Anatomical study of the pterygopalatine fossa using an endoscopic endonasal approach: spatial relations and distances between surgical landmarks

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Object. The pterygopalatine fossa is an area that lies deep within the skull base. The recent extensive use of the endoscopic endonasal approach has provided neurosurgeons with a method to reach various areas of the skull base through a less invasive approach than traditional transcranial or transfacial approaches. This study aims to provide neurosurgeons with new data concerning direct endoscopic measurements and precise anatomical topography features of the pterygopalatine fossa.

Methods. An anatomical dissection of six fixed cadaver heads (12 pterygopalatine fossae) was performed to analyze spatial relationships and distances between the most important neurovascular structures in this region, and to estimate the size of the endoscopic surgical field for operations in this area. The endoscopic endonasal approach offers direct access to the pterygopalatine fossa through its anteromedial walls.

Conclusions. Using an endoscopic endonasal approach makes it possible to identify all of the anatomical landmarks of the pterygopalatine fossa and almost all of the contiguous skull base areas.

**KEY WORDS**  • pterygopalatine fossa  • skull base  • endoscopy  • endonasal approach  • anatomical study

THE pterygopalatine fossa is a small area limited anteriorly by the posterior wall of the maxillary sinus, medially by the palatine bone, and posteriorly by the lateral plate of the pterygoid process of the sphenoidal bone. It is narrower at its inferior part due to the convergence of the pterygoid process and the posterior wall of the maxillary sinus. Extending from the middle cranial fossa to the facial skull, the pterygopalatine fossa communicates with the middle cranial fossa, orbit, nasal cavity, oral cavity, and infratemporal fossa via six foramina and canals, through which many important neurovascular structures reach and cross over the pterygopalatine fossa. Thus, several neoplastic and inflammatory diseases of these surrounding areas can diffuse into the pterygopalatine fossa.20,21

Most of the surgical procedures that have been used for the removal of lesions involving this area were extensive transcranial or transfacial approaches.8,14,17,28,29 The use of an endoscopic endonasal approach has led neurosurgeons to evaluate the possibility of introducing this technique for the treatment of lesions of the pterygopalatine fossa and other areas of the skull base.1–3,7,9,12,13,15,22,28,30,33 The aim of this anatomical study is not to suggest a new surgical technique, which has already been described;2,9,13,24,28,34 rather, we attempted to quantify, through microsurgical measurements and topographical photographs, the operative space in the pterygopalatine fossa that the surgeon could obtain while approaching this region through the endonasal route.

**Materials and Methods**

Six fixed cadaver heads were dissected for the anatomical studies (12 pterygopalatine fossae). An endoscopic endonasal approach, extended to the pterygopalatine fossa, was used in all cases. Endoscopic dissections were performed in the laboratories of the International Neuroscience Institute of Hannover using a rigid endoscope (Karl Storz and Co.) that was 4 mm in diameter, 18 cm long, and equipped with 0° lenses. The endoscope was connected to a light source through a fiberoptic cable and to a camera connected to a 21-in monitor. To guarantee a suitable file of anatomical images, a digital video-recorder system (also known as a DV cam) was used.

**Results**

Endoscopic Endonasal Exposure of the Pterygopalatine Fossa

Using an endoscopic endonasal approach allows the ex-
The surgical corridor is enlarged by the removal of the omolateral middle turbinate, lateralization of the middle turbinate in the other nostril, and removal of the posterior nasal septum to create conditions that allow the use of the endoscope and instruments through both nostrils. The medial wall of the maxillary sinus is removed to gain access to the posterior wall of the maxillary sinus, which constitutes the anterior wall of the pterygopalatine fossa, and to the sphenopalatine foramen, through which the sphenopalatine artery reaches the nasal cavity. The orbital process of the palatine bone is removed and the sphenopalatine foramen is enlarged to expose the anterior portion of the pterygoid process. The posterior wall of the maxillary sinus is then removed superiorly up to the roof of the maxillary sinus, inferiorly up to the floor of the sinus, medially up to the vertical process of the palatine bone, and laterally up to the angle between the lateral and posterior wall of the maxillary sinus. At this point, a quadrangular window measuring an average of 27.1 mm high and 23.8 mm wide (Table 1; Fig. 1) is open, giving a direct view of the pterygopalatine fossa.

To simplify the description of the anatomical contents of the pterygopalatine fossa as seen through the endoscope, we have described vascular, nerve, muscle, and bone structures separately, in the order in which they appear during the dissection.

### Vascular Structures

After opening the posterior wall of the maxillary sinus, the fat tissue is visualized. All of the structures of the pterygopalatine fossa are fully immersed in this fat tissue. By gently dissecting and removing the fat tissue with microforceps and scissors, all vascular, nerve, and muscle structures begin to appear.

