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The Effect of Condylectomy on Extreme Lateral Transcondylar Approach to the Anterior Foramen Magnum

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Summary

The dorsolateral, suboccipital, transcondylar technique was used in this cadaveric study. The angle and distance measurements in the corridors were taken intradurally both superior and inferior of the foramen magnum level. In the first stage of this study, the findings which were gained from the standard lateral suboccipital approach were compared with the findings after condyle and lateral atlantal mass removal. After condylectomy, the approach to anterior foramen magnum via both corridors was found to be shorter and the lateral angle of the exposure of the anterior foramen magnum was found to be wider. The considerable shortening of the distances to the anterior foramen magnum, especially in the superior corridor, emphasises the necessity of combining standard approaches with condylectomy. In addition, it was found that after condylectomy, considerable widening of both transverse and longitudinal planes in the inferior corridor allows the surgeon greater access to work on lesions. Furthermore, the freed space between the superior corridor and the inferior corridor, which was gained by condylectomy, shows that condylectomy provides a combined approach to the inferior and superior parts of the foramen magnum anteriorly.

Keywords: Transcondylar approach; cadaver study; occipital condyle; anterior foramen magnum.

Introduction

The intradural extramedullary tumours which are located anterolateral or ventral to the neuroaxis around the lower clivus, foramen magnum (FM) and upper cervical spine are mostly meningiomas and neurofibromas. These tumours generally tend to extend cranially and caudally from the FM [9].

The anterior, lateral, posterior, and posterolateral approaches and a combination of them have been used in this area [1, 3, 6, 8, 10, 11]. Each of these approaches has got advantages and disadvantages.

Among these approaches, the particular aim is to gain sufficient exposure of the cord/brain stem-tumour interface and its base attachment to the anterior FM to achieve safe and total removal [4, 12, 14]. For this reason the exposure of the anterior aspect of the FM must be widened and shortened and simultaneous access must be gained into the superior and inferior levels of the FM.

The extreme lateral transcondylar approach can be considered for cases in whom the conventional posterior approach has failed because of the points stated above.

The lateral suboccipital approach can be successful if the lesion is not attached by a broad base and not adherent to the anterior surface of the brain stem [14]. By combining jugular tubercle drilling and laminectomy with this approach, it is possible to access the cranial and caudal parts of the lesion [13]. But the existence of the occipital condyle still restricts access between the superior and inferior areas of the FM. Besides this, the occipital condyle reduces the area available to reach the anterior FM.

The aim of this study is to investigate both how the occipital condyle restricts the view of the anterior FM and to what extent condylectomy decreases the distance to the anterior FM while at the same time increasing the exposure.

Technique

This study was carried out by using microsurgical technique in 9 sides of 5 formalin fixed cadaver specimens. The dorsolateral, suboccipital, transcondylar approach as defined by Bertalanffy and Seeger [4] previously was used on cadavers in the lateral decubitis position.

In addition, because of restrictions caused by bone structures in the skull, some measurements have been taken in dry skulls in order to clarify the progress of the study (Table 2).

Skin incision and soft tissue dissection were performed as defined [4]. The vertebral artery (Va) was identified but it was not separated from the transverse foramen of C-1. Lateral suboccipital craniectomy was carried out by unroofing the sigmoid sinus. Then the jugular tubercle was drilled away and the drilling was continued anteriorly to expose the hypoglossal canal. Following this, the caudal exposure was enlarged by C-1 hemilaminectomy. After the dura was opened, intradural structures were examined under the microscope.

Access to the anterior FM was decided upon by means of two corridors superior and inferior to the N. Hypoglossus. The reason for choosing the hypoglossal nerve trace, to act as a border for the superior and inferior corridors, is because it leaves the skull just above the occipital condyle. These corridors are titled as "A"-superior, "B"-inferior (Fig. 1 b).

