Extended endoscopic endonasal approach to the pterygopalatine fossa: anatomical study and clinical considerations

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Object. The pterygopalatine fossa is an area located deep in the skull base. The microsurgical transmaxillary–transantral route is usually chosen to remove lesions in this region. The increasing use of the endoscope in sinonasal functional surgery has more recently led to the advent of the endoscope for the treatment of tumors located in the pterygopalatine fossa as well.

Methods. An anatomical dissection of three fresh cadaveric heads (six pterygopalatine fossas) and three dried skull base specimens was performed to evaluate the feasibility of the approach and to illustrate the surgical landmarks that are useful for operations in this complex region.

The endoscopic endonasal approach allows a wide exposure of the pterygopalatine fossa. Furthermore, with the same access (that is, through the nostril) it is possible to expose regions contiguous with the pterygopalatine fossa, either to visualize more surgical landmarks or to accomplish a better lesion removal.

Conclusions. In this anatomical study the endoscopic endonasal approach to the pterygopalatine fossa has been found to be a safe approach for the removal of lesions in this region. The approach could be proposed as an alternative to the standard microsurgical transmaxillary–transantral route.

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

The pterygopalatine fossa is limited anteriorly by the posterior wall of the maxillary sinus and posteriorly by the anterior aspect of the pterygoid process. It is shaped like an inverted, quadrangular pyramid, with the apex directed inferiorly and the base superiorly. This is because the pterygoid process and the posterior wall of the maxillary sinus are almost in contact inferiorly, whereas they diverge superiorly. The pterygopalatine fossa communicates with the middle cranial fossa, orbit, nasal cavity, oral cavity, and the infratemporal fossa via six foramina and canals, through which the different neurovascular structures pass. For this reason, it represents a major pathway for the spread of inflammatory or neoplastic disease between these various compartments.

The pterygopalatine fossa is small (its height is ~2 cm and the bases measure ~1 cm), but given its deep location, extensive surgical approaches, including the transfacial one, are often necessary for skull base lesions involving this region.

The widespread use of endoscopic endonasal techniques has progressively led to interest among neurosurgeons in the treatment of lesions arising in or extending to the pterygopalatine fossa by using these techniques instead of the microsurgical transmaxillary–transantral approach. Furthermore, the increasing use of image guidance systems during endoscopic endonasal procedures has increased the accuracy and the safety of the approach, giving the surgeon constant, accurate surgical orientation in a deep area.

Only a few anatomical and clinical papers describing the endoscopic endonasal approach to the pterygopalatine fossa have been published to date. Therefore, to illustrate the surgical landmarks used to operate in this complex region via the endoscopic endonasal approach, we have performed an endoscopic anatomical study on the pterygopalatine fossa.

MATERIALS AND METHODS

Specimen Preparation and Equipment Used

For the anatomical dissection, three fresh cadaver heads were dissected using an extended endoscopic endonasal approach to the pterygopalatine fossa. On these heads, only
the arterial system was injected with colored rubber. The bone relationships were examined in three dried specimens of human skull bases. Endoscopic dissections were performed using rigid endoscopes (Karl Storz and Co., Tutlingen, Germany) that were 4 mm in diameter, 18 cm long, and equipped with 0°, 30°, and 45° lenses, according to the different steps of the anatomical dissection protocol.

The endoscope was connected to a light source through a fiberoptic cable and to a camera fitted with 3-charge-coupled device sensors. The video camera was connected to a 21-in monitor supporting the high resolution of the 3-charge-coupled device technology. To guarantee a suitable file of anatomical images, a digital video-recorder system (also known as a DVcam) was used.

**Endoscopic Endonasal Exposure of the Pterygopalatine Fossa**

The endoscopic endonasal route allows exposure of the pterygopalatine fossa through its anteromedial surface (Fig. 1). To simplify the description of the endoscopic anatomy of the pterygopalatine fossa, we considered bone, vascular, and nerve structures separately.

The medial wall of the maxillary sinus and the middle turbinate are removed to gain access to the posterior wall of the maxillary sinus and the sphenopalatine foramen, through which the sphenopalatine artery reaches the nasal cavity (Fig. 2).