The first structures to be visible in the pterygopalatine fossa will be vascular, all of which are branches of the maxillary artery, which emerges from the bottom and lateral part of the pterygopalatine fossa along the anterior margin of the lateral pterygoid muscle. In the anterior position is the posterior superorbital alveolar artery, which originates from the maxillary artery in a position that appears approximately in the middle of the fossa when observed using the endoscope (Fig. 2). The posterosuperior alveolar artery courses downward, laterally and slightly anteriorly toward the anteroinferior margin of the pterygopalatine fossa, entering the maxillary bone where the frontal wall of the fossa (removed) meets the floor and lateral wall of the maxillary sinus. The infraorbital artery originates from the posterosuperior alveolar artery 2 to 3 mm after branching from the maxillary artery, or sometimes from the maxillary artery itself. The infraorbital artery courses upward in a winding and variable route to reach the infraorbital fissure, together with the infraorbital nerve. This artery can be seen easily and recognized in the endoscopic view (Fig. 3). The maxillary artery then proceeds medially and superiorly with wide curves toward the orbital process of the palatine bone and the vidian artery (on either side of the mandible) to form the vidian trunk, which carries the vidian nerve. The vidian trunk then proceeds medially and inferiorly toward the mandible, giving rise to the vidian nerve and the sphenopalatine foramen.

### TABLE 1

Summary of the anatomical measurements of the pterygopalatine fossa in six fixed cadaver specimens

<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>Width of aw of Pterygopalatine Fossa (mm)</th>
<th>Height of aw of Pterygopalatine Fossa (mm)</th>
<th>Depth of Inferior Pterygopalatine Fossa from awMS to Pterygoid Process (mm)</th>
<th>Depth of Superior Pterygopalatine Fossa from awMS to Pterygoid Process (mm)</th>
<th>Sphenopalatine Artery &amp; Vidian Nerve on Sphenopterygoid Process (mm)</th>
<th>Width of Sphenopalatine Artery &amp; Vidian Nerve (mm)</th>
<th>Width of Foramen Rotundum (mm)</th>
<th>Width of Pterygoid Canal (mm)</th>
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<tr>
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<td>27 lt; 25 rt</td>
<td>32 lt; 30 rt</td>
<td>7 lt; 7 rt</td>
<td>12 lt; 12 rt</td>
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<td>3.4 lt; 3.3 rt</td>
<td>3.0 lt; 2.8 rt</td>
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<td>13 lt; 13 rt</td>
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<td>22 lt; 23 rt</td>
<td>7 lt; 8 rt</td>
<td>12 lt; 12 rt</td>
<td>4.6 lt; 4.7 rt</td>
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<tr>
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<td>9 lt; 7 rt</td>
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<td>27.1 lt; 7.3</td>
<td>11.3 lt; 4.5</td>
<td>11.3 lt; 4.5</td>
<td>3.4 lt; 3.4 rt</td>
<td>3.4 lt; 3.4 rt</td>
<td>3.6 lt; 2.9 lt</td>
<td>2.9 lt; 2.8 lt</td>
</tr>
</tbody>
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* aW = anterior wall; awMS = anterior wall of the maxillary sinus; pwMS = posterior wall of the maxillary sinus.
palatine nerves in close contact with the lateral surface of the vertical process of the palatine bone.

After giving rise to the descending palatine artery, the maxillary artery ends at its terminal branch, the sphenopalatine artery. This artery courses medially in a large “S” shape and pierces the sphenopalatine foramen. Very often, this last tract of the sphenopalatine artery cannot be seen unless the orbital process of the palatine bone, which covers it, is removed. Immediately as the sphenopalatine artery reaches the nasal cavity it divides into the nasopalatine artery superiorly and medially, and the posterior nasal artery inferiorly and laterally.34

**Nerve Structures**

In the highest part of the pterygopalatine fossa, the V2 of the trigeminal nerve becomes visible, traveling medially to laterally and slightly upward from the underlying foramen rotundum to the infraorbital fissure (Fig. 4), where it penetrates the fissure together with the infraorbital artery. Soon after emerging from the foramen rotundum, the V2 gives rise to two to three minor nerve branches that run downward to reach the pterygopalatine ganglion. Subsequently, just beneath the inferior orbital fissure, the V2 curves laterally; at this level, three to four small branches separate from the nerve. These small branches are the zygomatic and posterosuperior alveolar nerves, which travel downward in close contact with the arterial stems that occupy the pterygopalatine fossa. Finally, the V2 turns medially and becomes the infraorbital nerve, and enters the infraorbital fissure.

Located medially and inferiorly to V2 are the vidian
nerve and its homonymous artery. The vidian nerve, after
having passed through the middle cranial fossa and the fora-
men lacerum, enters the pterygopalatine fossa through the
pterygoid canal to reach the pterygopalatine ganglion. The
vidian nerve is formed by the union of parasympathetic fi-
bers from the facial nerve, which extends through the great
petrosal nerve (at the level of the geniculate ganglion), to-
gether with sympathetic fibers from the superior cervical
ganglion.

