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Anterolateral and Posterolateral Approaches to the Foramen Magnum: Technical Description and Experience from 97 Cases

Abstract—Over a 12-year period (1981–1993), 97 lesions located in the foramen magnum area were treated using either the posterolateral or the anterolateral approach. The former is a lateral extent of the midline posterior approach; the latter is the technique of exposure of the cervical vertebral artery applied at the C-1 to C-2 level. The choice between the two types of lateral approaches was made following three modes of localization: anteroposterior attachment, relation to the dura, and relation to the vertebral artery. Both techniques are described in detail, with special attention paid to the bone and dural openings, which vary according to the localization.

The treated lesions include 91 tumors, 4 craniocervical junction malformations, 1 synovial cyst, and 1 abcess. A complete resection was realized in 95% of the tumoral cases, with a very limited morbidity and mortality (3%). (*Skull Base Surgery, 5(1):9–19, 1995*)

The foramen magnum (FM) region can be approached in three ways: anteriorly mainly by the transoral approach,[1–17] posteriorly by the midline posterior approach,[18,19] and laterally through the recently described lateral approaches.[20–26] The latter were christened by several authors under different names including lateral, far lateral, extreme lateral, and transcondylar.

In fact, the lateral approach is a concept of turning around the nervous axis as much as necessary to reach a laterally or anteriorly located lesion without any retraction. Practically, it means to be able to expose and control the vertebral artery (VA) above the arch of the atlas.

This report deals with our experience from 1981 to 1993 on 97 lesions, mainly tumors of the craniocervical junction. To resect these lesions, the lateral approach (LA) was performed using two routes: the posterolateral approach (PLA) and the anterolateral approach (ALA). Each one has particular indications according to the localization and extension of the lesion.

SERIES

The 97 lesions of our series were located in the FM area. As previously reported,[24] this area includes anteriorly the lower third of the clivus, the anterior arch of C-1, the odontoid, and the upper part of the body of C-2; posteriorly the anterior edge of the occipital bone, the posterior arch of C-1, and the superior edge of C-2 laminae; and laterally the jugulare tubercule, the occipital condyle, the lateral mass of C-1, and the facet joint of C-1 to C-2. Therefore, the intradural spaces corresponding to these bone limits are the prebulbar, laterobulbar, premedullary and lateromedullary cisterns, and the cisterna magna.

The series includes 91 tumors, 4 craniocervical junction malformations, 1 infection (actinomyces), and 1 synovial cyst. Among the tumors were observed 35 meningiomas, 19 neurinomas, 10 other nonosseous tumors, 7

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chordomas, and 20 osseous tumors (Table 1). Intra-axial tumors were excluded from this series.

Imaging exams allow classification of the localization of lesions in three ways. The first is the anteroposterior localization, in which the only thing taken into account is the attachment of the lesion to any structure, whatever it may be[24]: dura mater for meningioma, nerve root for neurinoma, bone for osseous tumors or lesions. In this classification, an anterior lesion is attached on both sides of the anterior midline, a lateral one is attached between the midline and the dentate ligament, and a posterior one is attached behind the dentate ligament. The second classification concerns the relationship between the extent of the lesion and the dura with three possibilities: intradural (ID), extradural (ED), or a combination of intra- and extradural (ID-ED). The third classification is the extent of the lesion with regard to the VA with three more possibilities: above, below, or on both sides of the VA. Tables 2, 3, and 4 indicate the distribution of our cases according to these three modes of localization.

Table 2. Localization

	Anterior	*Lateral*	*Posterior*
Meningioma	18	16	1
Neurinoma	—	19	—
Chordoma	3	4	—
Osseous tumor	6	13	1
Other tumors	2	3	5
Synovial cyst	1	—	—
Infection	—	1	—
Craniocervical junction malformation	—	4	—
Total	30	60	7

SURGICAL TECHNIQUES

Lateral approaches were applied in all anterior and lateral lesions using either the posterolateral or the anterolateral approach, as indicated in Tables 5 and 6.

Posterolateral Approach (Figs. 1–4)

The posterolateral approach is performed in most cases in the sitting position, but the prone or the lateral position can be used as well. Great attention must be given to the positioning of the head so as to avoid flexing it forward or bending it laterally. The table is rotated at 30° on its long axis so as to position the surgeon more laterally than usual. The incision is vertical on the midline and then curved laterally along the occipital crest down to the mastoid process. The posterior muscles are separated from the occipital bone on both sides but more laterally on the tumoral side in order to expose the mastoid process. The occipital bone and laminae of C-1 and, occasionally, C-2 are exposed. Then the lamina of C-1 is subperiosteally ruginated, working from the midline towards the transverse process and also from the inferior edge to the superior one. Then, using a smooth spatula, the groove of the VA on the superior aspect of the arch of the atlas is exposed subperiosteally. The internal end of this groove is clearly indicated by an abrupt change in the height of the posterior arch. While this is done, the inferior aspect of the periosteal sheath of the VA can be freed. Then the VA is completely controlled and may be displaced upwards or downwards. This is done laterally as far as desired. The more anterior the tumor the more lateral this exposure of the VA must be. At the utmost, it reaches the transverse foramen. Whatever the extent of the VA exposure, it must be done preserving its periosteal sheath, which surrounds not only the VA but also the perivertebral venous plexus.[21,22,27]

The inferior part of the occipital bone and the posterior arch of C-1 and occasionally the laminae of C-2 are resected. This is done on both sides of the midline. The goal is to decompress the nervous axis as soon as possible. Therefore, an anterior tumor displacing the nervous axis posteriorly needs a bilateral midline opening, and a lateral tumor displacing the nervous axis posterolaterally needs a still more lateral opening on the side opposite to the tumor.

