The relationship between the superior petrosal sinus and the porus trigeminus: an anatomical study

Laboratory investigation

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Object. During intracranial approaches to the skull base, vascular relationships are important. One relationship that has received scant attention in the literature is that between the superior petrosal sinus (SPS) and the opening of the Meckel cave (that is, the porus trigeminus).

Methods. Cadaver dissections were performed in 25 latex-injected adult cadaveric heads (50 sides). Specifically, the relationship between the SPS and the opening of the Meckel cave was observed. The goal was to enhance knowledge of the relationship between the SPS and the opening of the Meckel cave.

Results. Of the 50 sides, 68%, 18%, and 16% of SPSs traveled superior to, inferior to, and around the opening to the Meckel cave, respectively. In the latter cases, a venous ring was formed around the proximal trigeminal nerve. No sinus entered the Meckel cave. In general, the porus trigeminus was narrowed on sides found to have an SPS that encircled this region. Sinuses that traveled only inferior to the porus were in general smaller than sinuses that traveled superior or encircled this opening. No statistically significant differences were noted between the various sinus relationships and sex, age, or side of the head.

Conclusions. Knowledge of the relationship between the SPS and the opening of the Meckel cave may be useful to the skull base surgeon. Based on this study, some individuals may retain the early embryonic position of their SPS in relation to the trigeminal nerve. (http://thejns.org/doi/abs/10.3171/2013.4.JNS122062)

Key Words • anatomy • skull base • superior petrosal sinus • neurosurgery • cadaver dissection

The SPS is a small, narrow venous channel located at the junction between the middle and posterior cranial fossae. It is adjacent to many important intracranial structures, and its vicinity to these structures makes it an important landmark for surgical approaches to the skull base. It originates in the CS and passes dorsolaterally to drain into the transverse-sigmoid junction. The sinus runs in the superior petrosal sulcus and begins from the postero-lateral base of the petrous ridge and travels at an anterome-

dial angle toward its apex, and is usually larger posteriorly and becomes smaller near its apex.23 This sinus travels in the attached margin of the tentorium cerebelli26 and receives drainage from the cerebellum, the inferior cerebral veins, and the veins of the tympanic cavity.20,31

Since knowledge of such regional anatomy is important to the neurosurgeon, and the relationship of the SPS to the Meckel cave has not been stressed in the literature, the current study was undertaken.

Abbreviations used in this paper: CS = cavernous sinus; SPS = superior petrosal sinus.
Methods

Cadaver dissections were performed in 25 formalin-fixed latex-injected adult cadaveric heads (14 male and 11 female specimens) with a mean age at death of 73 years (range 39–90 years). Specifically, the relationship between the SPS and the opening of the Meckel cave was observed. Measurements of the SPS were made at this location with the aid of digital calipers. Statistical analysis was performed using Statistica for Windows, with significance set at p < 0.05.

Results

Of the 50 sides, 68%, 18%, and 16% of SPSs traveled superior to, inferior to, and around the opening to the Meckel cave (Figs. 1–4). In the latter cases, a venous ring was formed around the proximal trigeminal nerve. No sinus entered the Meckel cave. In general, the porus trigeminus was narrower on the sides found to have an SPS that encircled this region. Sinuses that traveled only inferior to the porus were smaller in general than sinuses that traveled superior or encircled this opening. No petrosal vein was found to empty into SPSs that were located below the Meckel cave. The mean diameter of the SPS at the level of the trigeminal nerve and when located above the Meckel cave was 2.1 mm; when located below it was 1.8 mm; and when found above and below it was 1.5 and 1.2 mm, respectively. No statistically significant differences were noted between the various sinus relationships and sex, age, or side of the head. No intracranial pathology was observed in any specimen.

Discussion

Embryonic Position of the SPS

The SPS is the last of the major adult sinuses to be formed and is derived from the metencephalic vein, which relates to the early development of the cerebellum. The SPS begins to appear in Stage 2 of development (14-mm embryo). At this point, the SPS rests between the trigeminal ganglion and the oculomotor and trochlear nerves. The more significant start of the development of the SPS occurs during Stage 3 (embryo 16–18 mm long). This stage is distinct because there is a sudden appearance of a large supraotic anastomosis, or cross-connection networking, linking the prootic and posterior rhombencephalic veins (Fig. 5). This new channel together with the terminal part of the posterior rhombencephalic veins forms the sigmoid sinus. At this stage, the SPS lies in the cavum epipircericum close to the anterior layer of dura mater forming the tentorium cerebelli. Its
Porus trigeminus and superior petrosal sinus

role is to act as an anteriorly directed branch of the main prootic vein joining either the peritrigeminal vein or the termination of the anterior cerebral vein. At Stage 6 (90 mm long and approximately 60 days old), the SPS runs along the upper margin of the otic capsule and then above the trigeminal ganglion in the roof of the Meckel cave. As it joins the CS it lies above the trigeminal ganglion and above the oculomotor and trochlear nerves.