Just in front of the pterygoid canal, the pterygopalatine
ganglion lies on the anterior surface of the pterygoid pro-
cess, 23 hidden by the vertical process of the palatine bone
and by the infraforaminal tract of the branches of the sphet-
opalatine artery. The pterygopalatine ganglion contains
postsynaptic parasympathetic nerve cell bodies and differ-
ent types of sensitive nerve fibers providing innervation for
the lacrimal gland, the nasal and the paranasal mucosa, and
the roof of the oral cavity. 25,27,36 The pterygopalatine gan-
glion gives rise to the greater and lesser palatine nerves
from its inferior surface, to the sphenopalatine and the pha-
ryngeal branches from its medial surface, and to the orbital
branch from its superior surface.

**Muscle Structures**

The medial pterygoid muscle is the most important mus-
cular landmark that can be seen upon endoscopic exposure
of the pterygopalatine fossa. It is easily recognizable, be-
cause its anterior margin has a pillar-like shape in the mid-
dle of the endoscopic view (Fig. 5). The medial pterygoid
muscle originates from two heads; the deeper one derives
from the medial surface of the lateral plate of the pterygoid
process, and the superficial one derives from the lateral side
of the pyramidal process of the palatine bone. The medial
pterygoid muscle is directed backward and laterally in the
deep infratemporal fossa, where it meets the medial surface
of the mandibular ramus.

Between the two heads of the medial pterygoid muscle,
seated deeper in the infratemporal fossa, lies the superior
belly of the lateral pterygoid muscle, which originates from
the infratemporal surface of the great wing of the sphenoid
bone, whereas its inferior head rises from the lateral plate of
the pterygoid process. The lateral pterygoid muscle crosses
the upper part of the infratemporal fossa directed inferiorly
and laterally toward the neck of the mandibular condylar
process, beneath the temporomandibular joint. Both the lat-
teral and medial pterygoid muscles are essential for mastication.

**Bone Structures**

The bone limits of the pterygopalatine fossa are exposed

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**Fig. 4.** Endoscopic photographs showing a close view of V2, the
pterygopalatine ganglion (PPG), and arterial branches.  A: Close-
up view of V2 crossing the upper part of the pterygopalatine fossa.
This nerve can be considered a boundary between the pterygopalat-
ine and infratemporal fossae. After giving rise to the zygomatic
nerve (Zn) and the posterosuperior alveolar branches of the maxil-
lary nerve (PSAV2), the V2 pierces the infraorbital canal.  B: De-
tail on the anatomical relationships between the arterial branches
and the pterygopalatine ganglion. Co = choana.

**Fig. 5.** Endoscopic photograph showing the muscle structures of
the pterygopalatine and infratemporal fossae after removal of fat tis-
sue, nerves, and vessels. LPM = lateral pterygoid muscle; MPM =
medial pterygoid muscle; PP = pterygoid process of the sphenoid
bone.
after the posterior wall of the maxillary sinus has been opened, the fat has been excised, and the vascular, nerve, and muscle structures have been removed. The vertical process of the palatine bone limits the pterygopalatine fossa medially; its orbital and sphenoidal processes constitute most of the sphenopalatine foramen, which is completed superiorly by the body of the sphenoid bone. After enlarging the sphenopalatine foramen by drilling extensively the orbital process of the palatine bone, the body and the pterygoid process of the sphenoid bone appear completely, making it possible to locate all of the anatomical bone landmarks of the pterygopalatine fossa.

The posterior wall of the pterygopalatine fossa is formed by the anterior part of the pterygoid process of the sphenoid bone, whereas its lateral plate, that bends posteriorly, can be considered the medial wall of the infratemporal fossa. In a medial and superior position on the pterygoid process, the pterygoid canal opens into the pterygopalatine fossa; the average diameter of the pterygoid canal is approximately 2.9 mm (Table 1, Fig. 6). Extending laterally and upward, at an average distance of 4.5 mm from the pterygoid canal, the foramen rotundum (average diameter 3.6 mm) lies on the inferior surface of the great wing of the sphenoid bone (Fig. 7). Between these two foramina, a small bony crest arises.

The lateral wall of the pterygopalatine fossa is not limited by a bony surface, but continues directly into the infra-temporal fossa through the pterygomaxillary fissure. Inferiorly, the angle formed by the union of the maxillary with the pterygoid process constitutes the edge of the pterygopalatine fossa in that direction.

