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Course and relationship of cranial nerves from end organs through foraminas to root entry zones. How far can they be mobilized: an anatomical study

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Abstract

In this study, the mobilization of all cranial nerves with drilling of several bony structure, cutting of ligaments, folds and dural attachments were performed via different skull base approaches.

Twenty cadaveric head specimens filled with microfil were dissected bilaterally. On 5 dry skulls, important bony structures were also studied.

We observed that the mobilization of the nerves II, III, VI, VIII, and XII were not easy comparing to other cranial nerves. The subfrontal parenchymal tissue should be removed and the olfactory nerve should be dissected for mobilization of the first cranial nerve. The mobilization of the nerves IV, V, VII, IX, and XI were dramatically remarkable after drilling of superior orbital fissure, foramen ovale, foramen rotundum, Fallopian canal, and jugular foramen.

Key words: [cranial nerve] [mobilization] [skull base] [approach] [anatomy]

Introduction

Especially in skull base surgery, the cranial nerves (CN) are under risk of iatrogenic injury due to manipulation of the nerves. To minimize the risk, drilling of bony structures and opening of foraminas, and cutting of different ligaments and dural attachments should be performed [1–6]. The capability of the nerve to direct and indirect compression is another important factor for mobilization. This study includes an anatomical study with review of several different factors which are playing role for the mobilization of several cranial nerves.

Material and Methods

All cranial nerves were dissected along their course from their end organs to their root entry zones, using 20 cadaveric head specimens bilaterally. Several approaches were performed including transbasal, orbitofrontozygomatic, pterional, infratemporal, subtemporal, transpetrosal, presigmoid, retrosigmoid, extreme lateral and suboccipital approaches. All related foraminas and bone structures were drilled. The ability of the cranial nerves to mobilization with and without drilling and cutting ligaments, folds and the tentorium were demonstrated. On 5 dry skulls, important bony structures were also studied.

Results

Cranial nerve I

It arises from olfactory receptor nerve cells, passes through the openings of the cribriform plate of the ethmoid bone to enter the olfactory bulb. Because the nerve is covered superiorly by the frontobasal cortex,

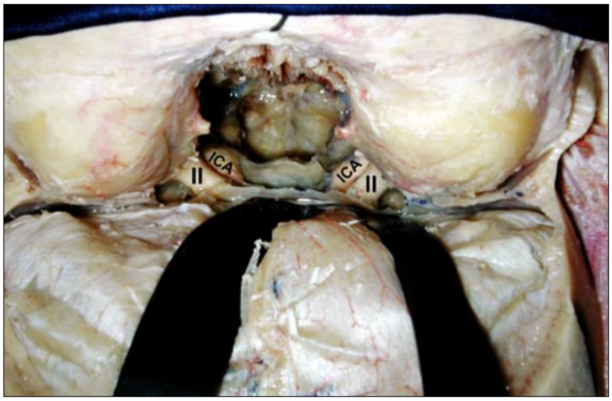

Figure 1. The transbasal approach enables unroofing of both optic nerves (II) and cutting of the falciparum ligaments. If the dura and interhemispheric fissure is opened, the optic chiasm is turned 15 degrees to clockwise and via versa. ***(ICA:** cavernous internal carotid artery)*

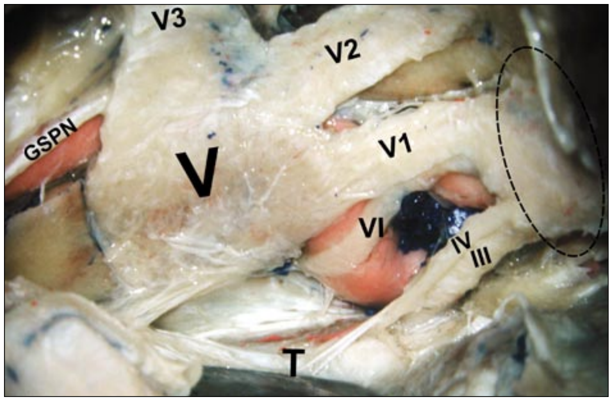

Figure 2. Via a left pterional or orbitofrontozygomatic approaches, opening of the superior orbital fissure (SOF) enables partial mobilization of the cranial nerves III, IV and VI. The encircled area demonstrates the drilled SOF. ***(V1:** ophthalmic nerve, **V2:** maxillary nerve, **V3:** mandibular nerve, **GSPN:** greater superficial petrosal nerve, **T:** tentorium)*