The orbital process of the palatine bone is removed and the sphenopalatine foramen is enlarged. The posterior wall of the maxillary sinus is then removed up to the vertical

![Fig. 1. Schematic drawings in sagittal (A) and coronal (B) views showing the endoscopic endonasal surgical route to expose the pterygopalatine fossa.](image)

![Fig. 2. Photographs showing endoscopic views of the bone landmarks of the right nostril. A: The middle turbinate and the medial wall of the maxillary sinus have been removed to gain access to the medial and posterior walls of the pterygopalatine fossa and to expose the sphenopalatine foramen. B: View of the entrance of the sphenopalatine artery through the sphenopalatine foramen in a fresh cadaveric specimen. Co = choana; EB = ethmoid bone; op = orbital process of the palatine bone; PB = palatine bone (vertical process); pwMS = posterior wall of the maxillary sinus; SB = sphenoid bone; SER = sphenoid ethmoidal recess; sp = sphenoid process of the palatine bone; SPA = sphenopalatine artery; SPF = sphenopalatine foramen; V = vomer.](image)
process of the palatine bone medially, and up to the angle between the lateral and posterior wall of the maxillary sinus laterally to expose the pterygomaxillary fissure, which represents the communication between the pterygopalatine and the infratemporal fossas (Fig. 3). The anterior surface of the pterygoid process now becomes visible, and the pterygoid canal, the foramen rotundum, and the inferior part of the superior orbital fissure, which is external to the pterygopalatine fossa, are finally identifiable.

The vidian nerve and artery pass through the pterygoid canal and reach the superior portion of the pterygopalatine fossa. The vidian nerve runs from the lacerum segment of the internal carotid artery as far as the pterygoid canal; passing through this canal it reaches the pterygopalatine ganglion in the upper portion of the pterygopalatine fossa. The vidian nerve is an important landmark for the foramen lacerum and for the intrapetrous carotid artery.

Through the foramen rotundum, the maxillary nerve travels from the cranial cavity into the pterygopalatine fossa. After piercing the foramen rotundum, this nerve passes through the pterygopalatine fossa and then reaches the inferior orbital fissure. Before it becomes the infraorbital nerve, the maxillary nerve gives rise to the posterior alveolar nerve. The infraorbital nerve is a consistent landmark that delimits the surgical boundaries between the pterygopalatine and the infratemporal fossa. The pterygopalatine fossa is located medially to it, whereas the infratemporal fossa is located laterally to it (Fig. 3D).

Located posteriorly and medially to the pterygopalatine fossa is the sphenoid sinus, which is full of landmarks that are useful in orienting the surgeon during live operations on lesions extending to the pterygopalatine fossa (Fig. 4).

After the fascia that covers the pterygomaxillary fossa is incised and the fat inside the fossa is removed, the maxillary artery (that is, the first vessel to be identified) becomes visible. The maxillary artery runs on the anterior edge of the lateral pterygoid muscle and reaches the pterygopalatine fossa through the pterygomaxillary fissure. This artery has a tortuous and variable route, but is always on an ante-

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Fig. 3. Photographs showing exposure of the bone landmarks of the posterior and lateral walls of the pterygopalatine fossa in a right nostril approach. A: Drilling of the orbital process of the palatine bone to enlarge the sphenopalatine foramen and expose the medial wall of the pterygopalatine fossa. B: Endoscopic view after removal of the posterior wall of the maxillary sinus. It is now possible to recognize the pterygoid process and the pterygomaxillary fissure, which form the posterior and lateral walls, respectively, of the pterygopalatine fossa. Note the fissure, foramen, and canal at the base of the pterygoid process. A needle has been inserted from the infratemporal fossa through the pterygomaxillary fissure. C: Endoscopic view of the lateral wall (that is, the pterygomaxillary fissure) of the pterygopalatine fossa through the infratemporal fossa. After removal of the posterior wall of the maxillary sinus, the pterygomaxillary fissure is enlarged in an ovoid fashion. D: A needle has been inserted from the intracranial surface of the skull base through the foramen rotundum and the infraorbital canal to define the limits between the infratemporal and pterygopalatine fossas. FR = foramen rotundum; gwSB = greater wing of the sphenoid bone; IOC = infraorbital canal; MB = maxillary bone; PC = pterygoid canal; PMF = pterygomaxillary fissure; PP = pterygoid process; SOF = superior orbital fissure; swMS = superior wall of the maxillary sinus; TB = temporal bone.
rior plane with respect to the nerves inside the fossa. The maxillary artery passes through the pterygopalatine fossa and ends with the origin of the sphenopalatine and the descending palatine arteries (Fig. 5A).

