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Ossification of the petrosphenoid ligament — a case study

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Abstract: The current study presents a case in which a human skull revealed a partially ossified petrosphenoid ligament. The ossified ligament appears as a hooked bony trabecula emerging below the right posterior clinoid process. Another bony trabecula arises from the petrous apex and runs towards the clivus. Both trabecula face each other but do not fuse, having a small gap between their tips. Their positions clearly indicate that they must have formed an overhang above the abducens nerve. Therefore, they should be considered a part of the walls of Dorello's canal, which is a conduit for the abducens nerve and associated vascular structures.

Key words: posterior clinoid process, petrous bone, sphenoid bone, petrosphenoid ligament.

Introduction

The petrosphenoid ligament, also known as the superior sphenopetrosal ligament or Grüber's ligament, appears as a fibrous trabecula consisting of dense collagen fibers which are stretched between the petrous apex (a spine usually located on the superior border of the petrous apex) and the posterior clinoid process or attached below this process to the lateral border of the dorsum sellae and the clivus [1, 2]. The length of the petrosphenoid ligament may vary from 8–14 mm and its average width measured at the midsection ranges from 1–2 mm. Dorello's canal, located below the petrosphenoid ligament, is a narrow (5–6 mm wide and 1–2 mm high) osteofibrous passage formed by a depression near the tip of the petrous bone [3–10]. The petrosphenoid ligament forms the roof of Dorello's canal through which the abducens nerve passes together with the dorsal meningeal artery (from the meningohypophyseal trunk) and the inferior petrous sinus. Inside the canal the abducens nerve occupies the lateral position, the meningeal artery lies medially, and the inferior petrosal sinus usually overlays the abducens nerve [11, 12]. Rarely, the abducens nerve may run outside Dorello's canal [13].

In some cases the petrosphenoid ligament may ossify and form a bony bridge connecting the apex of the petrous bone with the sphenoid bone. Up to date, the petrosphenoid ligament has been found as complete, fragmented, or hypoplastic with frequencies varying from a few percent up to 10% [4–6]. In such cases, there is an increased risk of injury to the abducens nerve in the petroclival region. Thereby, the topographical relationship between the abducens nerve, dura mater and bones are of clinical interest considering the course of the abducens nerve and its important role in innervation of the lateral rectus muscle engaged in movement of the eye.

The abducens nerve is relatively long (five segments: three intracranial — cisternal, gulfar, cavernous, and two orbital — fissural, intraconal) and is therefore vulnerable to mechanical failure and palsy which may lead to its malfunction [4]. Lesions of the abducens nerve may occur in the brainstem, subarachnoid space, petroclival region [14, 15], cavernous sinus and orbit [16]. These lesions may result from trauma, mass effect, insufficient vascular blood supply and infections [17–21]. In turn, Özveren *et al.* [3] suggested that enlargement of the dural sleeve at the petroclival region may coexist with abducens nerve palsy. When the petrosphenoid ligament is ossified the abducens nerve may be fixed inside Dorello's canal and this condition can increase vulnerability of the nerve in situations of increased intracranial pressure [7]. According to Umansky *et al.* [19], brainstem shifting may result in compression and stretching of the abducens nerve within Dorello's canal. Tubs *et al.* [22] mentioned that the mobility of the abducens nerve within Dorello's canal is strictly limited due to the inner meningeal tube surrounding this nerve.

Anatomical literature presents various examples of inconstant bony prominences or processes located in the petroclival region, as well as consideration of their potential influences on nearby neurovascular structures. Morphometrical analysis and descriptive characteristics of such structures deepen our knowledge on anatomical variation of the cranial base and its usage in the neurosurgical procedures. These circumstances were the inspiration to perform the current study and describe another presentation of an ossified petrosphenoid ligament found in the human skull.

Materials and methods

After dissection of the calvaria of one of the human skulls housed in the Department of Anatomy of the Medical College of the Jagiellonian University, we observed a bony bridge extending from the clivus towards the petrous apex. The skull is not complete because only the braincase was preserved. Both the cranial base and the calvaria show normal morphology and lack of any deformations. Anatomical structures observed on the external and internal aspect of the cranial base are properly developed and clearly pronounced. According to anthropological procedures allowing for estimation of sex and age at the time of death, we established that it was the skull of a woman, approximately 50–55 years old.

