The Laryngoscope

Endoscopic Anatomy of the Palatovaginal Canal (Palatosphenoidal Canal): A Landmark for Dissection of the Vidian Nerve During Endonasal Transpterygoid Approaches

Carlos D. Pinheiro-Neto, MD; Juan C. Fernandez-Miranda, MD; Carlos M. Rivera-Serrano, MD; Alessandro Paluzzi, MD; Carl H. Snyderman, MD, MBA; Paul A. Gardner, MD; Luiz U. Sennes, MD

Objectives/Hypothesis: Demonstrate the endoscopic anatomy of the palatovaginal (PV) canal and artery for identification and dissection of the vidian nerve during endoscopic transpterygoid approaches. Evaluate the length of the PV canal and its relation with the vidian nerve. Show that the traditionally known PV canal is a misnomer and should be renamed.

Study Design: Experimental study: anatomical and radiological.

Methods: Dissection of eight cadaveric heads was performed to demonstrate the endoscopic anatomy of the PV canal. Computed tomography scan analysis of 20 patients was used to evaluate the length of the PV canal, the angle formed between this canal and the vidian nerve, and the distance between the vidian canal and the PV canal. Study of 10 dry skull bases was performed to verify the structures involved in the formation of the PV canal.

Results: Anatomic steps and foundations for dissection of the vidian nerve using the PV canal as a landmark were described. The mean length of the PV canal was 7.15 mm. The mean proximal distance between the vidian and the PV canal was 1.95 mm, and the mean distal distance was 4.14 mm. The mean angle between those canals was 48 degrees. The osteology study showed the vaginal process of the sphenoid bone did not contribute to the formation of the PV canal.

Conclusions: Our anatomic investigations, radiologic studies, and surgical experience demonstrate the important anatomic relationship of the PV canal with the vidian canal and the relevance of the PV canal as a surgical landmark in endoscopic endonasal transpterygoid approaches. Anatomically, PV canal is a misnomer and should be replaced with palatosphenoidal canal.

Key Words: Transpterygoid approaches, endoscopy, vidian nerve, palatovaginal canal, skull base.

***Laryngoscope,* 122:6–12, 2012**

INTRODUCTION

The pterygopalatine fossa is a narrow pyramidal space that directly communicates with seven different regions. It communicates with the infratemporal fossa through the pterygomaxillary fissure, the middle cranial fossa through the foramen rotundum, the foramen lacerum through the vidian canal, the nasopharynx through the palatovaginal (PV) canal, the oral cavity through the greater and lesser palatine foramina, the nasal cavity through the sphenopalatine foramen, and the orbit through the inferior orbital fissure.[1] There are three foramina located in the posterior wall of the pterygopalatine fossa that are oriented in an oblique line within the inferior border of the sphenoid bone. From superolateral to inferomedial, these openings are the foramen rotundum, vidian canal, and PV canal.[1]

The vidian canal is a critical landmark for safe identification of the petrous internal carotid artery during endoscopic endonasal transpterygoid approaches. The vidian nerve guides the surgeon to the lateral margin of the anterior genu of the petrous internal carotid artery, at the level of the foramen lacerum.[2–4]

The PV canal has been classically described as a bony tunnel formed by the sphenoid process of the palatine bone and the vaginal process of the sphenoid bone that communicates the pterygopalatine fossa with the nasopharynx.[5] The PV canal contains the arterial pharyngeal branch arising from the maxillary artery and neural branches of the pterygopalatine ganglion and opens posteriorly into the roof of the nasopharynx.[6] Few studies of the PV canal have been reported.

Based on the medial location of the PV canal in relation to the vidian canal, an understanding of the endoscopic anatomy of the PV canal is imperative to safely identify and preserve the vidian nerve. The objective of this report is to demonstrate the endoscopic anatomy of the PV canal and artery for identification and dissection of the vidian nerve during endoscopic transpterygoid approaches. A radiologic study was performed to

From the Department of Neurological Surgery (J.C.F.M., A.P., C.H.S., P.A.G.) and the Department of Otolaryngology (C.D.P.N., C.M.R.S., C.H.S.), University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania, U.S.A.; and the Department of Otolaryngology, University of Sao Paulo (C.D.P.N., L.U.S.), Sao Paulo, Brazil.

Editor's Note: This Manuscript was accepted for publication January 14, 2011.

The authors have no funding, financial relationships, or conflicts of interest to disclose.