The caudal cranial nerves (9th, 10th, and 11th cranial nerves) form the upper border of corridor "A". The entry of Va into the dura and its intradural proximal portion form the inferior border of corridor "B". These two corridors are separated by the hypoglossal nerve. The upper and the lower brain stem and the intradural course of the Va form the medial edge of these two corridors. The Va, beyond the point of its posterior inferior cerebellar artery (PICA) branch, is medial to the superior corridor, but in the inferior corridor the Va should be moved gently towards the medial side in order to reach the anterior FM. In the superior corridor N. Accessorius lies in lateral; its rootless in the inferior corridor should be moved to the medial side to provide access. The following bone structures form the border on the lateral side of both corridors; the condylar fossa and the superior-posterior edge of the occipital condyle in the superior corridor, the condyle itself and the lateral atlantal mass in the inferior corridor (Fig. 1 a, b).

After having taken the measurement of the angle and distance from the points which were decided upon in both corridors, the posteromedial portion of the condyle and the lateral atlantal mass were drilled away to approach the anterior FM as close as possible. In the superior corridor, in order to investigate the effect of condylectomy in combination with the lateral suboccipital craniectomy, a point was defined on the condylar fossa at the same level as the posterior

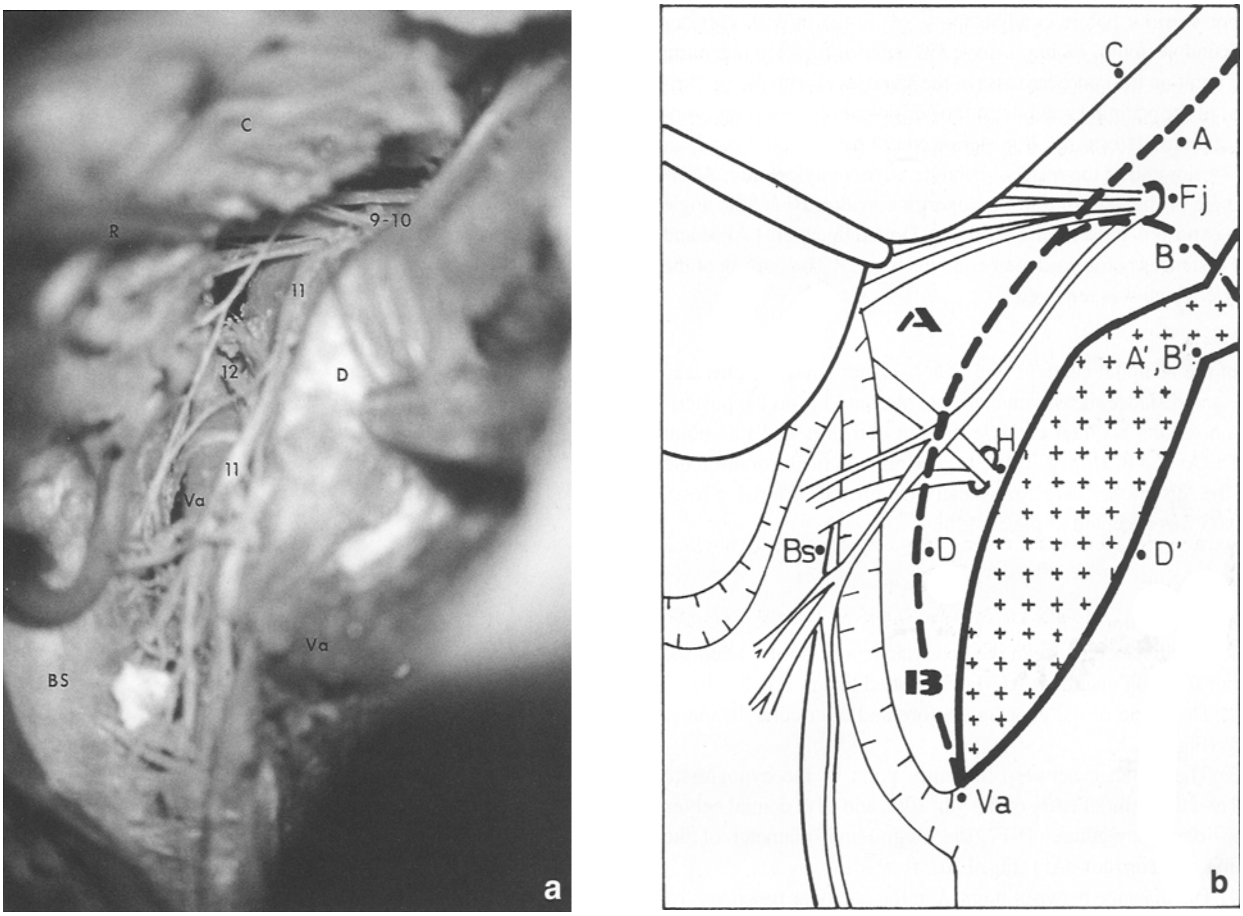

Fig. 1. (a) Intradural exposure of the cadaver specimen, after condylectomy. *BS* brain stem, *C* cerebellum, *D* dura mater is curled on the residual part of the occipital condyle, *R* retracter, *Va* vertebral artery, *9–10* 9th and 10th cranial nerves, *11* 11th cranial nerve, *12* 12th cranial nerve. (b) Illustration showing the borders of the superior (*A*) and inferior (*B*) corridors. *A* Superior corridor; *B* inferior corridor; *Points*: *A* The point on the condylar fossa at the same level with the posterior end of the occipital condyle, *A′* posterior end of the residual condyle, *B* posterior end of the occiplital