The next step is the lateral drilling. It varies with the

Table 1. Distribution of Pathology

Meningioma	35	Infection	1
Neurinoma	19	Synovial cyst	1
Chordoma	7	Craniocervical jct. malformation	4
Osseous tumors	20	Other tumors	10
Metastasis	8	Hémangioblastoma	2
Fibrous dysplasia	3	Epidermoïd cyst	3
Osteochondrome	1	Melanoma	1
Osteoïd osteoma	2	Angiomyolipoma	1
Plasmocytoma	1	Lymphoma	1
Rhabdomyosarcoma	2	Ependymoma	2
Sarcoma	2		
Aneurysmal cyst	1		

N = 97.

Table 3. Localization—Dura Mater

	ID	*ID-ED*	*ED or Osseous*
Meningioma	30	4	1
Neurinoma	5	5	9
Chordoma	—	—	7
Osseous tumors	—	—	20
Other tumors	7	—	3
Synovial cyst	—	—	1
Infection	—	—	1
Craniocervical junction malformation	—	—	4
Total	42	9	46

ID = intradural, ED = extradural, ID-ED = a combination of intra- and extradural.

Table 4. Localization—Vertebral Artery

	Above	*Below*	*Above and Below*
Meningioma	3	16	16
Neurinoma	2	16	1
Chordoma	—	4	3
Osseous tumors	4	14	2
Other tumors	5	4	1
Synovial cyst	—	1	—
Infection	—	1	—
Craniocervical junction malformation	2	2	—
Total	16	58	23

Table 6. Surgery

	MPA	*PLA*	*ALA*	*ALA + MPA*	*Other*
Anterior					
ID	1	18	—	—	—
ED	—	1	7	1	2
Lateral					
ID	6	12	—	—	—
ED	2	9	15	2	—
ID-ED	—	3	2	4	—
Posterior					
ID	5	—	—	—	—
ED	1	1	—	—	—

MPA = midline posterior approach, PLA = posterolateral approach, ALA = anterolateral approach, ID = intradural, ED = extradural.

location and the extent of the tumor. Anterior tumors need a more extensive drilling than the lateral ones, but it never exceeds one third of the condyle or lateral mass of C-1. When a tumor is located below the VA, the VA is displaced upwards so as to drill under it, mainly on the lateral mass of C-1 and only the inferior part of the condyle. On the other hand, when a tumor is located above the VA, the VA is displaced downwards allowing the drilling to be done above it, mainly on the jugulare tubercle and condyle and only the superior part of the lateral mass of C-1. In the rare cases of large tumors extending on both sides of the VA, the drilling includes the entire lateral wall of the FM. That may sometimes necessitate opening the transverse process of C-1 and transposing the VA medially and inferiorly. This VA transposition is especially useful in cases of ED tumoral extension.

The next step is the dural opening. It is done vertically slightly laterally to the midline on the tumoral side. A contraincision is performed on both sides at the superior and inferior limits of the bone opening. The aim is again a primary decompression of the nervous axis. However, the dura covering the medulla and spinal cord is not folded but kept in place. On the tumoral side, the dura is folded laterally with one or two other contraincisions. In cases where lesions are located below the VA, one contraincision is made below the vessel; when they are above the VA, it is made above the vessel. If the lesion is on both sides of the VA, the dura is cut above and below and occasionally all around the VA to allow its mobilization superiorly or inferiorly when required during tumor resection.

The Anterolateral Approach (Figs. 5–7)

The anterolateral approach is done on a patient in a supine position, with the head slightly extended and rotated towards the opposite side of the lesion. The incision follows the anterior edge of the sternomastoid muscle on its upper third and then is curved along the mastoid process and the occipital crest. The sternomastoid muscle and other posterior muscles are separated from the mastoid process and the lateral part of the occipital bone. The internal aspect of the sternomastoid muscle is dissected, opening the plane between it and the internal jugular vein. The spinal accessory nerve is exposed and freed. The fatty sheath located deep in the field is dissected and rolled around the spinal accessory nerve so as to insure its protection while gently retracting it inferiorly.

The C-1 transverse process is then visible 1 cm below and in front of the tip of the mastoid process. After the muscles inserted on it are cut (superior and inferior oblique and levator scapulae muscles), the VA is exposed between C-1 and C-2. It is again of utmost importance to preserve the periosteal sheath surrounding the VA and its venous plexus. The anterior branch of the second cervical nerve that crosses the VA is divided. Then, after the

Table 5. Surgery

	MPA	*PLA*	*ALA*	*ALA + MPA*	*Other*
Meningioma	4	27	1	3	—
Neurinoma	4	8	6	1	—
Chordoma	—	—	4	2	—
Osseous tumors	1	3	11	1	2
Other tumors	6	1	1	—	2
Synovial cyst	—	1	—	—	—
Infection	—	—	1	—	—
Craniocervical junction malformation	—	4	—	—	—
Total	15	44	24	7	7

MPA = midline posterior approach, PLA = posterolateral approach, ALA = anterolateral approach.

