Dorello Canal Revisited: An Observation that Potentially Explains the Frequency of Abducens Nerve Injury After Head Injury

R. Shane Tubbs[1], Virginia Radcliff[1], Mohammadali M. Shoja[2], Robert P. Naftel[1], Martin M. Mortazavi[1], Anna Zurada[3], Marios Loukas[4], Aaron A. Cohen Gadol[5]

Key words
- Abducens nerve
- Anatomy
- Cranial nerve
- Injury
- Neurosurgery
- Skull base

Abbreviations and Acronyms
PVC: Petrovenous gulf

From the [1]Section of Pediatric Neurosurgery, Children's Hospital, Birmingham, Alabama, USA; [2]Neuroscience Research Center, Tabriz University of Medical Sciences, Tabriz, Iran; [3]Department of Anatomy, Medical Faculty, University of Varmia and Masuria, Olsztyn, Poland; [4]Department of Anatomical Sciences, St. George's University, Grenada, West Indies; and [5]Goodman Campbell Brain and Spine, Department of Neurological Surgery, Indiana University, Indianapolis, Indiana, USA

To whom correspondence should be addressed: Aaron A. Cohen-Gadol, M.D., M.Sc. [E-mail: acohenmd@gmail.com]

Citation: World Neurosurg. (2012) 77, 1:119-121.
DOI: 10.1016/j.wneu.2011.03.046

Journal homepage: ***www.WORLDNEUROSURGERY.org***

Available online: ***www.sciencedirect.com***

■ OBJECTIVE: **The abducens nerve is frequently injured after head trauma and some investigators have attributed this to its long intracranial course. The present study aimed to elucidate an additional mechanism to explain this phenomenon.**

■ METHODS: **Twelve fresh adult cadavers underwent dissection of Dorello canal using standard microsurgical techniques. In addition, traction was applied to the nerve at its entrance into this canal before and after transection of Gruber ligament to observe for movement.**

■ RESULTS: **In all specimens, a secondary tunnel (i.e., tube within a tube) was found within Dorello canal that exclusively contained the abducens nerve. This structure rigidly fixated the abducens nerve as it traversed Dorello canal, thereby not allowing any movement. Transection of Gruber ligament did not detach the nerve, but after release of the inner tube, the nerve was easily mobilized.**

■ CONCLUSIONS: **Rigid tethering of the abducens nerve with a second tube within Dorello canal affords this nerve no ability for movement with motion of the brainstem. We hypothesize that this finding is a main factor in the high incidence of abducens nerve injury after head trauma.**

INTRODUCTION

The abducens nerve travels a long intracranial course, and as a result it is commonly injured after head trauma. The abducens nerve can be divided into five segments: three are intracranial (cisternal, gulfar, and cavernous) and two are orbital (fissural and intraconal) (5).

Along its midway course, the abducens nerve travels in Dorello canal, which has controversy in the literature regarding its boundaries. Dorello (4) and Gruber (7) described the canal as lying between the apex of the petrous bone and the petrosphenoidal ligament (Gruber ligament) (**Figure 1**). Dolenc (3) described the canal as beginning from the entrance of the abducens nerve at the dura covering the clivus to the cavernous sinus. Umansky et al. (15) described the posteromedial wall as consisting of Gruber ligament, yet Destrieux et al. (2) used this ligament as the roof of the canal.

Besides the abducens nerve, and depending on the definition used, the dorsal meningeal artery and inferior petrosal sinus travel in Dorello canal. As an example of how various definitions of this canal can affect what contents are included within its confines, Umansky et al. (15) did not include the inferior petrosal sinus within this space.