Send correspondence to Juan C. Fernandez-Miranda, MD, Department of Neurosurgery, University of Pittsburgh Medical Center, 200 Lothrop Street, Suite 500, Pittsburgh, PA 15213. E-mail: fernandezmirandajc@upmc.edu

DOI: 10.1002/lary.21808

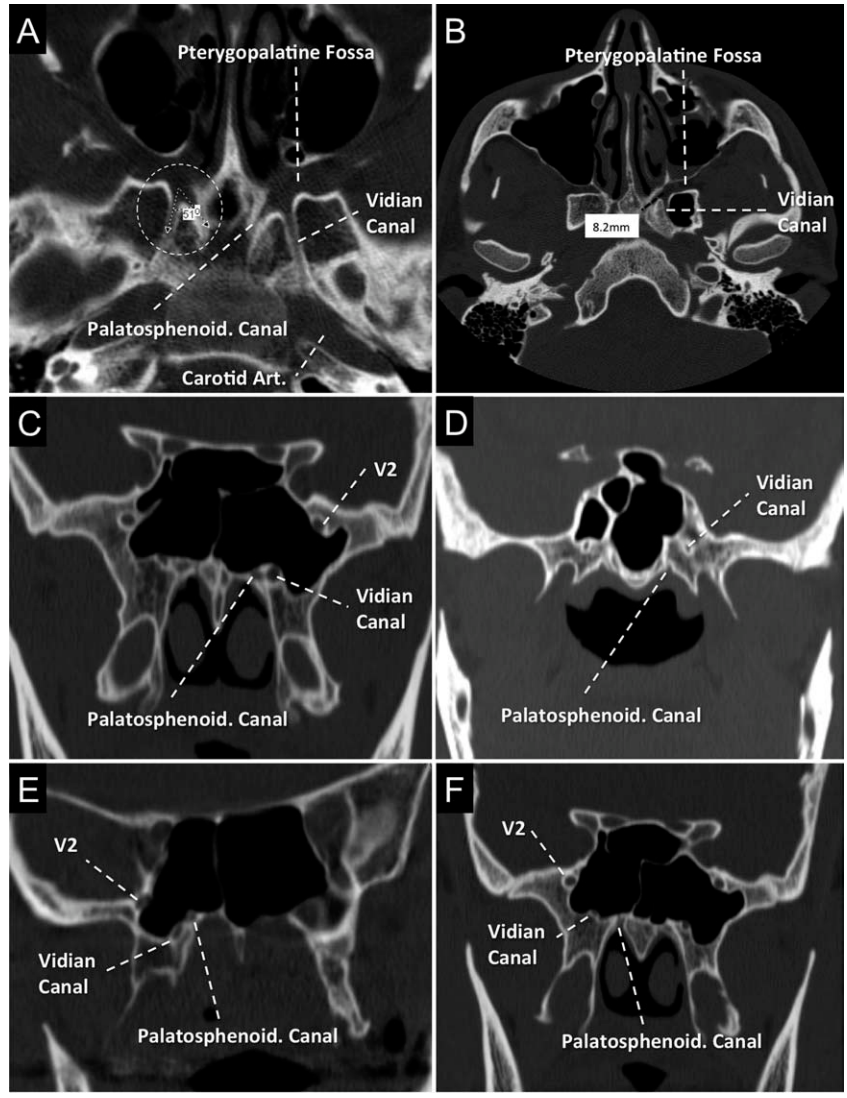

Fig. 1. Position between the palatosphenoidal (PS) canal and the vidian canal. (A) Computed tomography (CT) scan axial view. Dashed circle shows the angle on the right side between the PS canal and the vidian canal. Note that on the left side the vidian nerve guides to the lateral margin of the anterior genu of the petrous internal carotid artery. (B) CT scan axial view. Note the measurement of the PS canal length. (C) CT scan coronal view. Proximal cut just posterior to the pterygopalatine fossa is shown. Note the proximity between the PS canal and vidian canal in the proximal cut. In this example, the relative position between both canals is horizontal. (D) CT scan coronal view. Distal cut at the level of the nasopharyngeal aperture of the PS canal is shown. Note the distance between both canals and the oblique position with the vidian nerve superior. (E) CT scan coronal view. Proximal cut illustrates an example of oblique position proximally between PS and vidian canal with the PS canal superiorly. (F) CT scan coronal view. Distal cut illustrates a case of horizontal position between PS and vidian canals distally. Palatosphenoid = palatosphenoidal; art = artery; V2 = maxillary division of trigeminal nerve.

evaluate the length of the PV canal and its relation to the vidian canal. In addition, we will show that the traditionally known PV canal is a misnomer and should be renamed the palatosphenoidal (PS) canal, a term that will be used for the remainder of this report.

MATERIALS AND METHODS

This study was approved by our institutional research board (IRB #0701107).