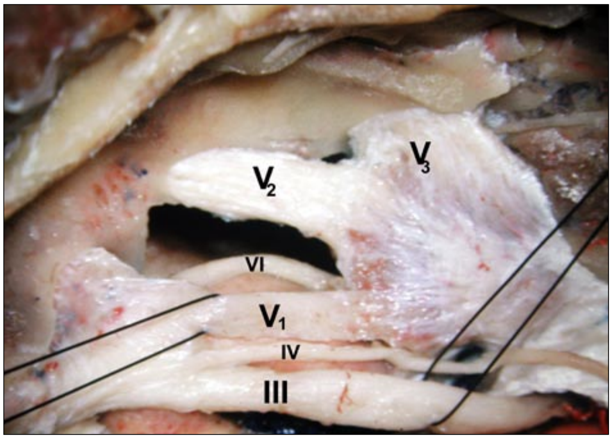

Figure 3. For the mobilization of the cranial nerve VI, the opening of the cavernous sinus subtemporally (right side) should be performed. ***(V1:** ophthalmic nerve, **V2:** maxillary nerve, **V3:** mandibular nerve)*

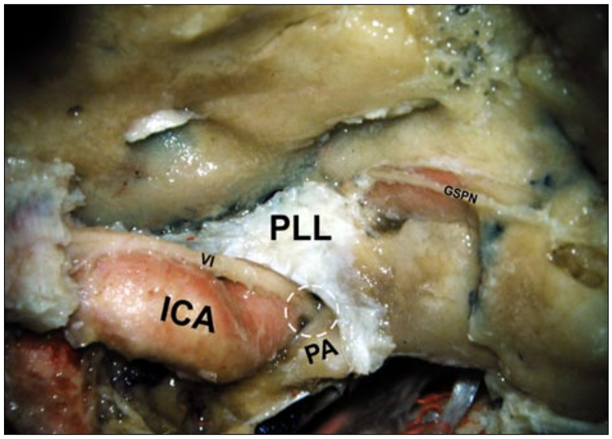

Figure 4. Via a right subtemporal approach, it is demonstrated that the cranial nerve VI leaves the cavernous sinus entering Dorello's canal (dotted line) between the cavernous internal carotid artery (ICA), the petrous apex and the petrolingual ligament (PLL). ***(GSPN:** greater superficial petrosal nerve, **PA:** petrous apex, **P:** pituitary gland)*

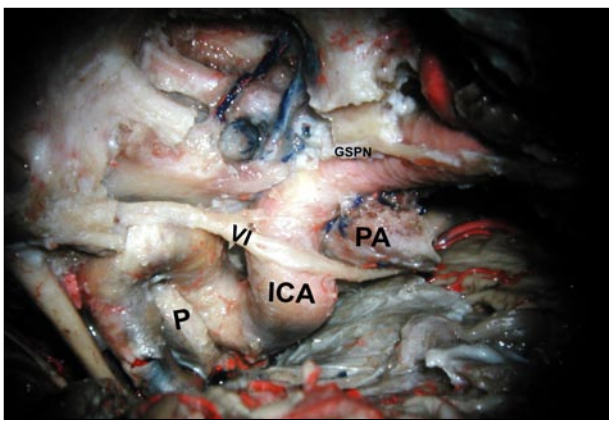

Figure 5. It is difficult to open the Dorello's canal surgically. ***(GSPN:** greater superficial petrosal nerve, **PA:** petrous apex, **P:** pituitary gland, **ICA:** internal carotid artery, **V1:** ophthalmic nerve)*

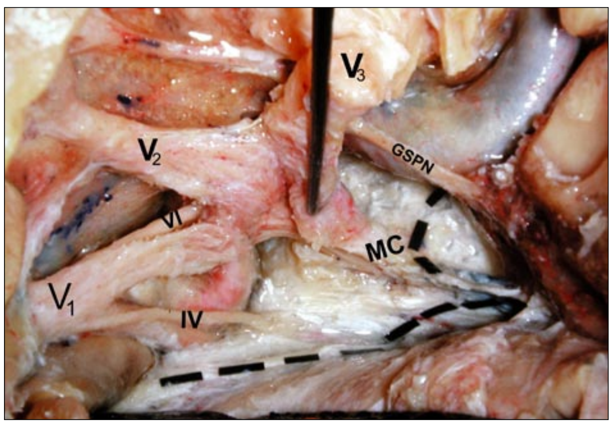

Figure 6. For the mobilization of the trigeminal nerve, the first step is drilling of the foramen ovale, rotundum, and the SOF via the extradural subtemporal approach (right side). To demonstrate the Meckel's Cave (MC), the mandibular division (V3) is cut. The dotted line shows opening of the tentorium. ***(V1:** ophthalmic nerve, **V2:** maxillary nerve, **GSPN:** greater superficial petrosal nerve)*