condyle, *B′* posterior end of the residual condyle, *C* cerebellum, *D* medial edge of the occipital condyle, *D′* the posterior point of the residual condyle at the same level as point "D". *H* The entry point of the hypoglossal canal, *Va* the entry of the vertebral artery into the dura, *Fj* the entry point of the foramen jugulare. The dotted line shows the area of bony resection, before condylectomy. (+) The part of the residual condyle after drilling

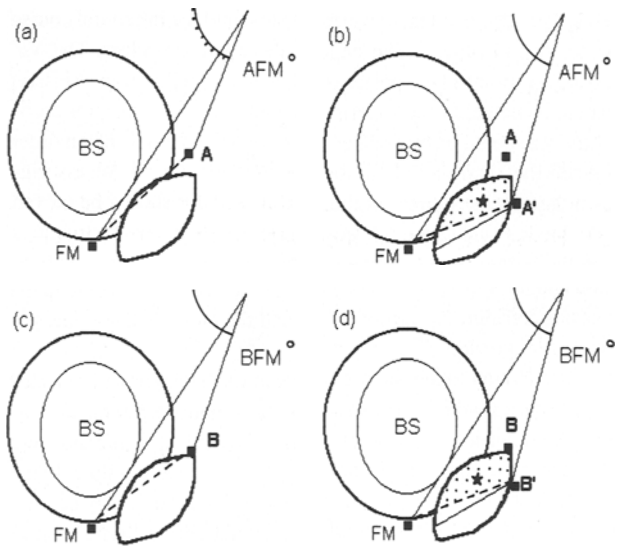

Fig. 2. Illustration showing the angle and distance measurements obtained from cadavers; (a) in the superior corridor before condylectomy, (b) in the superior corridor after condylectomy, (c) in the inferior corridor before condylectomy, (d) in the inferior corridor after condylectomy. *BS* brain stem; *FM* anterior foramen magnum; *A* the point on the condylar fossa at the same level with the posterior end of the occipital condyle; *A′* posterior end of the residual condyle after condylectomy; *B* posterior end of the occipital condyle; *B′* posterior end of the residual condyle after condylectomy; *AFM°* the angle of the exposure in the superior corridor. *BFM°* the angle of the exposure in the inferior corridor. Dotted line points AFM and BFM distances before and after condylectomy. * The portion of the condyle which was removed

end of the occipital condyle (Fig. 2 a, b). After condylectomy, the angle and distance measurements were measured from the posterior point of the residual condyle in both corridors and this point titled as A′ and B′ (Fig. 2, Table 1). The measurements of the angle and the distances were statistically compared (Paired t-test). $P < 0.05$ was accepted as meaningful.

Measurements

In "A" corridor:

(1) The distance between the condylar fossa (Point A) and the anterior foramen magnum; AFM (The dotted line in Fig. 2 a, b).

(2) The angle of the exposure before and after condylectomy; AFM° (Fig. 2 a, b).

(3) The distance between the entry point of the hypoglossal canal and the point of entry of the 9th, 10th, and 11th cranial nerves at the foramen jugulare; H-Fj (the longitudinal diameter of the opening into corridor "A") (Fig. 1 b).

