Dorello's Canal and Gruber's Ligament: Historical Perspective

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Abstract

Wenzel Leopold Gruber and Primo Dorello were great anatomists and researchers during the 19th and 20th centuries. Their contributions to neuroanatomy—namely the Gruber's (petrosphenoidal) ligament and Dorello's canal, respectively—have come to be important structures in various approaches through the middle fossa. These structures have also helped provide us with an understanding of the mechanism of sixth nerve paresis in various pathological conditions, such as raised intracranial pressure and Gradenigo syndrome. Their numerous publications have stood as a reference to anatomical researchers. Gruber's description of internal mesogastric hernia and the Meckel-Gruber anastomosis are also widely known in medical literature. The following article is an attempt to reflect upon the life and works of Gruber and Dorello and the importance of their research.

Keywords

- Dorello
- Gruber
- petrosphenoidal ligament
- abducens nerve

Introduction

The anatomical relationships of abducens nerve in the petroclival region are of clinical interest, as the nerve is relatively fixed in this region and so is affected by a variety of pathological processes. Petrous apicitis, herniation syndromes, compression by a tumor, aneurysm, and trauma can affect this area and cause paresis of the nerve. Sixth nerve paresis is also one of the false localizing signs in neurology, indicating raised intracranial pressure. Dorello's canal is the invagination of the dura in the petroclival region from the petroclival entrance point to the posterior end of cavernous sinus. The first description of the canal at the apex of the petrous bone was by Wenzel Leopold Gruber in 1859.¹ The anatomical relationship of structures within the canal was described in 1905 by Primo Dorello, an Italian anatomist.² The first description of Dorello's anatomical observations in English literature was by Vail in 1922.³

Wenzel (Weneslaus) Leopold Gruber

Wenzel Gruber (►Fig. 1) was a Russian anatomist, born on December 24, 1814, at Castle Krukanitz in Bohemia, Czech

Republic.⁴ In his childhood, he attended a spiritual institution in Marienbad. Later, he went on to study at the University of Prague and received his doctorate in 1842 and medical degree in 1844. He was a prosector of normal anatomy at the University of Prague under the leadership of Joseph Hyrtl and Vincenz Alexander Bochdalek between 1842 and 1846. In 1847, under the influence of Nikolai Ivanovich Pirogov, he became the first prosector of normal and pathological anatomy at the medical academy in St. Petersburg. The department was headed then by Pirogov. Gruber became the chair of pathological anatomy in 1855 and rose to the position of professor in 1858. He remained in this position until his retirement in 1882. It was during this period, in 1859, that he described the petrosphenoidal ligament and the petrosphenoidal canal.¹ He is also credited with the description of internal mesogastric hernia, which came to be known as Gruber's hernia and the Meckel-Gruber anastomosis, which is a neural connection between the median and ulnar nerves in the forearm. He also contributed to the establishment of the anatomical and physiological institute and museum at St. Petersburg. He was a voracious writer and published over 500 anatomical works, notable of which were *Beiträge zur*

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Fig. 1 Wenzel Leopold Gruber (1814–1890).

Anatomie des Keilbeins und Schläfenbeins (–**Fig. 2**), *Anatomia Monstri bicorporei*, and *Oesterreichische Zeitschrift für praktische Heilkunde*. Gruber died on September 30, 1890, in Vienna.

Primo Dorello

Born in 1872 in Narni, Italy, Dorello (–**Fig. 3**) obtained his degree in medicine and surgery from the University of Rome in 1897. He then worked in the department of human anatomy as an assistant until 1922 when he moved to Sassari, Italy as professor of human anatomy. He was promoted to the chair of human anatomy at Perugia in 1926. During this period, from 1939 till his retirement in 1946, he also served as the dean of medicine and surgery. He was the president of the seventh congress of Italian Society of Anatomy and Histology held in Perugia in 1937. He published around 83 scientific publications in topics related to anatomy, notable of which were *Le ossa del Perugino* and *Una necropoli Umbra entro la città di Narni*. He was also an active member of the Academy of Surgical Anatomy of Perugia, Medical Academy of Rome, and the Italian Academy of Experimental Biology. Apart from being a great anatomist and researcher, he had great interest in photography and anthropology.⁵

Discovery of the Canal

The history leading to the discovery of the Dorello's canal is interesting. In 1859, Gruber W. described the presence of an

Fig. 2 Book published by Gruber describing the petrosphenoidal ligament and foramen petrosphenoidum.