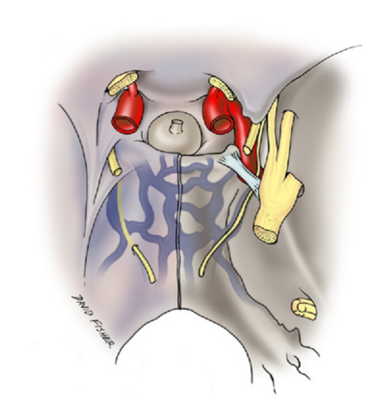

Figure 1. Schematic drawing of the abducens nerve as it travels through Dorello canal. On the left side, the nerve enters the dura (beginning of canal) and travels anteriorly toward the cavernous sinus (end of the canal) by entering inferior to Gruber ligament, seen on the right side of this image.

Because the abducens nerve may become trapped within Dorello canal (10) and is commonly injured after head injury, the present study aimed to further elucidate its arrangement in this region.

MATERIALS AND METHODS

For the present study we chose to define Dorello canal as beginning at the dural entrance of the abducens nerve (i.e., postcisternal or gulfar segment) to its entrance into the cavernous sinus (**Figure 1**). Twelve fresh adult cadavers (24 sides), aged 47–81 years at death (mean 75 years) and latex injected, underwent microsurgical dissection of the skull base at Dorello canal. Seven

compartmentalizing it from the more laterally located inferior petrosal sinus.

DISCUSSION

Cranial nerve entrapment neuropathies may be due to edematous pressure, venous congestion, arterial compression that may respond to microvascular decompression, lymphatic stasis at extracranial exit sites, bony impingement, membranous tension, or ligamentous pull (10).

Ono et al. (11) mentioned briefly that the petroclival segment of the abducens nerve was covered by an envelope composed of an arachnoid cell layer. Destrieux et al. (2) appreciated this arrangement but observed it inconstantly. Tsitsopoulos et al. (14) found such an envelope in all of their specimens and commented that such an envelope isolated the abducens nerve from the inferior petrosal sinus within Dorello canal, and our findings concur with this. Destrieux et al. (2) defined the "petrovenous gulf" (PVC) as a venous space bordered by endothelium and continuous with the cavernous, basilar, and inferior petrosal sinuses. Gruber ligament has been regarded by some investigators as dividing the PVC into superior and inferior compartments with the abducens nerve, generally, traveling through the inferior compartment, where it was fixed to the surrounding dura mater. We found an inner meningeal tube surrounding the abducens nerve within Dorello canal in all specimens. This morphology separated the nervous from venous structures within Dorello canal. Such anatomy is reminiscent of the relationship seen in the jugular foramen with a medial pars nervosa and a lateral pars venosum. In cadavers, Ozveren et al. (12) found an arachnoid membrane on the clivus that extended within the dural sleeve surrounding the abducens nerve as far as the petrous apex. The average length of the dural sleeve, described by them, was 9.5 mm and the average width was 1.5 mm at the apex, where the nerve entered the cavernous sinus. They (12) found that the subarachnoid space inside the dural sleeve of the abducens nerve can be defined by using thin-slice magnetic resonance imaging scans and that enlargement of the dural sleeve at the petroclival region may coexist with abducens nerve palsy.

A dolichoectatic vertebral artery (6, 9) and anterior inferior cerebellar artery (8) have been implicated in isolated abducens nerve palsies, which may be transient. Linn et al. (8) have suggested a neurovascular compression syndrome involving the abducens nerve. Similarly, De Ridder and Menovsky (1) noted intermittent abducens nerve palsy from a dolichoectatic basilar artery that was successfully treated with microvascular decompression. Sandvand et al. (13) reported an adult with right-sided intermittent abducens nerve palsy due to vascular compression of the abducens nerve at its root exit zone by the anterior inferior cerebellar artery. In each of these cases, tethering of the abducens nerve as it enters a separate tunnel within Dorello canal, may contribute to this nerve's sensitivity because there is no "give" from mass effect such as from an ectatic vascular structure.

Based on our findings, abducens nerve compression would not be relieved by simply opening of Dorello canal. In addition, the inner meningeal tube needs to be opened to decompress the nerve. Manipulation of the abducens nerve near the PVC, as described by Destrieux et al. (2), would necessitate opening of the inner meningeal tube.