The overall developmental process that occurs during this stage is as follows: the oculomotor and trochlear nerves and the SPS are close to the anterior dural fold and well in front of the otic capsule, from which they are separated by the trigeminal ganglion. As the temporal lobe expands and excavates the middle cranial fossa, it presses the anterior tentorial layer backward. This presses the oculomotor and trochlear nerves, the trigeminal ganglion, and the SPS toward the otic capsule. This causes the nerves and the sinus to achieve their adult positions. Because of this, the SPS runs above the trigeminal ganglion and below the oculomotor and trochlear nerves. The expanded CS now protrudes toward the trigeminal ganglion and receives the SPS. The connection of the SPS with the CS is a comparatively late event and, as shown in our study, is not constant.

Sinus-to-Nerve Relationships

In 1934, Coates conducted a study to clarify the relationship between the SPS and the sensory root of the trigeminal nerve. In 8 of the cases, both the right and left sinuses passed over the cranial surface of the trigeminal nerve. In 3 cases, the left and right sinus passed under the nerve. Finally, in 3 cases, the sinus divided lateral to the root, meaning that a portion passed over the root and a portion passed under the root. These divisions were re-united at the CS. In the present study, we found that 68%, 18%, and 16% of SPSs traveled superior to, inferior to, and around the opening to the Meckel cave.

Endovascular Treatment and Surgery

Even though the SPS may not always be seen on angiograms, it can be obliterated with detachable coils, from distal to proximal. Endovascular therapy is often necessary to manage effectively the pathological entities involving this sinus, such as dural arteriovenous fistulas.

The venous anatomy of the skull base and its variations are important in approaches to this region. Dolenc classified the CS region through the depiction of 10 triangles. The inferolateral triangle was defined as lines connecting the dural entry point of the trochlear nerve, the dural entry point of the abducent nerve, and the entry point of the petrosal vein into the SPS. The SPS also forms the superior boundary of the Trautmann triangle, which is used for posterior petrosectomy approaches, and the medial border of the Kawase triangle (rhomboid; posteromedial triangle), which is used for anterior petrosectomy.

Approaches around the Meckel cave have been based on petrosal vein drainage types. Tanriover et al. classified the drainage types of the petrosal vein. Type I com-
plexes called for a subtemporal transtentorial approach, with or without anterior extradural petrosectomy, because the petrosal vein drained into the SPS posteriorly and near the porus acusticus. In Types II and III, the petrosal vein drained into the SPS near the Meckel cave, making the working space in a subtemporal transtentorial approach smaller, and making alternative approaches such as a retrosigmoid suprameatal approach more desirable. A detailed preoperative MR venogram or a venous-phase CT angiogram demonstrating the site of entry of the superior petrosal venous complex into the SPS might be helpful in assessing the unique drainage patterns prior to subtemporal transtentorial and retrosigmoid suprameatal approaches. Interestingly, such classifications have not taken into consideration the position of the SPS relative to the Meckel cave. If the sinus were in an inferior position in relation to the trigeminal nerve, drainage of regional veins might take a variable route into this sinus. Therefore, tumors or arteriovenous malformations of this specific area may have drainage that is considered uncommon.

Because we appreciated an overall narrowing of the porus trigeminus in our cases found to have a venous ring, surgical access to the Meckel cave via a posterior fossa approach might be limited when this anatomy is present. Moreover, with a middle fossa approach to the Meckel cave, the surgeon may not visualize the inferior aspect of the sinus. If the sinus were in an inferior position in relation to the trigeminal nerve, drainage of the SPS might be derailed due to such venous rings as were identified in our study.

Conclusions

Knowledge of the relationship between the SPS and the opening of the Meckel cave may be useful to the skull base surgeon. Based on our study, some individuals may retain the early embryonic position of their SPS in relation to the trigeminal nerve, that is, inferior to the opening of the Meckel cave. Such a relationship should be considered by the surgeon and by those who interpret cranial vascular imaging.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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Porus trigeminus and superior petrosal sinus


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