Endoscopic Anatomy

Eight fresh cadaveric heads were used in this study. Both sides were dissected in each specimen. All heads had been previously evaluated for the absence of craniofacial trauma/surgery, sinonasal neoplasms, skull base tumors, or any other condition that could modify the anatomy of the region of interest. All specimens were prepared for dissection after the intravascular injection of colored liquid silicone by using a previously described technique.[7] The specimens were stored in a 75% alcohol solution. A complete exposure of the PS canal and the pharyngeal branch artery was performed before dissection of the vidian nerve and pterygopalatine fossa contents.

Radiologic Study

Computed tomography (CT) scans from 20 consecutive patients who were admitted to the facial trauma service were evaluated. All patients underwent maxillofacial CT scanning with intravenous contrast using an axial 1.0-mm-section protocol. Coronal reconstruction was generated from the axial images. The measurements were performed by using Stentor software (Philips, Brisbane, CA), which permits a dynamic analysis of the images, thus allowing the precise localization of each structure.

Patients with any preexistent condition or fracture or artifact in the sphenoid sinus, posterior wall of maxillary sinus, or palatine bone were excluded from the study. From the initial 20 patients, five were excluded (three patients had bone fractures and two patients had metallic artifact preventing an adequate analysis). CT scans of 15 patients (12 males) were included for radiologic analysis. A total of 30 sides were measured.

In the axial plane, the length of PS canal and the angle between the PS canal and vidian canal were measured (Fig. 1A and 1B). In the coronal plane, the distance and the position between the PS and vidian canal were evaluated. The distance was measured as a line from the most medial aspect of the vidian canal to the most lateral aspect of the PS canal. The position was classified as horizontal, vertical, or oblique. Two