(4) The distance between point A in the condylar fossa and the cerebellar hemisphere; A–C (The transverse diameter of the opening into corridor "A") (Fig. 1 b).

In "B" corridor:

(5) The distance between the posterior end of the occipital condyle (Point B) and the anterior foramen magnum; BFM (The dotted line in Fig. 2 c, d).

(6) The angle of the exposure before and after condylectomy; BFM° (Fig. 2 c, d).

Table 1. *The Angle and Distance Measurements Taken from Superior and Inferior Corridors*

Mean ± Sd			
mm	BC	AC	
AFM	34.7 ± 4.3	29.4 ± 2.8	$P < 0.001$
AFM°	8.9 ± 2.1	11.1 ± 1.8	$P < 0.05$
BFM	26.4 ± 2.3	23.7 ± 1.7	$P < 0.01$
BFM°	4.9 ± 1.5	6.7 ± 1.7	$P < 0.05$
H-Va	4.2 ± 1.9	4.6 ± 2.1	$P < 0.01$
H-Fj	10.2 ± 1.9	11.3 ± 2.1	NS
D-Bs	2.3 ± 0.8	5.5 ± 2.8	$P < 0.01$
A-C	2.8 ± 1.1	3.5 ± 1.4	NS

BC before condylectomy; *AC* after condylectomy; *NS* non significant; *Sd* standard deviation; *mm* milimeter. *AFM, AFM°, BFM, BFM°, H-Fj, H-Va, D-Bs, A-C* values see "Technique".

(7) The distance between the entry point of the hypoglossal canal and the entry of the Va into the dura; H-Va (The longitudinal diameter of the opening into corridor "B") (Fig. 1 b).

(8) The distance between the medial edge of the occipital condyle and the lower brain stem at the same level; D-Bs (The transverse diameter of the opening into corridor "B") (Fig. 1 b).

Results

It was observed in cross-cuts of the dry skulls that the condyles make the view to the anterior FM narrower due to the convex shape of their medial edge. It was confirmed after this examination that this convex shape made the exposure, A°–B°: 6.2°–8° (Right/Left) narrower (Fig. 3). And also the sigmoid sinus and the jugular tubercle may obstruct the extreme lateral view of the anterior FM by their anatomical locations. The elbow-shaped angle 164.9°/164.4° (C°: Right/Left)

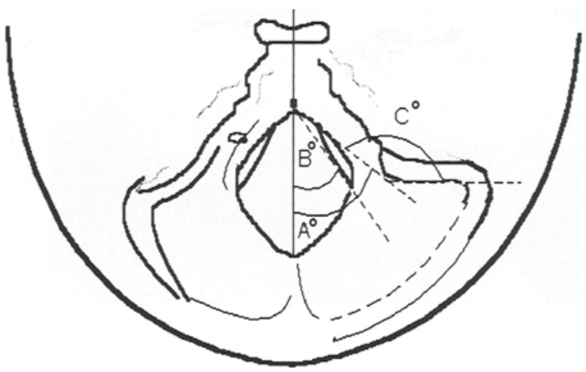

Fig. 3. Illustration showing the measurements obtained from dry-skull crosscuts. *A°* The angle between the foramen magnum midline and the anterolateral rim of the foramen magnum. *B°* The angle between the foramen magnum midline and the medial convexity of the occipital condyle. *C°* The elbow-shaped angle which exists between the sigmoid sinus trace and the anterolateral rim of the FM

Table 2. *Measurements Taken From 15 Dry Skull Specimens*

Mean ± Sd		
mm	R	L
A°	50.4 ± 4	54 ± 5.1
B°	44.2 ± 5.4	46 ± 6.1
C°	164.1 ± 2.9	164.4 ± 4.5

A° The angle between the foramen magnum midline and the anterolateral rim of the foramen magnum, *B°* the angle between the foramen magnum midline and the medial convexity of the occipital condyle, *C°* the elbow-shaped angle which exists between the sigmoid sinus trace and the anterolateral rim of the FM. *R* Right; *L* left; *sd* standard deviation; *mm* millimeter.

which exists between the course of the sigmoid sinus and the anterolateral rim of the FM causes a particular obstruction to this view (Fig. 3).