Fig. 3 Primo Dorello (1872–1963).

Fig. 4 Article published by Dorello describing the canal and course of abducens nerve.

osteofibrous canal at the apex of the petrous bone, which he called the “foramen petrosphenoidum.”¹ In his book he stated that under the “ligament petrosphenoidum” is an osteofibrous “foramen petrosphenoidum” through which the abducens nerve passes.¹ This foramen measured 6 to 12 mm in length and 1 to 3 mm in width and contained the inferior petrosal sinus and sixth cranial nerve. His observations were not acknowledged until Giuseppe Gradenigo, an Italian otologist, in 1904, described a syndrome related to infection and inflammation of the apex of petrous temporal bone.⁶ The triad consists of acute or chronic suppuration of the ear, paralysis of the ipsilateral sixth cranial nerve and ipsilateral trigeminal neuralgia. There followed numerous hypotheses regarding the involvement of the sixth cranial nerve.⁵ Dorello, not convinced by the mechanism of abducens nerve involvement, decided to investigate himself and performed cadaver dissections on the course of the sixth cranial nerve. He described a narrowing of inferior petrous sulcus at the tip of petrous temporal bone. This narrowing was transformed into a canal by the sphenopetrosal ligament. This canal, which contains inferior the petrosal sinus and sixth

cranial nerve, is, according to Dorello, the only area where the abducent nerve might be compressed by an inflammatory process. He also published his observations in the article entitled “Considerazioni sopra la causa della paralisi transitoria dell'abducente nelle flogosi dell'orecchio medio” (►Fig. 4) in 1905.² The same observations were arrived at independently later by Baldenweck⁷ and Baratoux.⁸ After an illustrious career as a researcher and anatomist, Dorello died in 1963.

Microanatomical Studies of Dorello's Canal and Gruber's Ligament

Since the description of its anatomy by Dorello in 1905, numerous researchers have conducted studies on the microanatomical relationships of the sixth nerve in this area. Vail,³ in his own anatomical dissections, observed that within the canal, the abducens nerve was lateral to the meningeal artery and inferior to the inferior petrosal sinus. Nathan et al⁹ described three patterns of the course of the abducens nerve before it enters the cavernous sinus. In a majority of cases (86.5%), the nerve originates as a single trunk and runs all its way as a single trunk. In about equal number of the rest of the cases, the nerve either originates as a single trunk and splits into two branches in the subarachnoid space, or it originates as two separate trunks. In both of these situations, Nathan observed that the nerve trunks perforate the dura independently and enter the cavernous sinus by passing one above and other below the petrosphenoidal ligament. Arias described two points of fixation in the course of abducens nerve, one at its entrance and another at its exit from the extradural space.¹⁰ Umansky et al¹¹ proposed that the main point of fixation of the sixth nerve is inside Dorello's canal and that the adhesions between the dural sheath of the nerve, the endosteal dura of the petrous apex and the petrosphenoidal ligament cause the nerve to angulate while on its way to the superior orbital fissure, and that this can lead to compression and stretching of the nerve in various pathological processes. They also observed that the inferior petrosal sinus opened in close proximity to the canal, but never within the canal.

Ozveren et al,¹² in an anatomical study in cadaver heads, observed that the canal is lined by an outer layer of dural sleeve and an inner arachnoid layer. The dural sleeve extends from the entrance of the canal to the posterior portion of cavernous sinus at the level of the petrosphenoidal ligament, and the arachnoid layer winds around the nerve till the end of the canal. The arachnoid around the nerve is also continuous with the arachnoid forming the anterior wall of the prepontine cistern. The point at which the nerve enters the canal was referred to as the *dural foramen* by Fukushima et al.¹³ Desrieux et al¹⁴ used the term *petroclival space* to describe the area through which the abducens nerve courses from the entry of the nerve into the petroclival dura to its entry into the cavernous sinus. This space is located between the two dural layers and is filled with blood from which the nerve is separated only by an arachnoidal sheath.