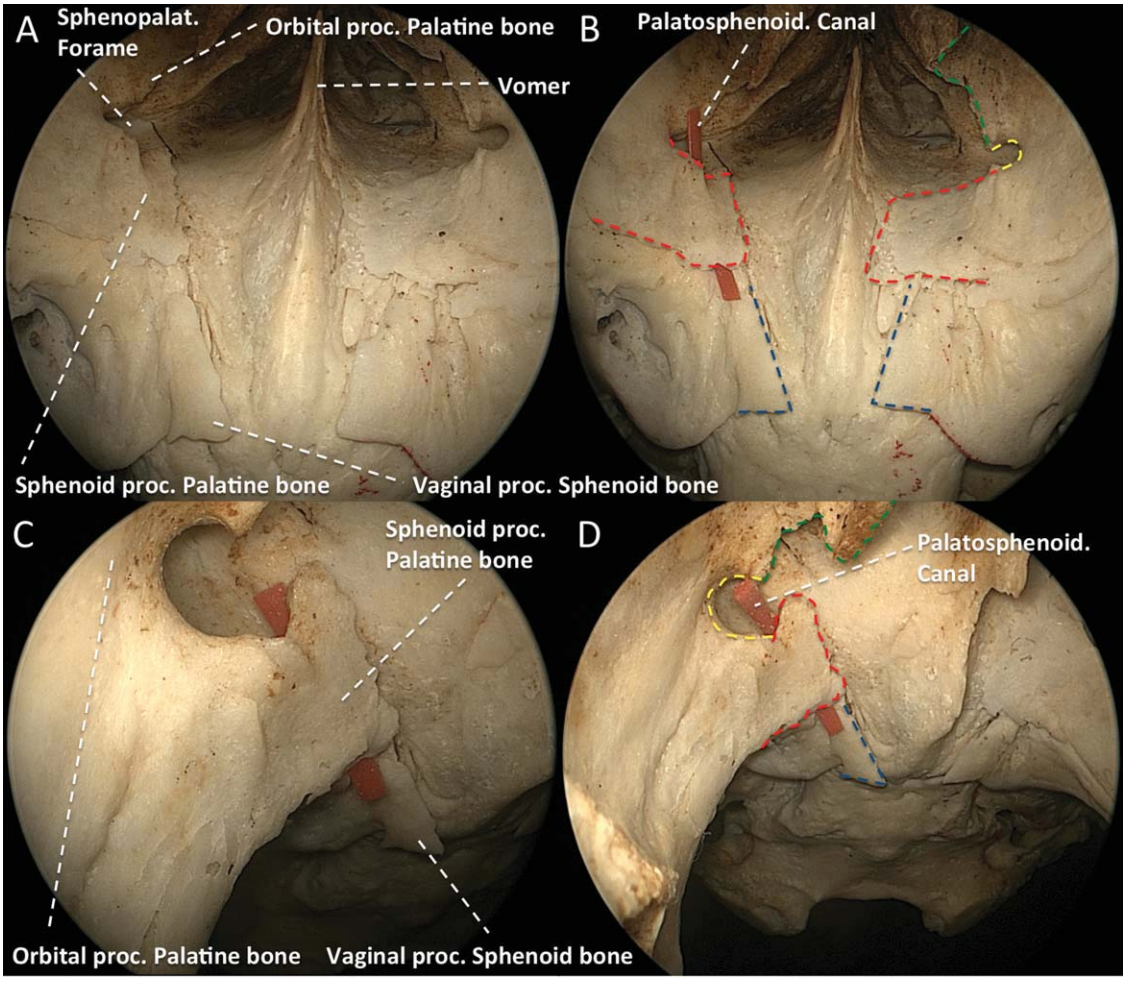

Fig. 2. Pictures from a dry skull base taken with a 0-degree endoscope. (A and B) View of the roof of the nasopharynx seen from below. (A) Note the relation between the sphenoid process of palatine bone and the vaginal process of sphenoid bone. (B) Red probe is passing through the right palatosphenoidal (PS) canal. Note the nasopharyngeal opening of the canal anterior to the vaginal process. (C and D) Endoscopic view of PS canal through the nose. (C) The sphenoid process of the palatine bone forms the inferior and medial parts of the PS canal. The sphenoid sinus floor contributes to the superior and lateral parts of the canal. The vaginal process of the sphenoid bone is consistently posterior to the nasopharyngeal aperture of PS canal. (B and D) Blue dashed line: vaginal process of sphenoid bone. Red dashed line: sphenoid process of palatine bone. Yellow dashed line: sphenopalatine foramen. Green dashed line: orbital process of palatine bone. Sphenopalat = sphenopalatine; proc = process; palatosphenoid = palatosphenoidal. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

slices were taken for those evaluations, one proximal (the first cut posterior to the pterygopalatine fossa) and the other one more distal (at the level of nasopharyngeal aperture of PS canal) (Fig. 1C, 1D, 1E, and 1F).

Osteology

To demonstrate that the traditionally known PV canal is a misnomer, we carefully studied 10 dry skull bases. In all specimens, the pterygopalatine fossa aperture of the PS was identified. A probe was inserted thorough the PS canal until the probe was seen through its nasopharyngeal opening. The vaginal process of the sphenoid bone and the sphenoid process of the palatine bone were highlighted in all dry skulls. The trajectory of the probe through the PS canal was evaluated in regard to those two bone structures (Fig. 2).

Statistical Analysis

The software SPSS 16.0 (SPSS Inc., Chicago, IL) was used for statistical analysis of the data from the radiologic study. The Student *t* test for paired samples was performed to compare the difference between the proximal distance from the vidian to PS canal (first cut posterior to the pterygopalatine fossa) and distal distance of both canals at the level of nasopharyngeal aperture of PS canal.

RESULTS

Endoscopic Anatomy

The exposure was initiated using a 0-degree rod lens endoscope (Karl Storz, Culver City, CA). For dissection standardization, the left side was always dissected first. Middle and inferior turbinectomies and anterior and posterior ethmoidectomies were performed. The sphenopalatine artery was transected laterally at the level of its foramen. All the mucosa that covers the perpendicular plate of the palatine bone and the sphenoid rostrum was removed, exposing the bony boundaries of the sphenopalatine foramen. The anterior boundary of