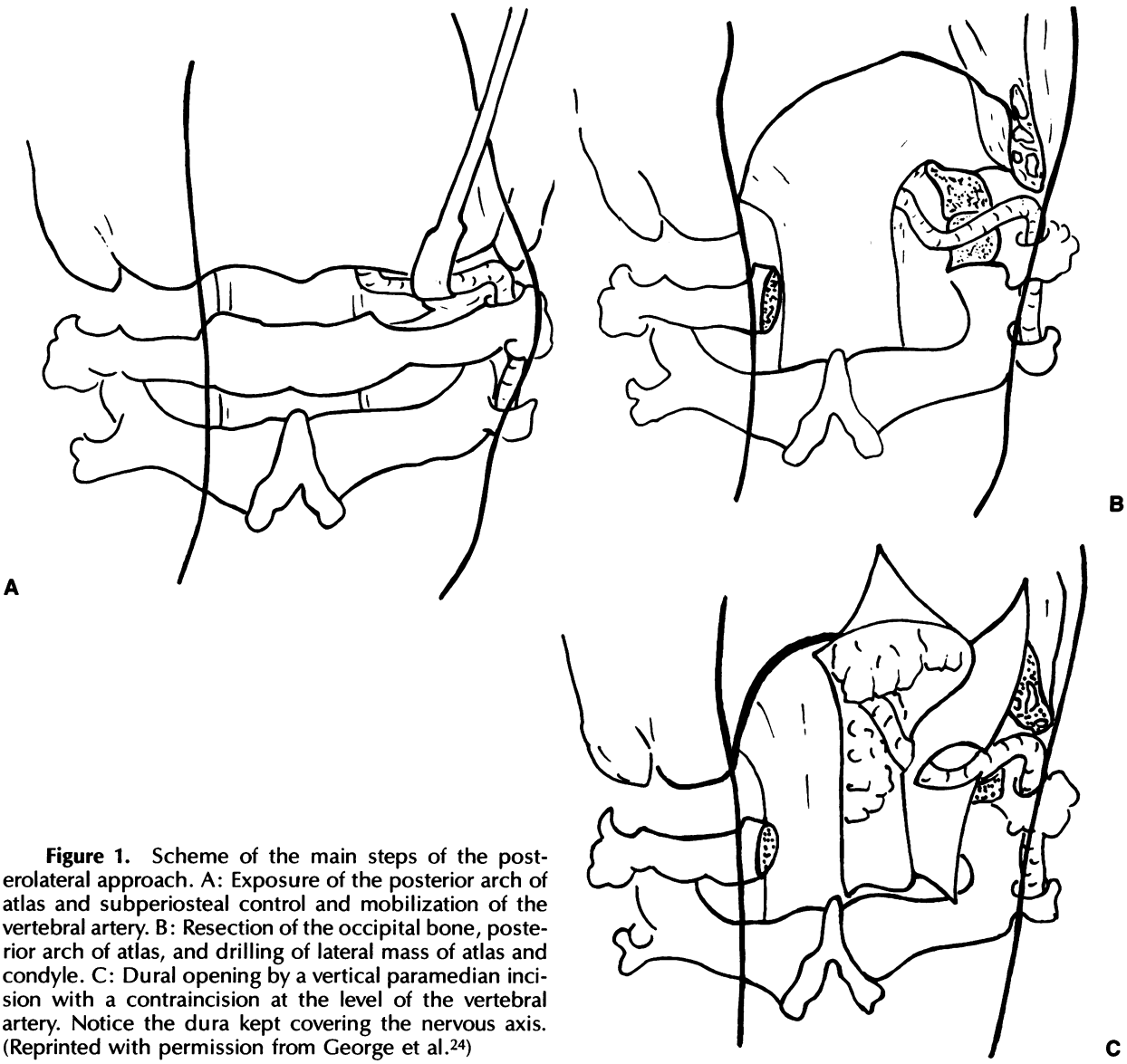


Figure 1. Scheme of the main steps of the posterolateral approach. A: Exposure of the posterior arch of atlas and subperiosteal control and mobilization of the vertebral artery. B: Resection of the occipital bone, posterior arch of atlas, and drilling of lateral mass of atlas and condyle. C: Dural opening by a vertical paramedian incision with a contraincision at the level of the vertebral artery. Notice the dura kept covering the nervous axis. (Reprinted with permission from George et al.[24])

transverse process and posterior arch of C-1 have been scraped, the VA above the arch of atlas is exposed, first on its inferior aspect out of its bony groove and then all around it. The C-1 transverse process is unroofed using a small rongeur. The VA is mobilized out of its bony environment and transposed medially and inferiorly. This allows exposure of the C-0 to C-1 and C-1 to C-2 facet joint, ie, the condyle and lateral mass of C-1.

Exposure can then be extended posteriorly to the ipsilateral part of the posterior arch of C-1 and C-2 and anteriorly to the anterior arch of C-1 and lateral aspect of the odontoid and C-2 vertebral body. Drilling of these bone elements can be done according to need depending on the extent of the lesion.

The dural opening can be done in a way similar to the one used in the posterolateral approach, but it frequently has to be tailored on demand.