CONCLUSIONS

Mobility of the abducens nerve within Dorello canal is strictly limited due to the inner meningeal tube surrounding this nerve. This finding may elucidate the mechanism for the frequency of abducens nerve palsy after head trauma. In addition, such information may assist neurosurgeons who operate in or near the cavernous sinus or Dorello canal.

REFERENCES

1. De Ridder D, Menovsky T: Neurovascular compression of the abducent nerve causing abducent palsy treated by microvascular decompression. Case report. J Neurosurg 107:1231-1234, 2007.
2. Destrieux C, Velut S, Kakou MK, Lefrancq T, Arbeille B, Santini JJ: A new concept in Dorello's canal microanatomy: the petroclival venous confluence. J Neurosurg 87:67-72, 1997.
3. Dolenc VV: Anatomy and Surgery of the Cavernous Sinus. New York: Springer-Verlag; 1989, 68-87.
4. Dorello P: Considerazioni sopra la causa della paralisi transitoria dell' abducent nelle flogosi dell' orecchio medio. In: Ferreri G, ed. Atti della Clinica Oto-Rion-Laringoiatrica. Roma: Tipografia del Campidoglio; 1905;209-217.
5. Iaconetta G, Fusco M, Cavallo LM, Cappabianca P, Samii M, Tschabitscher M: The abducens nerve: microanatomic and endoscopic study. Neurosurgery 61:7-14, 2007.
6. Giray S, Pelit A, Kizilklic O, Karatas M: Isolated abducens nerve palsy caused by contralateral vertebral artery dolichoectasia. Neurol India 53:246-247, 2005.
7. Gruber W: Beitrage zur Anatomie des Keilbeins und Schlafenbeins. In: Richter HE, Winter A, eds. Schmidt's Jahrbucher der In-Und Auslandischen. Gesammten Medicin, II, Anatomie und Physiologie. Leipzig: Verlag von Otto Wigard; 1859:40.
8. Linn J, Schwarz F, Reinisch V, Straube A: Ophthalmoplegic migraine with paresis of the sixth nerve: a neurovascular compression syndrome? Cephalalgia 28:667-670, 2008.
9. Lin JY, Lin SY, Wu JI, Wang IH: Optic neuropathy and sixth cranial nerve palsy caused by compression from a dolichoectatic basilar artery. J Neuroophthalmol 26:190-191, 2006.
10. Magoun HI: Entrapment neuropathy of the central nervous system. Part II. Cranial nerves I-IV, VI-VII, XII. J Am Osteopath Assoc 67:779-787, 1968.
11. Ono K, Arai H, Endo T, Tsunoda A, Sato K, Sakai T, Makita J: Detailed MR imaging anatomy of the abducent nerve: evagination of CSF into Dorello canal. AJNR Am J Neuroradiol 25:623-626, 2004.
12. Ozveren MF, Erol FS, Alkan A, Kocak A, Onal C, Türe U: Microanatomical architecture of Dorello's canal and its clinical implications. Neurosurgery 60: ONS1-7, 2007.
13. Sandvand KA, Ringstad G, Kerty E: Periodic abducens nerve palsy in adults caused by neurovascular compression. J Neurol Neurosurg Psychiatry 79: 100-102, 2008.
14. Tsitsopoulos PD, Tsonidis CA, Petsas GP, Pantelis NH, Ndungu Njau S, Anagnostopoulos IV: Microsurgical study of the Dorello's canal. Skull Base Surgery 6:181-185, 1996.
15. Umansky F, Elidan J, Valarezo A: Dorello's canal: a microanatomic study. J Neurosurg 75:294-298, 1991.

Conflict of interest statement: The authors declare that the article content was composed in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

received January 10, 2011; accepted March 30, 2011

Citation: World Neurosurg. (2012) 77, 1:119-121.
DOI: 10.1016/j.wneu.2011.03.046

Journal homepage: ***www.WORLDNEUROSURGERY.org***

Available online: ***www.sciencedirect.com***