The petrosphenoidal ligament (Gruber's ligament) extends from the petrous apex to the posterior clinoid process

and forms the roof of Dorello's canal through which the abducens nerve passes. It forms the superior portion of the falciform ligament and is located at the confluence of the basilar plexus, cavernous sinus, inferior petrosal sinus, and sphenoparietal sinus. The petrolingual ligament forms the inferior portion of falciform ligament and covers the lateral segment of internal carotid artery. The length of the ligament has been reported to be between 13.2 and 13.9 mm in various studies.^{12,15–17} Destrieux et al¹⁴ and Icke et al¹⁶ described the ligament as either butterfly shaped or triangular, with the base inserting on the posterior clinoid process. However, Iaconetta et al¹⁵ and Liu et al¹⁷ found the base attached to the petrous apex. The ligament has been found to be either complete, fragmented, or hypoplastic. Hypoplastic ligament occurred up to 10% in the study by Liu et al, 3% in the study by Iaconetta et al,¹⁵ and 5% by Icke et al.¹⁶ Calcification of the ligament was also noted in 5% of the specimens in the study by Icke et al.¹⁶ The petrosphenoidal ligament functions to fix the sheath of the abducens nerve in the petroclival area. It protects the abducens nerve from damage during petrous drilling for anterior petrosectomy and serves as a landmark for the abducens nerve during surgery.¹²

Conclusion

Anatomy of the petroclival area is of prime importance when dealing with lesions in this region. The article has provided an overview of historical background of two of the greatest anatomists.

References

- 1 Gruber WL. Beiträge zur Anatomie des Keilbeins und Schlafenbeins. Leipzig: Verlag Von Otto Wigand; 1859
- 2 Dorello P. Considerazioni sopra la causa della paralisi transitoria dell'abducente nelle flogosi dell'orecchio medio. Atti della Clinica Oto-Rino-Laringoiatrica della R. Università di Roma; 1905
- 3 Vail HH. Anatomical studies of Dorello's Canal. Laryngoscope 1922;32(8):569–575
- 4 Matousek O. [Anatomist Wenzel Gruber]. Cas Lek Cesk 1952; 91(35):1023
- 5 Felisati D, Sperati G. Gradenigo's syndrome and Dorello's canal. Acta Otorhinolaryngol Ital 2009;29(3):169–172
- 6 Gradenigo G. Über circumscribte Leptomenigitis mit spinalen Symptomen und über Paralyse des N. abducens otitischen Ursprungs. Arch Ohrenheilk. 1904;62:255–270
- 7 Baldenweck L. Recherches anatomiques sur la pointe de rocher. In: Lermoyez M, et al. Annales des Maladies de l'Oreille, du Larynx du Nez et du Pharynx. Paris: Masson & Cie; 1907:33–122
- 8 Baratoux J. La paralysie du moteur oculaire externe au cours des otites. Archives Internationales de Laryngologie, d'Otologie et de Rhinologie 1907:XXIII
- 9 Nathan H, Ouaknine G, Kosary IZ. The abducens nerve. Anatomical variations in its course. J Neurosurg 1974;41(5):561–566
- 10 Arias MJ. Bilateral traumatic abducens nerve palsy without skull fracture and with cervical spine fracture: case report and review of the literature. Neurosurgery 1985;16(2):232–234
- 11 Umansky F, Valarezo A, Elidan J. The microsurgical anatomy of the abducens nerve in its intracranial course. Laryngoscope 1992;102(11):1285–1292
- 12 Ozveren MF, Erol FS, Alkan A, Kocak A, Onal C, Türe U. Microanatomical architecture of Dorello's canal and its clinical implications. Neurosurgery 2007;60(2, Suppl 1):ONS1–ONS7, discussion ONS7–ONS8
- 13 Fukushima T, Day JD, Hirahara K. Extradural total petrous apex resection with trigeminal translocation for improved exposure of the posterior cavernous sinus and petroclival region. Skull Base Surg 1996;6(2):95–103
- 14 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 1997;87(1):67–72
- 15 Iaconetta G, Fusco M, Cavallo LM, Cappabianca P, Samii M, Tschabitscher M. The abducens nerve: microanatomic and endoscopic study. Neurosurgery 2007;61(3, Suppl):7–14, discussion 14
- 16 Icke C, Ozer E, Arda N. Microanatomical characteristics of the petrosphenoidal ligament of Gruber. Turk Neurosurg 2010; 20(3):323–327
- 17 Liu XD, Xu QW, Che XM, Mao RL. Anatomy of the petrosphenoidal and petrolingual ligaments at the petrous apex. Clin Anat 2009; 22(3):302–306