INDICATIONS (TABLES 5 AND 6)

The LA was used in almost all anterior and lateral lesions. Whereas the intradural lesions were treated using the PLA in most cases (81%) and the midline posterior approach more rarely (19%), hourglass (ID-ED) tumors were treated by the PLA in 33% of the cases, by the ALA in 22%, or by the ALA followed by a midline posterior approach in 44%. For ED lesions, the ALA was applied in 57%, the combined ALA and midline posterior approach in 27%, and midline posterior approach in 6%. As a whole, when the lateral approach is chosen for an anterior or lateral lesion, the PLA is used in all ID cases and the ALA alone or with the midline posterior approach in 70% of ED or ID-ED cases. For ED nonosseous lesions either the PLA or the ALA was used; conversely, for osseous

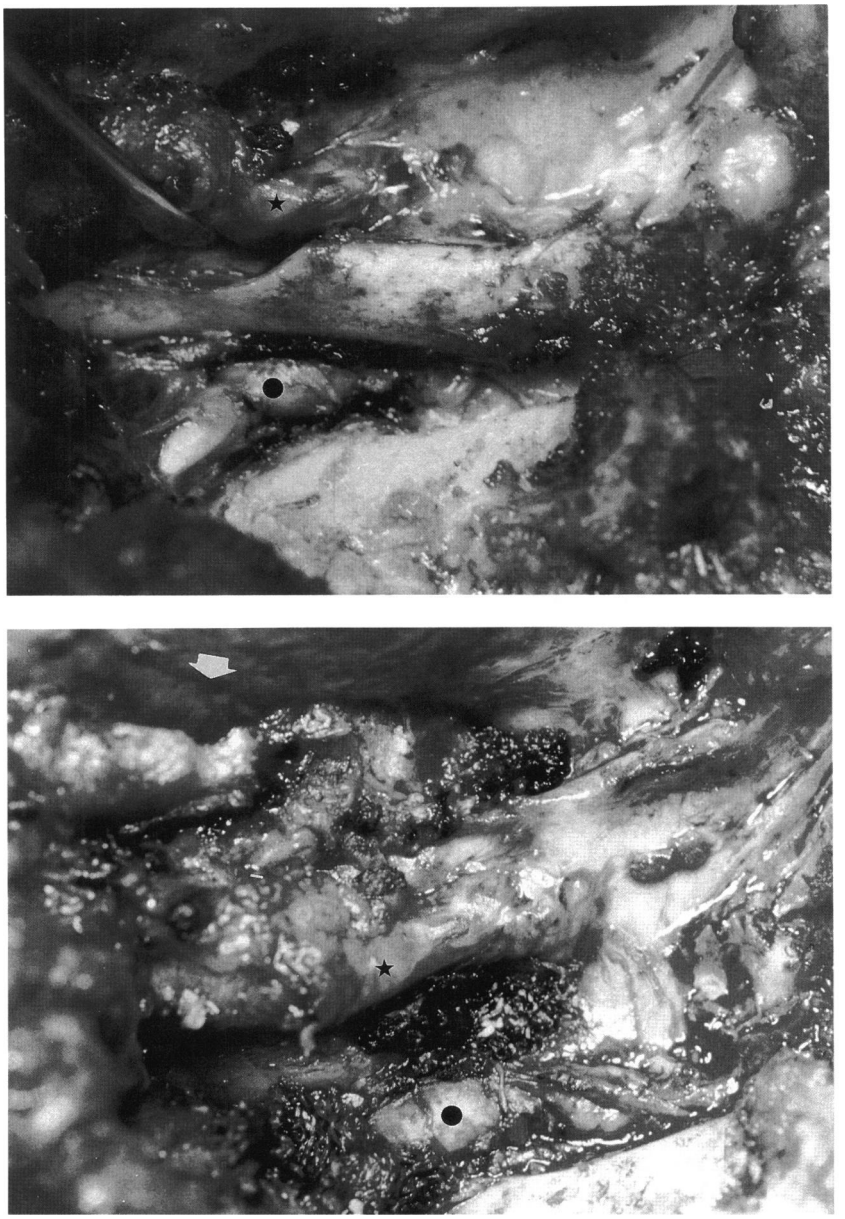


Figure 2. Posterolateral approach. Operative view. A: Exposure of the vertebral artery (black star) above the arch of atlas. B: Resection of occipital bone and arch of atlas with drilling of the lateral mass of atlas and condyle. Note the C-2 nerve root (black circle) and sigmoid sinus (white arrow). (Reprinted with permission from George.[23])

lesions the ALA was applied in most cases. Only one case of an osseous tumor (an osteoid osteoma of the lateral mass of C-1), the 4 cases of craniocervical junction malformation, and the case of a synovial cyst were treated by PLA.

RESULTS

Mortality was observed in three of our early cases. One was related to air embolism in a case for which prevention by G-suit and hypervolemia was not yet available. Another one was an anterior meningioma in a patient in a poor preoperative condition with coma and tetraplegia. The third death was due to a massive pulmonary embolism in a patient otherwise doing perfectly well.