Visual inspection of the parasellar and petroclival regions was performed using a magnifying glass and stereo microscope (Motic SMZ-168). We applied the following magnification: eyepieces at 10x and zoom set to 1x with a standard objective. To provide optimal visibility of the studied structures we used a combination of halogen and LED illumination (lateral and top light). Linear measurements of the investigated osseous trabecula and petrous apex were performed using an ocular micrometer equipped with a ruled scale in millimeters. Photographs documenting the abnormally ossified structures in the petroclival region were taken using a digital camera (Canon EOS 5D).

Results

Visual inspection of the middle cranial fossa revealed a partially ossified petrosphenoid ligament on the right side of the skull. It appeared as a hooked bony trabecula emerging from the lateral margin of the clivus and below the posterior clinoid process. Another bony trabecula arose from the petrous apex and ran towards the clivus. Both trabeculae faced each other but did not fuse, therefore in the middle part of the supposed petrosphenoid ligament was a small gap. The position of the bony trabecula clearly indicates that it must have hanged over the abducens nerve. Therefore, this osseous trabecula should be considered as a part of the roof of Dorello's canal which is normally a conduit for abducens nerve as it runs towards the superior orbital fissure. The superior part of the petrous apex arises towards the above mentioned bony trabeculae. This part of the petrous apex might have served as an insertion of the petrosphenoid fold of the dura matter which apparently ossified and formed a narrow, flat, osseous lamina emerging anteriorly from the trigeminal impression for the ganglion of the trigeminal nerve. The appearance and location of the ossified parts of the petrosphenoid ligament are shown in Fig. 1. Measurements of the osseous trabeculae forming the almost complete petrosphenoid bridge (having just a small gap in the midle) are presented in Fig. 2.

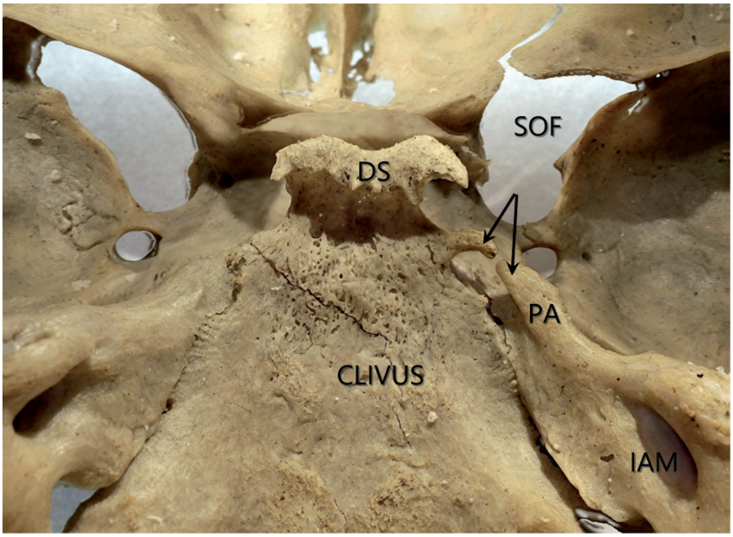

Fig. 1. Superior view of the middle cranial fossa showing the ossified petrosphenoid ligament represented by the bony spike emerging from the clivus, below the dorsum sellae of the sphenoid bone and towards the petrous apex (indicated by arrows). DS — dorsum sellae, PA — petrous apex, SOF — superior orbital fissure, IAM — internal acoustic meatus.

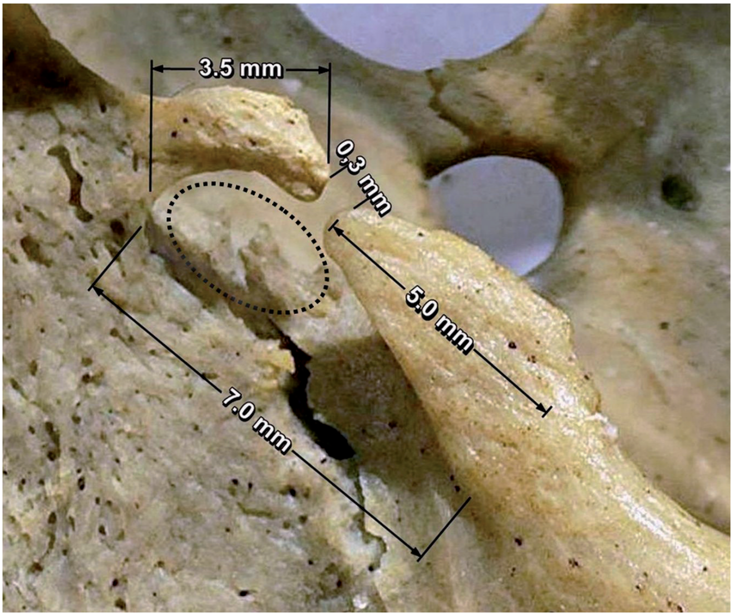

Fig. 2. Measurements of the bony bridge (ossified petrosphenoid ligament) passing above Dorello's canal (marked by the dotted ellipse as the petrosphenoidal foramen whose diameters were measured as 2.5 × 3.0 mm).