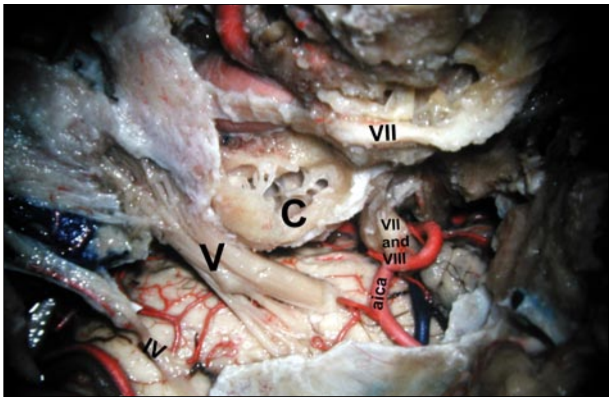

Figure 7. The right subtemporal and transpetrosal approaches demonstrate the trigeminal nerve entering posterior fossa via the opened Meckel's Cave. The labyrinth and the IAC is drilled and the facial nerve (VII) is unroofed. *(**C:** cochlea, **aica:** anterior inferior cerebellar artery, **VIII:** vestibulocochlear nerve)*

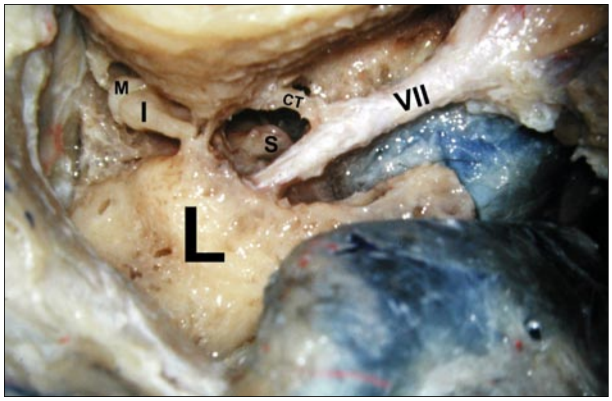

Figure 8. Opening of the stylomastoid foramen and the fallopian canal via right transpetrosal approach enables mobilization of the mastoid and extracranial segments of the facial nerve (VII). *(**L:** labyrinth, **I:** incus, **M:** malleus, **S:** stapes, **CT:** chorda tympani)*

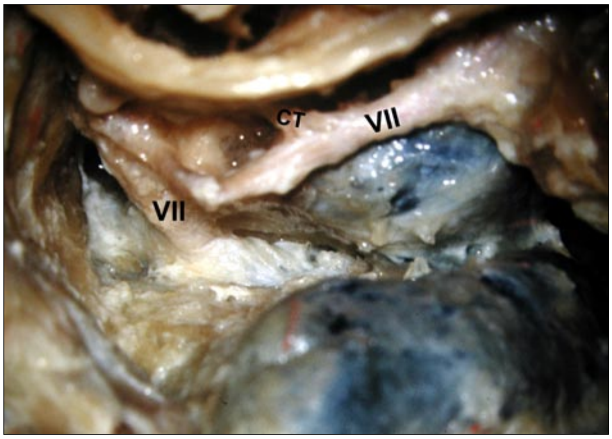

Figure 9. Removal of the labyrinth, incus, malleus and stapes via a right transpetrosal approach may enable the mobilization of the labyrinthine segment with distal part of the facial nerve (VII). *(**CT:** chorda tympani)*