Morbidity is very limited. It is analyzed by using a clinical grading that allows one to compare the pre- and postoperative conditions. In this grading, derived from the one proposed by Yasargil for clival meningioma, grade 0 corresponds to no sign or symptom, grade 1 to one minor sign or symptom, grade 2 to minor symptoms, grade 3 to major symptoms, grade 4 to a bedridden patient, and grade 5 to a dead patient. The mean value of grades allows definition of an index of severity for different populations of patients. Table 7 summarizes the pre- and postoperative indexes of severity for the whole series and for the main groups of pathologies. In Table 8 are given the rate of complete resection, good results (grades 0, 1, and 2), and postoperative improvement for the two main types of tumors (neurinomas and meningiomas) in our series and in the French cooperative study, which collected 230 cases of foramen magnum tumors over 10 years.

Figure 3. Posterolateral approach. Operative view. Aspect after removal of an anterior meningioma. Notice the dura covering the nervous axis (white star) and the contraincision of the dura along the vertebral artery (black arrow). (Reprinted with permission from George et al.[22])

The rate of complete resection is important for every type of tumor or lesion. It ranges from 88% to 100% with an average rate of 95%. There is only one partial removal performed intentionally in a comatose tetraplegic patient with a meningioma. In four other cases of meningioma, the resection was considered subtotal (Simpson grade III). Three of the latter were invasive with an ED-ID and bony extension.

DISCUSSION

Lateral approaches are recently described techniques that aim to work on lesions located anteriorly or laterally in the FM region.[21–24]

It must be stressed that in previously published reports, a clear definition of what is called the FM has never been given. The FM limits suggested here, lower third of the clivus to upper part of C-2, permit clear differentiation of the FM area from the clival area and the upper cervical region. This is in agreement with the classification generally given in series of meningiomas of the posterior fossa; the clivus area is the region around the spheno-occipital synchodrosis and above it up to the dorsum sellae, in front of the pons and cerebral peduncles.[18,19]

Similarly, no criteria has ever been proposed to differentiate anterior and lateral localization in the FM. However, this is a very important point because it is related to surgical difficulties. Hence, it is the attachment of the lesion to any structure that must be taken into account, and not its extension; it would therefore be the insertion for a meningioma or the rootlet for a neurinoma. Anterior lesions are located on both sides of the midline, while lateral ones remain on one side. For instance, using this classification, neurinoma is always lateral even if it has some anterior or posterior development. Consequently, an ante-

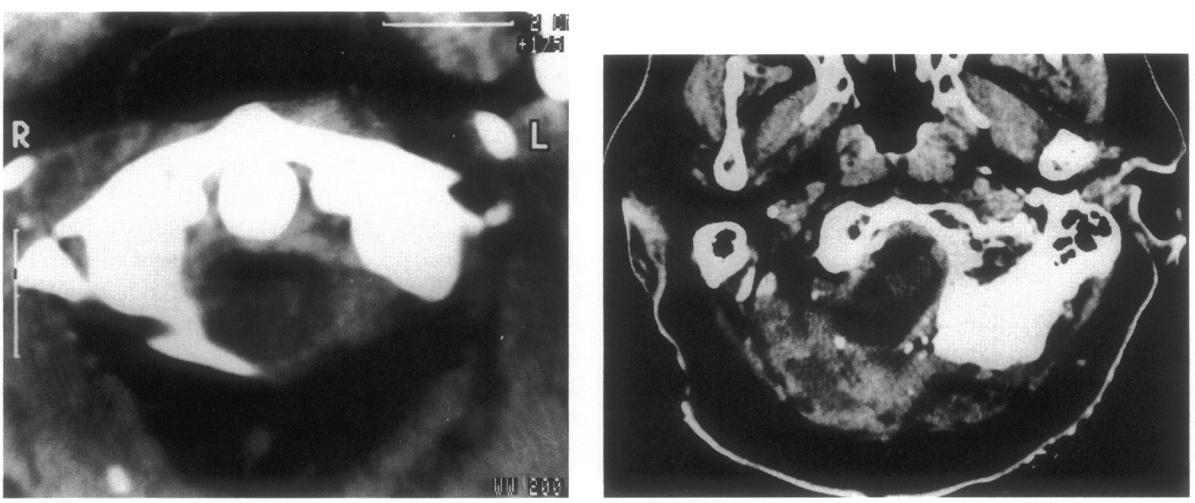


Figure 4. Postoperative computed tomography scan in two cases of meningiomas removed through the posterolateral approach. A: At the level of C-1. B: At the level of occipital condyle.