In the cadaver specimens both corridors were exposed by retraction of the cerebellar tonsils. It was found that the view of the entry of the jugular foramen and the hypoglossal canal were revealed more fully after condylectomy (Fig. 1 a, b).

According to the values taken from cadavers, the mean value of the distances to the anterior FM was found to be shorter in corridor "B" compared to "A" before condylectomy (Mean BFM < Mean AFM). However, in corridor "A" the angle of the exposure to the anterior FM proved to be wider in contrast to corridor "B", (Mean AFM° > Mean BFM°). After condylectomy it was detected that there was a statistically meaningful shortening in both corridors towards the anterior FM ($p < 0.01$, $p < 0.001$, respectively) and a statistically significant increase in the angle of the exposure of the anterior FM ($p < 0.05$, $p < 0.05$, respectively) (Table 1).

The longitudinal diameter of the opening into corridor "A" (H-Fj) was found to be wider than the opening into corridor "B" (H-Va) before condylectomy. But after condylectomy the widening was only found statistically significant in corridor "B" ($p < 0.01$) (Table 1).

The transverse diameter of the opening into corridor "B" (D-Bs) showed statistically significant widening compared to corridor "A" (A–C) ($p < 0.01$) after condylectomy (Table 1).

Discussion

The main difference between the lateral suboccipital and the extreme lateral transcondylar approach is the drilling of the occipital condyle and the lateral atlantal mass. This technical difference enables a shorter and more direct route to the anterior part of the pontomedullary junction without brain stem retraction, whilst providing access with a wider lateral exposure of the tumour-cord/brain stem interface; as suggested in previous clinical studies [2–4, 12, 14, 15]. However, as to which part of the occipital condyle should be removed is open to discussion.

Both, the removal of the posteromedial or the posterior half to two thirds of the occipital condyle, together with the lateral atlantal mass drilling have been frequently carried out in practice [3, 4, 12, 14, 15]. However, for extradural tumours involving the occipital condyle, entire condyle resection and subsequent occipitocervical fusion is recommended [2]. In our study on dry skulls, exposure of the anterior foramen magnum was found to be insufficient when only the posterior half of the condyle was removed. Therefore we carried out a removal of the posteromedial portion of the condyle to be as close as possible to anterior foramen magnum. In addition, the lateral atlantal mass was also drilled.

Besides condylectomy, alternative procedures have been recommended because the surgical results of the lateral suboccipital approach were sometimes disappointing for anteriorly placed lesions. Some authors have recommended mobilisation of the vertebral artery [3, 4, 12], partial mastoidectomy [2, 14, 15] and sigmoid sinus incision [3, 6]. In our dry skull measurements we confirmed George's [6] observation, in that the elbow-shaped angle which exists between the course of the sigmoid sinus and the anterolateral rim of the foramen magnum, restricted the far lateral exposure of the anterior foramen magnum. This lack of exposure can be eliminated by sigmoid sinus incision. In contrast, these procedures pointed out above except mobilisation of the vertebral artery have been found unnecessary when craniectomy was carried out with the removal of the condylar fossa and the drilling of the jugular tubercle [4, 12].

A very radical removal of bone in the area of the condylar fossa just posterior to the occipital condyle have been described by Heros which he used in the far lateral inferior suboccipital exposure [7, 8]. The most important aspect of this exposure is to widen the lateral angle of the exposure for the surgeon and thereby to reach the anterior part of the brain stem with minimal or no brain stem retraction. Then he emphasises that "Laterally, the bone edge becomes more vertical. This is usually the limit of removal since to go beyond would require opening the capsule of the atlanto-occipital articulation which is not necessary". This observation indicates that occipital condyle could cause an anatomical obstruction for lesions, which require a combined approach through the superior and inferior level of the foramen magnum, even if a wide lateral bone resection is done.

With our study in cadaver specimens, even with drilling continued anteriorly to expose the hypoglasal canal and cranially until the jugular tubercle was resected providing a wider area in the superior corridor, sufficient exposure down to the foramen magnum, was found to be difficult because of the presence of the occipital condyle. At the same time, brain stem retraction is also required. In addition to this, in the dry skull crosscuts, the convexity of the occipital condyle has a narrowing effect on the possible access to the anterior foramen magnum from the direction of the anterolateral rim of the foramen magnum; thus the occipital condyle proves to be an anatomical obstruction.