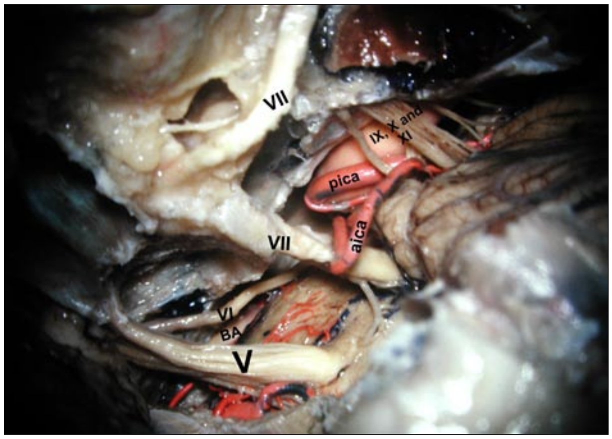

Figure 10. The dissection demonstrates right combined subtemporal, transpetrosal and extreme lateral approaches. The labyrinth and the IAC is drilled and the facial nerve (VII) is unroofed.The jugular foramen should be drilled via the extreme lateral approach. To demostrate the lower cranial nerves, the jugular vein and the jugular bulb is removed. *(**IX:** glossopharyngeal nerve, **X:** vagus nerve, **XI:** accessory nerve, **aica:** anterior inferior cerebellar artery, **pica:** posterior inferior cerebellar artery, **BA:** basilar artery)*

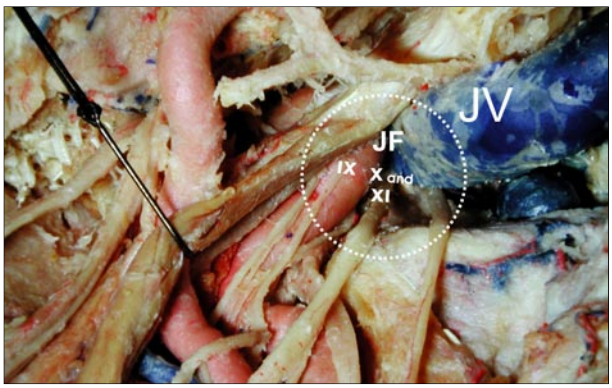

Figure 11. Drilling of the jugular foramen (encircled area) with an additional infratemporal approach (left side) is useful for the extensive mobilization of the IX., X. and XI. cranial nerves. The jugular vein (JV) is cut and mobilized.

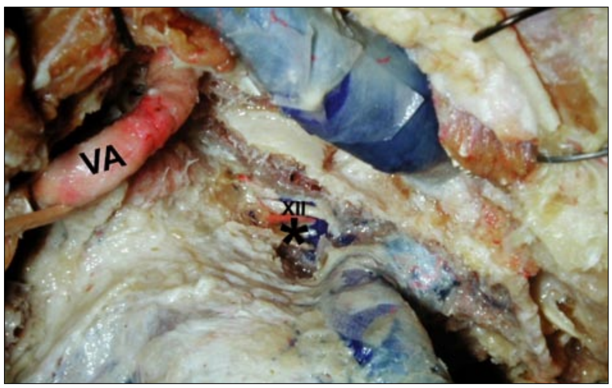

Figure 12. For the exposure of the hypoglossal canal and for the mobilization of the hypoglossal nerve (XII), removal of the jugular tubercle (star) during extreme lateral approach (left side) is extremely important. The condyle is removed and the vertebral artery (VA) is mobilized.

the resection of the parenchymal tissue enables some mobilization of the nerve.

Cranial nerve II

The fibers are coming from the retina. The nerve leaves the orbital cavity through the optic canal and constitutes the optic chiasm with the nerve of the opposite side. Then, the nerve fibers enter the brain parenchyma. Opening of one optic canal and cutting of the falciparum ligament enables minimal mobilization of the nerve on that side, and opening of both optic canals enables to turn the optic chiasm more 15 degrees to clockwise and via versa. With a transbasal approach, both optic nerves are mobilized in some degree (Figure 1).

Cranial nerves III, IV and VI

The fibers of these cranial nerves end in several orbital muscle groups. The superior orbital fissure (SOF) is the bony canal before entering the orbit. Opening of the SOF makes partial mobilization of this nerve complex possible (Figure 2). The attachments and ligaments should be opened. These cranial nerves course in the cavernous sinus (CS) [3]. The distance between the end organ and the brain stem is too short for the III. nerve, therefore anterior and posterior petroclinoid folds should be cut for better mobilization. The IVth nerve follows the edge of the tentorium and leaves it with an increasing angle before entering the brainstem. The tentorium may be cut vertically or horizontally along the IVth nerve. In the CS, the VIth nerve lies below and lateral to the internal carotid artery (ICA). It leaves the CS entering Dorello's canal. Mobilization of the VIth nerve is only possible with opening of the CS (Figure 3), drilling of the petrous apex and cutting of the petrosphenoid and petrolingual ligaments [1]. It is difficult to open the Dorello's canal surgically [4] (Figure 4 and 5).