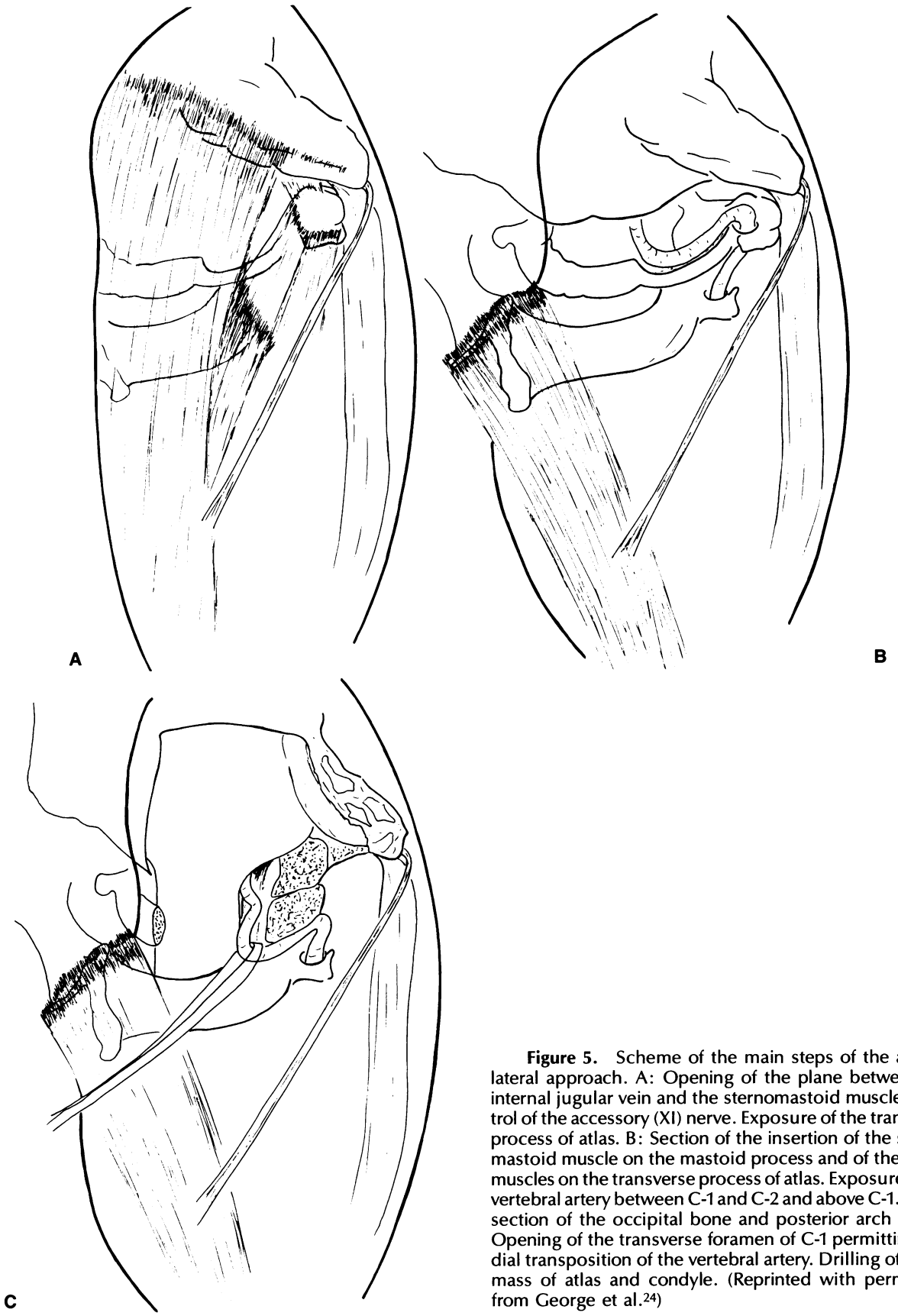
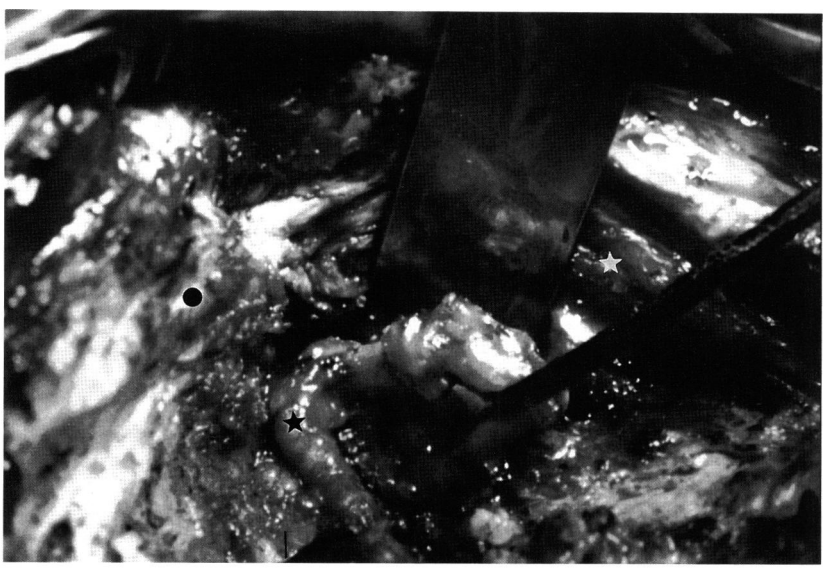


Figure 5. Scheme of the main steps of the anterolateral approach. A: Opening of the plane between the internal jugular vein and the sternomastoid muscle. Control of the accessory (XI) nerve. Exposure of the transverse process of atlas. B: Section of the insertion of the sternomastoid muscle on the mastoid process and of the lateral muscles on the transverse process of atlas. Exposure of the vertebral artery between C-1 and C-2 and above C-1. C: Resection of the occipital bone and posterior arch of C-1. Opening of the transverse foramen of C-1 permitting medial transposition of the vertebral artery. Drilling of lateral mass of atlas and condyle. (Reprinted with permission from George et al.[24])