**Discussion**

The pterygopalatine fossa is frequently involved in lesions originating from the skull base, orbits, face, and oro-nasal cavity. Most of the surgical routes that have been used in the past to reach the pterygopalatine fossa required extensive approaches, despite its reduced size. The extensive use of endoscopic approaches in patients undergoing functional sinus surgery has led to an increased use of the endoscope in the management of tumors in the region around the nasal cavities. From a neurosurgical perspective, using the endoscopic endonasal transsphenoidal approach to the sellar region represents the most important innovation.

The endoscopic endonasal approach to the pterygopalatine fossa has been described recently by investigators who performed anatomical studies, and some authors have reported the removal of benign lesions in this region using such an approach. In the present study we made a series of measurements between the different anatomical landmarks inside the pterygopalatine fossa to give the surgeon an idea of the size of this region when approached through the endoscopic endonasal route. In this way, we tried to improve the surgeon’s orientation during the exposure of this area through its anterior aspect, as well as the evaluation of the topography and relative position of the main anatomical landmarks (Table 1).

From a neurosurgical point of view, the value of the anatomical knowledge of the pterygopalatine fossa using an endoscopic approach is that frequently, lesions involving the sellar and parasellar region, the clivus, and the middle cranial fossa extend through the lateral recess of the sphenoid sinus to reach the pterygopalatine fossa. In such circumstances it is possible to extend the endoscopic endonasal approach to the pterygopalatine fossa to obtain direct access to the most lateral portion of these lesions. In fact, only a limited dissection and bone removal of the pterygopalatine fossa portion, enclosed between the pterygoid canal and the foramen rotundum, is required to expose widely the lateral recess of the sphenoid sinus.

The endoscopic endonasal approach we have employed has been achieved without endangering all other nasal struc-
The use of both nostrils during the dissection enables one to obtain a field of vision and operative space for the surgical instruments that is sufficient to accurately dissect and isolate all major vascular and nerve structures. It should be noted that the pterygopalatine fossa can also be reached with a single-nostril approach after removing the omolateral middle turbinate, as reported by other authors. In this approach the use of straight endoscopic instruments and 0° lenses laterally limits the surgical field to almost half of what is obtainable with a two-nostril approach after removing the posterior septum.

Although in this study the endoscopic endonasal approach appears to be a safe and direct way to reach the pterygopalatine fossa (especially compared with the conventional transmaxillary or transantral approaches), the surgeon who intends to practice this approach must bear in mind that some points of attention and potential danger remain. First, the surgeon must remember that there is a limited space for movement; the pterygopalatine fossa has a depth of approximately 9.3 mm (deeper superiorly and shallower inferiorly) between the posterior wall of the maxillary sinus and the anterior surface of the pterygoid process. Within this small space are most of the vessels that we have already described, in close contact with one another and with the nerve branches that cross the fossa. The use of the endoscope will offer the surgeon the possibility to have a wide view of these structures and their orientation, including close-up views, but such a view will be two-dimensional. This lack of a three-dimensional field of vision, which is the main drawback of the endoscopic approach, can be overcome by active movement of the endoscope to provide a sense of depth.

A ring of fibrous tissue, strictly adherent to the sphenopalatine artery and to the surrounding bones, is found when removing the vertical process of the palate bone to open the sphenopalatine foramen during dissection. During surgical maneuvers, excessive traction put on the vertical process of the palatine bone during the opening of the foramen could potentially damage the underlying sphenopalatine artery. To prevent such damage, this maneuver could be monitored by the use of a 30° vision endoscope, which could have a better view of the sphenopalatine foramen, the nasal exit of the sphenopalatine artery, and the vidian nerve, which enters the nasal cavity from the pterygoid canal at an average distance of 4.5 mm (Table 1). In many similar cases, the possibility of changing the angle in the field of vision offers additional value to using the endoscope as opposed to a solely microsurgical approach.

Finally, two areas of potential danger must be noted. In our opinion, during dissection of the pterygopalatine fossa it would be wise not to extend one’s approach too laterally toward and deeply into the infratemporal fossa, because the maxillary artery (which emerges toward the pterygopalatine fossa) and the lateral and medial pterygoid muscles lie in that region; an approach that was too extensive could cause intense bleeding during the surgical procedure and permanent impairment of mastication if this artery or these muscles were damaged. As noted previously, the use of the endoscope can enable the surgeon to avoid these areas of danger by moving around the fossa to establish an orientation through important anatomical landmarks and by permitting movements in and out to provide a closer and more accurate view of the selected area.

Conclusions

This anatomical study has demonstrated, through precise measurements and topographical revelations, the feasibility of using an endoscopic endonasal approach to the pterygopalatine fossa. We have found that this approach is appropriate given the complex anatomy of the region, and permits a safe and accurate management of the nerve and vascular structures that are encountered. We therefore believe that the endoscopic endonasal approach to the pterygopalatine fossa is a suitable procedure for those surgeons who are already familiar with using endoscopy for endonasal surgery.

References

Endoscopic anatomical measurements of the pterygopalatine fossa


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