Cranial nerve V

The trigeminal nerve may be divided into six segments: extracranial, foramino-fissural, preforamino-fissural, gasserian, cisternal and pontine [6]. For the mobilization of the trigeminal nerve, the first step is drilling of the foramen ovale (FO), foramen rotundum (FR), and the SOF (Figure 6). The three divisions constitute the so called 'trigeminal ganglion', or the trigeminal plexus [5,6]. The nerve enters posterior fossa via the Meckel's cave (Figure 7). This space is surrounded by the petrous apex, the tentorium and several dural folds. The petrous apex should be drilled, and the tentorium should be cut.

Cranial nerve VII

The facial nerve is divided into five segments: extracranial, mastoid, labyrinthine, intracanalicular, cisternal. Opening of the stylomastoid foramen and the fallopian canal enables mobilization of the distal part of the facial nerve [2] (Figure 8). Removal of the labyrinth, incus, malleus and stapes may add the labyrinthine segment to mobilized distal facial nerve (Figure 9). At this point, the chorda tympani stabilizes the nerve. The internal acustic canal (IAC) may be drilled via the translabyrinthine and middle fossa approaches, and partially via the retrosigmoid approach. Because the cisternal and intracanalicular segments form an angle of 120 degrees with the labyrinthine, mastoid and extracranial segments, total mobilization of the facial nerve is very difficult in surgical application. The geniculate ganglion also hinders this maneuver.

Cranial nerve VIII

Drilling of the IAC followed by removal of horizontal and vertical crests, and microdissection of superior vestibular, inferior vestibular and cochlear branchs, may permit to move these three components of the VIIIth nerve.

Cranial nerves IX, X and XI

The main bony structure between the pathway of these cranial nerves (between the infratemporal fossa and the medulla) is the jugular foramen. This foramen should be drilled via the extreme lateral approach (Figure 10). The nerves should be dissected from each other. Drilling of the jugular foramen with an additional infratemporal approach was useful for extensive mobilization (Figure 11). These nerves are followed in the infratemporal fossa with blunt dissection.

Cranial nerve XII

Even though opening of the hypoglossal canal makes the manipulation of the XIIth nerve easier, it was not adequate as expected. For the exposure of the hypoglossal canal, removal of the jugular tubercle is extremely important (Figure 12). The nerve is mobilized better with an additional infratemporal fossa approach.

Discussion

In neurosurgical practice, cranial nerve palsies are not rare, especially during removal of intracranial mass lesions. Frequently, the lesion fills the intracranial space and compresses the nerve. Saving of extra space may be performed with removal of the bone, cutting or opening of folds, ligaments and dural attachments. Our study revealed that the mobilization of the nerves II, III, VI, VIII, and XII were not easy comparing to other cranial nerves. Optic chiasm and the eye creates a short optic nerve segment between. Even, the III. nerve is short between the orbit and the brain stem. On the other hand, the Dorello's canal, which is part of the petrous bone cannot be easily drilled during surgery. This point stabilizes the VIth nerve. The deep course of the nerve in the CS close to the cavernous ICA needs meticulous dissection. The VIIIth nerve is very short. Its three divisions may only be dissected with drilling of the IAC, the transverse and vertical crests. The dissection should be performed carefully. Drilling of the jugular tubercle enables slight mobilization of the XIIth nerve. However, the infratemporal fossa dissection should also be performed.

The olfactory nerve may be dissected and the subfrontal parenchymal tissue should be removed. The mobilization of IV, V, VII, IX, X, and XIth cranial nerves were dramatically remarkable after drilling of SOF, FO, FR, fallopian canal and jugular foramen. If freed from the edge of the tentorium, the manipulation of the IV.

nerve is easy. The course of the VIIth nerve through the stylomastoid foramen, the fallopian canal, the chorda tympani, the labyrinth, the geniculate ganglion and the IAC makes the manipulation of the nerve more complex. The necessity for the preservation of hearing allows the mobilization of only the mastoid segment. If the labyrinth is removed, this maneuver may be extended. With opening of the IAC, cisternal and intracanalicular parts of the nerve may be mobilized. The IX, X, and XIth cranial nerves are mobilized with opening of the jugular foramen and dissecting in the infratemporal fossa.

Conclusion

Drilling of related bone structures and cutting of different type of attachments enables the neurosurgeon more extensive mobilization of some cranial nerves. The type and size of the pathological lesion and the capability of the cranial nerves to traction should also be taken into consideration before planning the approach.

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