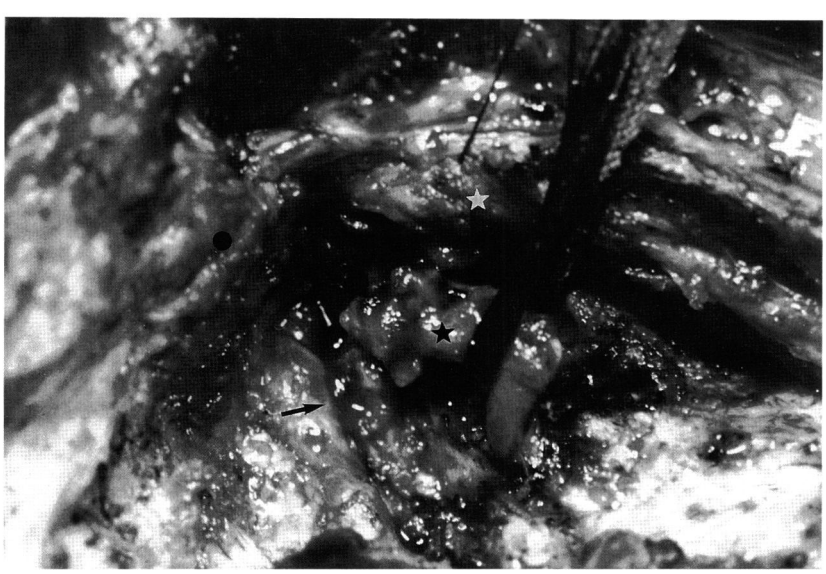
A

B

Figure 6. Chordoma involving the lateral part of the foramen magnum. A: Preoperative computed tomography scan. B: Computed tomography scan after surgical resection through anterolateral approach.



A



B

Figure 7. Anterolateral approach. Operative view. A: Exposure of the vertebral artery (black star) from C-2 to the foramen magnum. B: Transposition of the vertebral artery. Exposure of the condyle-lateral mass joint (black arrow). Note the mastoid process (black circle) and the internal jugular vein (white star).

Table 7. Results

	Preoperative Index of Severity	*Postoperative Index of Severity*
Meningioma	2.74	1.28
Neurinoma	2.17	0.44
Chordoma	2.16	1.5
Osseous tumor	1.65	1.31
Other tumors	1.17	1.25
Synovial cyst	2	0
Infection	1	0
Craniocervical junction malformation	2	0.75

rior tumor generally displaces the nervous axis posteriorly and a lateral one posterolaterally.

Lateral approaches provide the most direct access to these anterior and lateral lesions. The general principle is the control of the VA, which enables the exposure and drilling of the lateral wall of the FM. In many reports,[20,25,26] the lateral approach is performed on a patient in the lateral position with a paramedian vertical incision and an extensive drilling of the condyle. In our experience, the lateral approach can be done in two ways: the anterolateral in a supine position with an anterior incision, and the posterolateral in a sitting position with a posterior incision. The drilling rarely needs to be extensive; most often, it is limited to the medial third of the FM wall and generally only on its upper (condyle and jugulare tubercle) or lower (C-1 lateral mass and C-1 to C-2 joint) part. The extent of the drilling depends on the localization and the extension of the lesion. The more anterior the lesion, the more extensive the drilling. However, in cases of anterior tumor, the posterior displacement of the nervous axis must be taken into account because it makes access to the tumor easier. Therefore, an extensive drilling is only to be done for invasive tumors with lateral and anterior development like some chordomas or some particular meningiomas. In most cases, the VA needs only to be exposed and controlled in order to permit a safe drilling. Opening of the transverse foramen of C-1 with transposition of the VA is essentially required in dealing with anterolateral extradural or osseous tumors through the ALA.

The anterolateral approach gives a better access to the bone and to the extradural anterior and lateral spaces. In fact, it is very similar to the lateral approach already proposed to treat anteriorly located lesions lower in the neck.[21,27] Furthermore, it can be easily enlarged downwards when the lesions extend to the C-2 and C-3 levels (and even lower). In addition, it can also be enlarged upwards and laterally towards the jugulare foramen and petrous bone (combined infratemporal approach)[28]; this allows the surgeon to reach clival or jugulare foramen tumors (meningioma, paraganglioma) extending to the FM. This superior enlargement of the anterolateral approach can be associated with a sigmoid sinus ligation and section.[22,23]

The posterolateral approach is most appropriate for reaching the intradural spaces. It corresponds to a lateral enlargement of the standard midline posterior approach. Therefore, it can easily be extended superiorly towards the lower cranial nerve cisterns and cerebellopontine angle cistern, and inferiorly to the upper cervical perimedullary cisterns. The best position is with the head straight without any flexion or rotation. The goal is not to increase the nervous axis compression, especially in the case of an anterior tumor. It has been shown that the distance in front of the spinal cord and medulla oblongata decreases markedly during head flexion, due to anterior displacement of the nervous axis.[24] In the same spirit, to give as much space as possible to the nervous axis, the bone and dura are opened on both sides. In fact, whatever the gentleness of the maneuvers on the tumor, some pressure can be transmitted to the nervous axis. Moreover, in some cases the symptoms are not related to the tumor compression but to the pressure of the bone on the side opposite to the tumor. This is sometimes well identified during surgery under the form of an imprint on the nervous axis corresponding to the edge of the FM or to the posterior arch of C-1. Therefore, because in anterior tumors the nervous axis is projected posteriorly, the bone is opened on the midline, while in lateral ones, displacing the nervous axis posterolaterally, it is extended further on the opposite side. Similarly, the dura is opened bilaterally but is kept in place for the part covering the nervous axis.