Discussion

The parasellar and petroclival regions were the scope of anatomical and clinical studies conducted on dry human skulls, cadaveric heads and living patients. Therefore, various investigating techniques (dissecting, radiological imaging) were applied to assess morphology of the dural folds and collagenous bends surrounding or crossing the nerves and blood vessels running across the cranial base. Numerous observations of the interior of the cranial base delivered evidence on abnormal ossifications which occur within the folds of the dura mater and collagen fibers stretched between various processes of the cranial bones. Such inconstant osseous bridges were found both on the external and internal aspects of the cranial base. On the exocranial surface, they were found between the pterygoid process and the sphenoid spine as the result of complete or partial ossification of the pterygospinous or pterygoalar ligaments [23–26].

Endocranially, osseous bridges were formed between the anterior and posterior clinoid processes (ossification of the interclinoid ligament) and between the anterior and middle clinoid process ossification of the caroticoclinoid ligament) [27–33].

Deposits of calcium and heterotopic bone formation were also noted within the folds of the dura mater, and spanned between the posterior clinoid process, dorsum sellae, clivus and the petrous bone.

Petrosphenoid ligament calcification was described as both partial and complete. Inal *et al.* [34] found partial calcifications of the petrosphenoid ligament on the right side in 9.8% of cases and complete calcifications in 2.3%. On the left side, partial calcifications were noted with similar frequency (9.8% and 2.9%). According to Inal *et al.* [34] there was no significant difference between petrosphenoid ligament calcification in males and females on the right and left sides.

A relatively small number of calcified petrosphenoid ligaments was reported by Icke *et al.* [5] who found it in 2 of 40 cases (5%) and Destrieux *et al.* [35] who examined 16 human cadaver heads and found only one calcified petrosphenoid ligament.

Apart from calcification of the petrosphenoid ligament, ossification of this ligament is also described in the literature. A microsurgical study performed by Tsitsopulos *et al.* [7] revealed that the petrosphenoid ligament was ossified in 10% of cases. Ozgur and Esen [36] examined 523 heads by computed tomography and found 61 ossified petrosphenoid ligaments (31 unilateral; 15 bilateral) which occurred on the right side (6.5%) and on the left side (5.1%). They recognized that 38 ligaments (3.6%) were partially ossified, whereas 23 ligaments (2.2%) were completely ossified.

Completely ossified petrosphenoid ligaments may reveal variable morphological appearance. Usually they are described as solid bony bridges or trabeculae. However, in some cases, ossified forms of this ligament reveal a suture-like appearance in the midpoint [36]. Nevertheless, they appear as an uninterrupted bony bridge, in contrast to ruptured forms being the effect of partial ossification. Such a partially ossified petrosphenoid ligament is composed of two separate bony processes having a gap in between. Results of our observations remain in accordance with descriptions of incomplete ossification of the dural bends forming the petrosphenoid ligament. In our study we exposed the natural appearance of the unilateral partial ossification of the petrosphenoid ligament because it was investigated directly on a sectioned dry skull. In the literature, ossified petrosphenoid ligaments are presented in radiological images or as the three-dimensional reconstructions obtained from CT-scans. Description of topographical relationships between osseous and neurovascular structures, as well as knowledge on their morphological variation, is necessary in neurosurgery. Therefore, structures like the petrosphenoid ligament are still the center of attention, despite the fact that they have been a subject of numerous studies originating from as early as the XIX century.

Conclusions

Anatomical studies concerning the coexistence of the petrosphenoid ligament, Dorello's canal and abducens nerve can deliver essential information about topographical relationships between the osseous, fibrous and nervous structures in the petroclival region. Understanding of the interplay between Dorello's canal and abducens nerve is particularly important when the petrosphenoid ligaments ossifies and may become a cause of abducens nerve palsy.

Conflicts of interest

None declared.

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