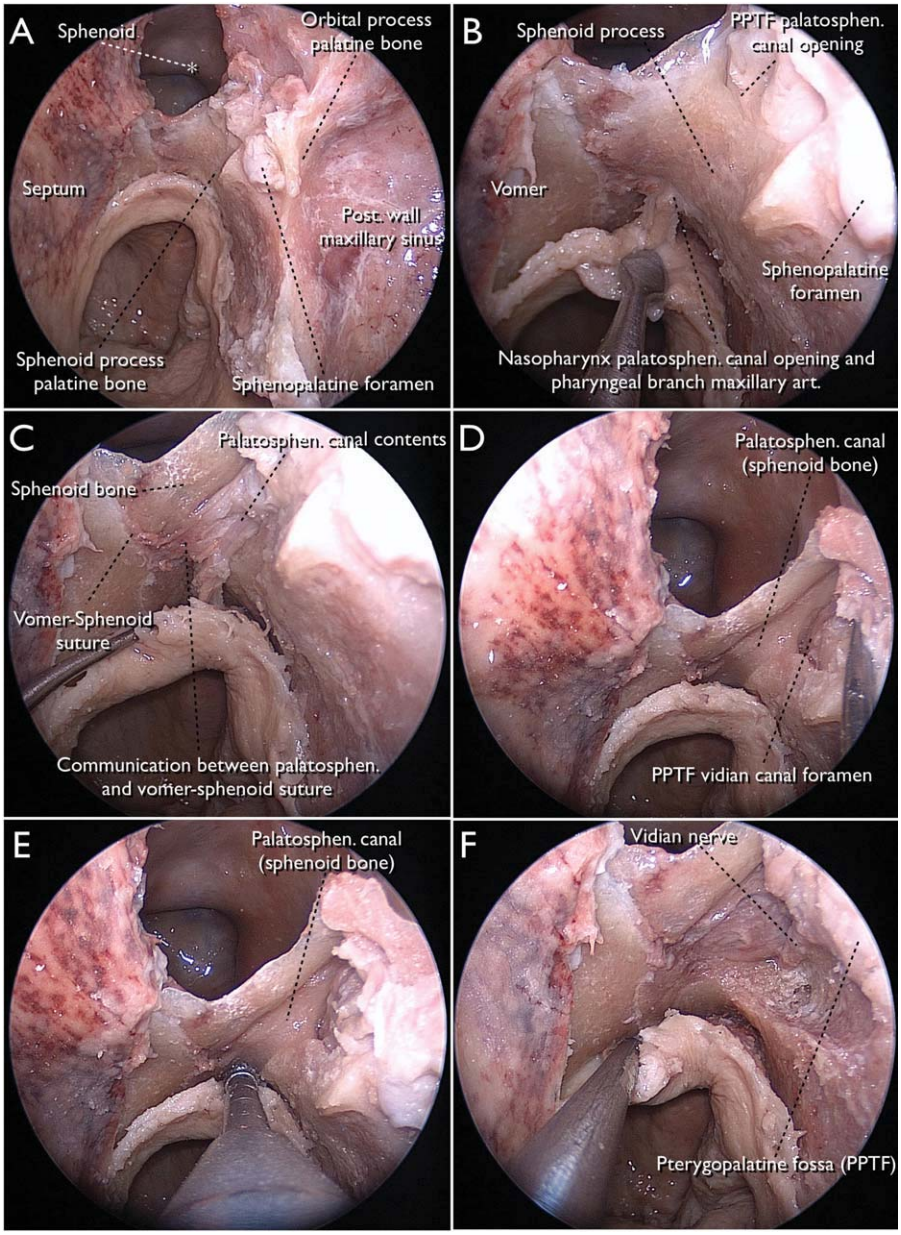

Fig. 3. Endoscopic cadaveric dissection of the left nasal cavity with a 0-degree endoscope. (A) Exposure the ascending process of palatine bone. Note the sphenopalatine foramen formed by the orbital process and the sphenoid process of palatine bone. (B) Exposure of the nasopharyngeal aperture of the palatosphenoidal (PS) canal and the pharyngeal branch of the maxillary artery. Note the opening of PS canal in the pterygopalatine fossa (PPTF). (C) After removal of part of the sphenoid process of palatine bone and exposure of the PS canal contents. Note the periosteal layer between the contents of PS canal and the vomer-sphenoidal suture. (D) Transection of the pharyngeal artery and periosteal layer with exposure of the superior and lateral aspects of PS canal. Note that this part of the PS canal is formed by the sphenoid sinus floor, and there is no contribution from the vaginal process of the sphenoid bone. Pushing laterally, the contents of the PPTF and exposure of the medial aspect of the vidian canal aperture are shown. Note the opening of PS canal in PPTF is just medial to the vidian. (E) Drilling starting from posterior to anterior. (F) Identification of the vidian nerve lateral to the PS canal. Palatosphen = palatosphenoidal; post = posterior; art = artery. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

the sphenopalatine foramen is the orbital process of the palatine bone, and the posterior boundary is the sphenoid process of the palatine bone (Fig. 3A). The soft tissues of the pterygopalatine fossa at the level of the sphenopalatine foramen were displaced laterally in order to identify the anterior opening of the PS canal. This opening is localized in the posterior and medial aspect of the pterygopalatine fossa, just lateral to the anterior boundary of the sphenoid process of the palatine bone. Subsequently, subperiosteal dissection at the level of the posterior and superior aspect of the sphenopalatine foramen was performed. Then, careful lateral displacement of the pterygopalatine fossa exposed the superior limit of the PS canal (Fig. 3B).

