was not able to resume any work life activity performed before the onset of neurologic deficits. In no patient the postoperative clinical outcome was related to total or gross total removal, because the tumoral remnant was very limited; in fact excellent clinical results were observed both in patients submitted to total and in patients submitted to gross total removal; clinical outcome was related, in our experience, to the preoperative neurologic status, to the absence of intramedullary T2 hyperintense or T1 hypointense signal, and to the absence of intraoperative spinal cord injuries thanks to the dedicated devices employed.

No recurrence was observed in the two patients submitted to total removal after a follow-up period of 6,5 and 7,1 years. In the other six patients submitted to gross total removal, no radiotherapic treatment was recommended by us after surgery, because in all cases the tumoral remnant was very small (subcentimetric) and in each patient the tumoral remnant itself had been left *in situ* after bipolar coagulation. If tumoral remnant growth is evident at the seriated MRI controls (once a year), stereotactic radiotherapy would be recommended. Actually, after an average follow-up time of 6, 9 years, the very small tumoral remnants are unchanged in all patients.

Discussion

Importance of Clinical Examination for Early Diagnosis

First of all, early diagnosis and surgery are very important (13), because inveterate permanent damage to the spinal cord (identified by intramedullary hyperintense signal in T2 weighted MR images) have a very low possibility of recovery, and surgery in these cases has the purpose to avoid further progression of neurologic deterioration, as well as for myelopathy due to cervical spondylosis. A delayed diagnosis, as in five of our eight patients, can be due to the insidious onset of clinical history: initial symptoms are usually represented by a slow progressive leg weakness and only after several months appears arm and hand movement impairment. This is due to the somatotopic distribution of the fibres of the corticospinal tract in the cervical spinal cord (14): fibres directed to the inferior limbs are externally located, and so they are the first structures damaged by the extrinsic compression, which only at a later time – because meningiomas are slow growing tumours – damages also the internal fibres directed to the superior limbs.

Indications for Anterior Approach and Intraoperative Technology for Tumour Removal

Anterior approach for cervical spinal tumours is recommended only for tumours located ventrally to the spinal cord (1, 4-9, 15-21), but papers concerning an anterior approach exclusively for lower cervical ventral meningiomas have been published very rarely (5, 6, 9). Advantages of a microsurgical anterior approach are represented by the possibility of a direct exposure of the tumour, without the necessity of spinal cord manipulation (1, 6); moreover, it can be considered a minimally invasive approach, because postoperative early mobilization of patients is performed and postoperative discomforts are rare. Disadvantages of this approach are the depth and narrowness of the operative field, which limit the possibility of surgical manoeuvres, and the necessity to perform corpectomy and successive bone fusion and stabilization. On the other hand, posterior and posterolateral approaches are recommended when the tumour presents lateral extension; their advantages are the exposure of a wider surgical field and that stabilization is not necessary; the most important disadvantage is the necessity of spinal cord manipulation to remove the anterior portion of the tumour with the related potential damages. In our experience, once an anterior approach was recommended on the basis of preoperative MRI (Figure 1), the extent of tumour removal was strictly dependent on the infiltration or preservation of the arachnoid plane: when it was not infiltrated, total removal could

be attempted because a separation between the tumour and spinal vascular structures was present. Moreover, intraoperative advanced technology was at the basis for a good clinical outcome. Ultrasonic aspirator (Sonopet Omni) was necessary to achieve tumour debulking without performing any damage to the adjacent nervous and vascular structures, and it was equipped with different tip according to the tumour consistency. Furthermore, intraoperative evoked potentials allowed to continuously control the integrity of motor and sensitive pathways during surgery.

Dural Plane Reconstruction and Vertebral Body Fusion

Because the anterior dura mater infiltrated by the tumour was necessarily removed, particular attention was paid to the reconstruction of the anterior dural plane, to avoid postoperative CSF leak and CSF fluid collection under the cutaneous plane and the related consequences, such as wound dehiscence and infections. Very few authors have focused on the importance of a tight closure of the anterior dural plane (6), and the presented paper is the only one which treats exclusively lower cervical spine meningiomas approached exclusively by anterior cervical route. A tight closure of the anterior dural plane is necessary to avoid any communication between the dural/subdural space and the extraneous materials employed for cervical body fusion and stabilization.

In our patients, dural plane was reconstructed by placing absorbable haemostat (surgicel) in direct contact with the spinal cord; then, a thin layer of synthetic absorbable dura mater substitute (Seamdura) was placed and covered by synthetic glue (Duraseal). The choice of materials to close anterior dural plane after surgery is very important in our experience: we prefer as much as possible absorbable and synthetic materials because, since absorption occurs after a period of 60-90 days, this is a sufficient time for the natural fibrosis to develop, so that no extraneous materials remain in contact with the spinal cord. Moreover, we prefer synthetic materials because a not negligible rate of infection is reported after use of biologic ones, such as biologic glue (22); finally, fascia graft was not used because, in our and other authors' opinion, synthetic materials allow optimal reconstruction of the dural plane with a low rate of postoperative CSF leak (23).

Lumbar drainage turned out to be very useful for resolution of CSF leak, as reported also by other authors (1), in two of our patients who suffered from CSF leak in the postoperative period; lumbar drainage was not routinely used because its presence confines the patients to bed for some days, while we prefer the patients to get out of bed as soon as possible.

Regarding vertebral fusion and stabilization, several techniques and materials are used according to the extent of the corpectomy (multilevel or single level corpectomy/discectomy) (24-31). In our patients, vertebral fusion after one-level or multilevel corpectomy was achieved through a tantalum cage and a titanium graft respectively; an anterior titanium plate fixed with screws (Figure 3) was placed in all patients.

Strategy for Recurrent Tumours

Although tumour recurrence was not observed in our patients, a therapeutic strategy should be taught for this occurrence. In our opinion, because meningioma growth is usually slow, a 1,5 tesla post-contrast MRI once a year is sufficient to highlight this event. Therefore, in our opinion, a hypofractionated stereotactic radiotherapy is the treatment of choice for recurrent tumours. However, in the extremely rare case of a recurrent tumour reaching a size larger than 1.5-2 cm with associated spinal cord compression, a reoperation should be mandatory; in this case, removal of the stabilization materials and then removal of the recurrent tumour should be performed.

Conclusions

Anterior microsurgical approach, performed by corpectomy, turned out to be a safe and effective method to treat ventral lower cervical spine meningiomas. This approach allowed a direct tumour exposure, without any necessity of spinal cord manipulation. The extent of tumour removal was related to the presence of a conserved arachnoid plane between the tumour and the spinal cord; the presence of a millimetric tumour remnant never affected the postoperative clinical outcome. Dedicated technologies are mandatory to perform this approach, and particular care should be taken with the reconstruction of the anterior dural plane, especially when the anterior dura mater has been removed because of tumour infiltration.

Conflict of Interest Statement

All authors certify that his manuscript has not been published in whole or in part nor is it being considered for publication elsewhere. The authors have no conflicts of interest to declare.

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