Lateral approaches are mainly indicated for tumors but can be proposed in some cases of bone lesions when they are lateral. In our series, there are two cases of laterally compressing bone malformations very similar to a recently published case.[29] There was also a case of Klippel Feil malformation inducing a bilateral VA compression during head rotation. Another one was an odontoid malformation that had a posterolateral oblique position. Obviously, these bone malformations are most often located medially and therefore generally require an anterior transoral approach to release the nervous compres-

Table 8. Results

	Total Resection	*Good Results*	*Improvement*
Meningioma			
French cooperative study[24] LA	81%	88%	75%
French cooperative study[24] MPA	76%	84%	71%
Personal series LA*	95%	88%	89%
Neurinoma			
French cooperative study[24] LA	92%	100%	91%
French cooperative study[24] MPA	82%	92.5%	85%
Personal series LA	94%	100%	100%

LA = lateral approach, MPA = midline posterior approach.
*In this series are excluded five cases of meningiomas with extradural and bony extension.

sion.[3,10,12] The same thing is observed in osseous tumors and in chordomas, which rarely have a lateral location. A transoral approach has also been proposed for intradural tumors such as meningiomas or neurinomas.[4] However, this approach through a septic cavity seems inadequate for intradural lesion. Conversely, LAs are rarely indicated in strictly anterior extradural or osseous lesions. In our series there is only one case of a synovial cyst quite anterior on the midline, extradural but protruding into the intradural space, which was resected by a PLA.

The LAs induce no additional morbidity. The VA control is a technique that requires an experienced surgeon. The main point is to preserve the periosteal sheath surrounding the VA and its venous plexus.[21,22,27] In doing so, no trouble is to be feared from venous bleeding. The bone drilling is usually limited to the medial third of the condyle and/or C-1 lateral mass and therefore does not require any fixation or grafting.

Finally, these LAs provide better results than the standard midline posterior approach in anterior or lateral tumors of the FM. In the 1993 French cooperative study[24] that collected 230 cases of FM tumors, it was shown that, in terms of clinical index of severity, rate of clinical improvement, and rate of complete removal, better results are always obtained with the LA. For the 49 cases of neurinomas, the LA provides rates of 92% of complete resection, 100% of good results (grades 0, 1, and 2), and 91% of postoperative improvement, as compared to 82%, 92.5%, and 85%, respectively, with the midline posterior approach. Similarly for the 106 cases of meningiomas, complete resection, good results, and postoperative improvement were observed in 81%, 88%, and 75% with LA and in 76%, 84%, and 71% with standard posterior approaches. In our series of 19 neurinomas and 35 meningiomas, complete resection was achieved in 94% of neurinomas and 95% of meningiomas, and good results and postoperative improvement were obtained in 100% of neurinomas and 88% to 89% of meningiomas.

Therefore, the LAs appear very efficient in dealing with tumors of the FM area. They provide better results than the standard midline posterior approach. They can be performed in two ways: the posterolateral approach and the anterolateral approach. The choice between these two techniques relies on the localization regarding the dura, the VA, and the attachment or involvement of any foramen structure in the horizontal plane. The posterolateral approach is mainly devoted to intradural lesions and to hourglass intra-extradural lesions, while the anterolateral approach is applied instead on extradural and osseous tumors.

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REVIEWER'S COMMENTS

This article benefits from the author's great experience in the management of tumors at the foramen magnum; they have written extensively on this subject as well as on issues dealing with the vertebral artery. The important article brings forth two main points. The vertebral artery is the key to management of craniocervical junction tumors. The type of lesion at hand dictates the operative approach to be used; hence, a surgeon managing lesions at the craniocervical junction must be familiar with all possible approaches to this area so that the most suitable one for the situation may be selected. The authors have explained the anterolateral and posterolateral approaches and also given their specific indications for using them. They have also defined the areas and the exact criteria for naming a tumor "anterior" or "anterolateral" in location. This is an important point to consider when comparing other series dealing with similar lesions because there is a significant difference in the technical difficulty of operations on these two types of lesions. It is also evident that patients with meningiomas in this location have a better outcome with regard to neurological function and the prospect of being free of the tumor when the lateral approach is used, although many intradural tumors at the foramen magnum can be removed by a retrosigmoid route. It would have strengthened the article further if the authors had elaborated on the types and frequency of complications encountered in the treatment of such tumors.

A point must be made about the venous plexus around the vertebral artery. It can be a source of troublesome bleeding and remains intact by staying outside the periosteal sheath that surrounds the plexus and the artery, but in some instances, extradural tumors may actually invade the sheath, which must then be excised. Once the venous plexus is entered, bleeding is best controlled by coagulating the entire thickness of the plexus between the tips of the bipolar forceps proceeding circumferentially around the artery and stripping it away from the vessel. This dissection is preferably done under magnification because the artery is relatively thin walled and can be easily injured. Another issue that has not been discussed is the need for stabilization[1] after extensive resection of the occiput–C-1–C-2 articulation for extradural tumors. Tumors like chordomas require wide bony resection, which destabilizes the craniocervical junction. An occipitocervical fusion with hardware and autogenous bone is necessary under these circumstances. Newly available titanium constructs are preferred because follow-up imaging capability is important when dealing with tumors that have a high propensity for recurrence.

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