Afterward, the posterior aperture of the PS canal in the roof of the nasopharynx was identified. Subperiosteal dissection was started at the level of the arch of the choana and progressed posteriorly until identification of the pharyngeal branch exiting the PS canal (Fig. 3B). After both anterior and posterior openings were identified, we removed the anterior wall of the PS canal, which corresponds to the sphenoid process of the palatine bone.

After complete removal of the anterior wall of the PS canal, it was possible to identify the periosteum covering the contents of the PS canal and the communication between the PS canal periosteum and the suture formed by the sphenoid bone and the vomer. Several small arterial vessels were found running inside the periosteal layer between the contents of PS canal and the vomer-sphenoidal suture (Fig. 3C).

To provide lateral mobilization of the pterygopalatine fossa and to start drilling the vidian canal, the periosteum between the PS canal and the vomer-

TABLE I.
Radiologic Measurements of the Palatosphenoidal Canal.

Measurements	Mean	SD	P*
Length of palatosphenoidal canal	7.15 mm	±1.12	
Angle between vidian and palatosphenoidal canal	48 degrees	±12.28	
Proximal distance between vidian and palatosphenoidal canal (first cut posterior to the pterygopalatine fossa)	1.95 mm	±0.95	<.0001
Distal distance between vidian and palatosphenoidal canal (level of nasopharyngeal aperture of palatosphenoidal canal)	4.14 mm	±0.71	

*Student *t* test for paired samples.
SD = standard deviation.

sphenoidal suture was transected. Then, the pharyngeal artery (traveling toward the nasopharyngeal mucosa) was cut, and the PS contents covered by periosteum were displaced laterally, exposing the posterior wall of the PS canal, which corresponds to the floor of sphenoid sinus. Subperiosteal lateral dissection on the posterior wall of the pterygopalatine fossa was performed until exposure of the medial limit of the opening of the vidian canal was achieved (Fig. 3D). The posterior aspect of the PS canal was drilled by using a 4-mm hybrid cutting/diamond burr, from the posterior aperture in the nasopharynx to the anterior opening in the pterygopalatine fossa, until the vidian canal and nerve were identified laterally (Fig. 3E and 3F).

Radiologic Study

A total of 76.7% of patients presented with a horizontal position between the PS canal and the vidian canal in the proximal cut (first cut posterior to the pterygopalatine fossa), and 66.7% of patients had a horizontal position in the distal cut (level of nasopharyngeal aperture of PS canal). An oblique position between vidian and PS canal was observed in 16.7% of patients in the proximal cut and 33.3% of patients in the distal cut. In those patients, the PS canal was observed inferior to the vidian. In only 6.6% of patients was the PS canal superior to the vidian in the proximal cut. None of the patients had a superior position of PS canal compared to vidian in the distal cut. Table I and Figure 4 summarize the results of the radiologic analysis.

Osteology

In all 10 dry skull bases studied, the vaginal process of the sphenoid bone did not contribute to the formation of the PS canal. In all specimens, the PS canal opening in the nasopharynx was consistently anterior to the vaginal process of the sphenoid bone.

DISCUSSION

In this article, we describe the surgical anatomy of the PS canal (also known as PV canal) and its importance for vidian nerve identification during endoscopic endonasal transpterygoid approaches. Despite an increased volume of literature describing endoscopic skull base anatomy, the PS canal anatomy, its anatomic relationships, and its importance in endoscopic endonasal transpterygoid approaches have not been studied in depth.

The initial surgical step for a transpterygoid approach is the identification of the vidian nerve and canal. This may prove challenging in the absence of reliable anatomic landmarks. From the results of this study, it appears that the PS canal represents an excellent landmark for intraoperative localization of the vidian canal. Early identification of the vidian canal requires opening of the PS canal by removal of the sphenoid process of the palatine bone (Fig. 5A). This maneuver exposes the neurovascular contents of the canal (pharyngeal branches) that are selectively coagulated and transected (Fig. 5B and 5C).

We have seen that the PS canal is often confused with the vidian canal by trainees and surgeons in the early phases of training. The medial location of the PS canal in relation with the vidian canal is of utmost importance and should be clearly understood by surgeons operating in this region (Fig. 5D). The trajectory of the PS canal is also very different from the trajectory of the vidian canal. The most frequent position between those canals in the coronal plane is horizontal. However, in some cases, the PS canal can present obliquely in relation to the vidian canal. The PS and vidian canals form a divergent angle from the pterygopalatine fossa (mean of 48.1 degrees). There is a thicker bone separating these canals posteriorly (mean distal distance between the canals is 4.14 mm) as compared with the bone near the pterygopalatine fossa (mean proximal distance is 1.95 mm). We can conclude that the PS canal and vidian canal assume a divergent trajectory from the pterygopalatine fossa. This differentiation has been useful in appropriately identifying the vidian canal and avoiding inadvertent vidian nerve damage when the nerve can be preserved.