In our study, following condylectomy it was found that the anterior foramen magnum is observed with a wider angle of exposure in both corridors and at the same time the distance to this point became significantly shorter especially in the superior corridor. These findings show us that the interface between the tumour and cord/brain stem can be viewed from a wider and a closer area in the superior corridor after condylectomy. This close proximity to the anterior foramen magnum, which is found to be more significant in the superior corridor, suggests the necessity of a combined procedure of condylectomy with lateral suboccipital craniectomy.

In addition, the space freed between the superior corridor and the inferior corridor, which was gained by condylectomy, shows that condylectomy provides a combined approach to the inferior and superior parts of the foramen magnum. At the same time, in the inferior corridor the significantly widened area on both transverse and longitudinal planes seems to allow the surgeon safer access to the lesions which compress the brain stem.

In conclusion, following condylectomy removal of lesions from the anterior foramen magnum is made easier by accessing the anterior foramen magnum through a shortened and widened angle of exposure. This procedure also enables a safe exposure of the tumour interface whilst avoiding manipulation of the brain stem. In conclusion, condylectomy provides a combined approach in a widened area in the transverse and longitudinal plane, while dealing with lesion from the superior part of the foramen magnum to the inferior part.

References

1. Al-Mefty O, Fox JL, Smith RR (1988) Petrosal approach for petroclival meningiomas. Neurosurgery 22: 510–517
2. Babu RP, Sekhar LN, Wright DC (1994) Extreme lateral transcondylar approach: technical improvements and lessons learned. J Neurosurg 81: 49–59
3. Baldwin HZ, Miller CG, Spetzler RF *et al* (1994) The far lateral/combined supra- and infratentorial approach. J Neurosurg 81: 60–68
4. Bertalanffy H, Seeger W (1991) The dorsolateral suboccipital transcondylar approach to the lower clivus and anterior portion of the craniocervical junction. Neurosurgery 29: 815–821
5. Crumley RL, Gutin PH (1989) Surgical access for clivus cordoma. Arch Otolaryngol Head Neck Surg 115: 295–301
6. George B, Dematons C, Cophignon J (1988) Lateral approach to the anterior portion of the foramen magnum. Surg Neurol 29: 484–490
7. Heros RC (1986) Lateral suboccipital approach for vertebral and vertebrobasilar artery lesions. J Neurosurg 64: 559–562
8. Heros RC (1991) The far lateral inferior suboccipital approach. In: Wilkins RH, Rengacherary SS (eds) Neurosurgery update. McGraw-Hill, New York, pp 106–109
9. Meyer FB, Ebersold MJ, Reese DF (1984) Benign tumors of the foramen magnum. J Neurosurg 61: 136–142
10. Miller CG, Van Loveren HR, Keller JT *et al* (1993) Transpetrosal approach: surgical anatomy and technique. Neurosurgery 33: 461–469
11. Miller E, Crockard HA (1987) Transoral transclival removal of anteriorly placed meningiomas at the foramen magnum. Neurosurgery 20: 966–968
12. Lang DA, Neil-Dwyer G, Iannotti F (1993) The suboccipital transcondylar approach to the clivus and cranio-cervical junction for ventrally placed pathology at and above the foramen magnum. Acta Neurochir (Wien) 125: 132–137
13. Samii M, Draf W (1989) Lateral suboccipital approach to the clivus. In: Samii M, Draf W (eds) Surgery of the skull base. Springer, Berlin Heidelberg New York Tokyo, pp 443–449
14. Sen CN, Sekhar LN (1990) An extreme lateral approach to intradural lesions of the cervical spine and foramen magnum. Neurosurgery 27: 197–204
15. Sen CN, Sekhar LN (1991) Surgical management of anteriorly placed lesions at the craniocervical junction – an alternative approach. Acta Neurochir (Wien) 108: 70–77

Comments

The authors have an important message.

The concept of surgical corridors for lesions above and below the foramen magnum is important. The idea of a condylectomy for the lower corridor deserves consideration by the readers even if they are less familiar with the complex surgical anatomy of this region.

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