The standard technique established for dissection of the vidian nerve during transpterygoid approaches

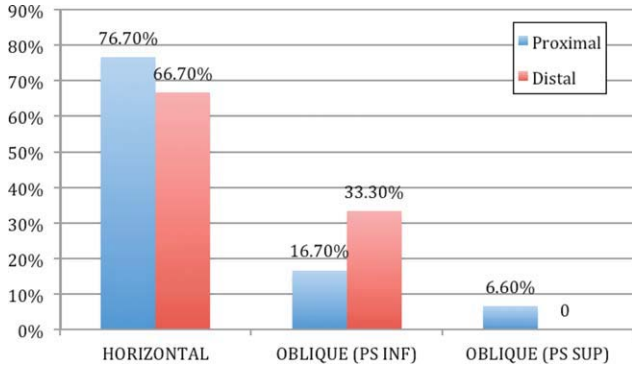

Fig. 4. Position between the palatosphenoidal (PS) canal and the vidian canal in the coronal plane. Proximal = first cut posterior to the pterygopalatine fossa; Distal = level of nasopharyngeal aperture of PS canal; PS INF = palatosphenoidal canal inferior to the vidian canal. PS SUP = palatosphenoidal canal superior to the vidian canal. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

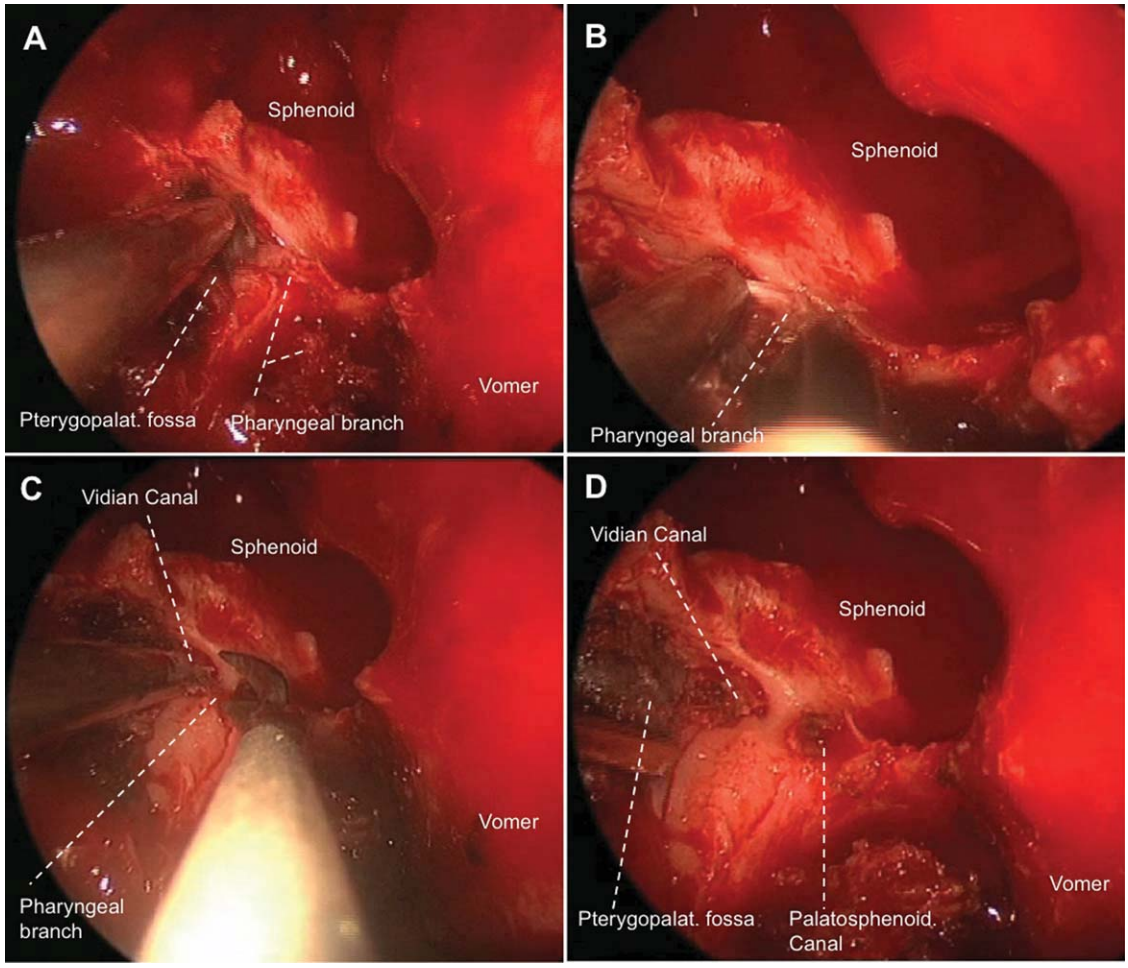

Fig. 5. Intraoperative pictures during a transpterygoid approach on the right side using a 0-degree endoscope. (A) After partial removal of the sphenoid process of palatine bone. Note the pharyngeal branch of the internal maxillary artery coming from the pterygopalatine fossa toward the roof of nasopharynx. (B) Cauterization with bipolar and (C) transection of the pharyngeal branch. (D) After transection of the pharyngeal branch and lateral mobilization of the pterygopalatine fossa, it is possible to identify the vidian canal in the pterygoid basis. Note the indentation of the palatosphenoidal canal in the sphenoid bone. Pterygopalat = pterygopalatine; palatosphenoid = palatosphenoidal. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

includes its sacrifice at the level of the pterygopalatine fossa.[2,3,8,9] Meticulous anatomic studies completed at our institution and transferred to the operating room have allowed for structural preservation of the vidian nerve and pterygopalatine fossa contents during most transpterygoid approaches.[10] The description of the PS canal as a surgical landmark for the vidian canal further helps in preservation of the vidian nerve during transpterygoid approaches.

In the literature, the PV canal has been traditionally described as formed by the sphenoid process of the palatine bone and the vaginal process of the sphenoid bone; however, our findings do not support this classic description. Our investigations revealed that the palatine bone does not articulate with the vaginal process of the sphenoid bone; thus, PV is a misnomer. The canal classically referred as PV, which contains the pharyngeal branch of the maxillary artery, is in fact formed by the sphenoid process of the palatine bone (Fig. 3B) and the anteroinferior wall of the sphenoid sinus (Fig. 3D); therefore, it should be named the PS canal. Immediately posterior to the exit of the pharyngeal branch of the internal maxillary artery from the canal, there is a bony cleft formed by the vomer and the vaginal process of the sphenoid bone that does not contain significant or named vessels.

CONCLUSIONS

Anatomic dissections, radiologic studies, and surgical experience demonstrate the important anatomic relationship of the PS canal with the vidian canal and the relevance of the PS canal as a surgical landmark in endoscopic endonasal transpterygoid approaches.

BIBLIOGRAPHY

1. Kim HS, Kim DI, Chung IH. High-resolution CT of the pterygopalatine fossa and its communications. *Neuroradiology* 1996;38(suppl 1): S120–S126.
2. Kassam AB, Vescan AD, Carrau RL, et al. Expanded endonasal approach: vidian canal as a landmark to the petrous internal carotid artery. *J Neurosurg* 2008;108:177–183.

3. Vescan AD, Snyderman CH, Carrau RL, et al. Vidian canal: Analysis and relationship to the internal carotid artery. *Laryngoscope* 2007;117: 1338–1342.
4. Fortes FS, Sennes LU, Carrau RL, et al. Endoscopic anatomy of the pterygopalatine fossa and the transpterygoid approach: development of a surgical instruction model. *Laryngoscope* 2008;118:44–49.
5. Rumboldt Z, Castillo M, Smith JK. The palatovaginal canal: can it be identified on routine CT and MR imaging? *AJR Am J Roentgenol* 2002;179: 267–272.
6. Osawa S, Rhoton AL Jr, Seker A, Shimizu S, Fujii K, Kassam AB. Microsurgical and endoscopic anatomy of the vidian canal. *Neurosurgery* 2009;64(suppl 2):385–411; discussion 411–412.
7. Brito RV, Bento RF, Yasuda A, et al. Anatomy of the lateral base of the skull: development of a method of study. *Rev Bras Otorrinolaringol* 2005;9:11–17.
8. Kassam AB, Prevedello DM, Carrau RL, et al. The front door to meckel's cave: an anteromedial corridor via expanded endoscopic endonasal approach- technical considerations and clinical series. *Neurosurgery* 2009;64:71–82.
9. Zanation AM, Snyderman CH, Carrau RL, Gardner PA, Prevedello DM, Kassam AB. Endoscopic endonasal surgery for petrous apex lesions. *Laryngoscope* 2009;119:19–25.
10. Prevedello DM, Pinheiro-Neto CD, Fernandez-Miranda JC, et al. Vidian nerve transposition for endoscopic endonasal middle fossa approaches. *Neurosurgery* 2010;67(2 Suppl Operative):478–484.