As soon as the maxillary artery enters the pterygomaxillary fossa, it branches into two collateral vessels: the posterosuperior alveolar branch, which is small, and the infraorbital branch, which courses with the infraorbital nerve in the homonymous canal (Fig. 5B).

The sphenopalatine artery is the uppermost and medially located vessel in the fossa and is sometimes hidden by the orbital apophysis of the palatine bone. Once the nasal fossa is reached posterior to the tail of the middle turbinate, the sphenopalatine artery divides in two branches: one, called the “nasopalatine artery,” is medial and directed to the nasal septum; the other, called the “posterior nasal artery,” is directed to the tails of the turbinates.

From a neurosurgical point of view, the two most important landmarks inside the pterygopalatine fossa are the vidian and the maxillary nerves. Both reach the pterygopalatine fossa from its upper part, and their identification allows the definition of a surgical corridor between them that enables the exposure of the lateral wall of the sphenoid sinus (Fig. 6A).

This surgical corridor has a quadrangular shape; it is delineated posteriorly by the intrapetrous segment of the intracavernous carotid artery and by the inferior segment of the vertical tract of the same vessel, and anteriorly by the pterygoid bone extending from the foramen rotundum to the pterygoid canal. This area is bordered superiorly by the maxillary nerve and inferiorly by the vidian nerve (Fig. 6B). The quadrangular area can be involved by lesions arising in the pterygopalatine fossa, extending toward the middle cranial fossa and/or the cavernous sinus, and vice versa. It can
Extended endoscopic endonasal approach to the pterygopalatine fossa

Fig. 6. Photographs showing results of the transethmoid–transpterygoid approach made with exposure of the lateral wall of the sphenoid sinus to gain access to the middle cranial fossa and/or to the cavernous sinus. A: The superior portion of the pterygopalatine fossa has been exposed and the neural landmarks have been identified. B: The fascia covering the pterygopalatine fossa has been exposed passing above the pterygopalatine fossa via a transethmoid–transpterygoid route, which requires sectioning of the vidian nerve and lateral displacement of the pterygopalatine contents, preserved within its fascia. The latter route is even more invasive when compared with the transethmoid–transpterygoid one, but it allows a more direct and wide access to the lateral wall of the sphenoid sinus. OCR = optocarotid recess; OP = optic protuberance; swPF = superior wall of the pterygopalatine fossa; VN = vidian nerve; V2 = maxillary nerve.

be exposed passing above the pterygopalatine fossa via a transethmoid–transpterygoid route or via a transsphephenoid–transpterygoid route, which requires sectioning of the vidian nerve and lateral displacement of the pterygopalatine contents, preserved within its fascia. The latter route is even more invasive when compared with the transethmoid–transpterygoid one, but it allows a more direct and wide access to the lateral wall of the sphenoid sinus. The limitation of this route involves the extension of bone removal of the pterygoid process. It cannot be extended too laterally if one wants to avoid destabilization of the pterygoid process and, consequently, problems with mastication due to malfunction of the lateral pterygoid muscle (which opens the jaw) and the medial pterygoid muscle (which governs the slight lateral shift of the mandible during chewing; Fig. 7).

DISCUSSION

During the past two decades there has been increased use and proliferation of the endoscope in sinonasal functional surgery. The confidence gained by surgeons, along with the potential offered by this device to visualize the surgical field safely and effectively, has recently expanded the use of the endoscope to include neoplasms and the regions around the nasal cavities. The endoscopic endonasal, transsphenoidal approach for the removal of sellar lesions is only one example of this evolution.\(^{2,4,5,11}\)

The use of the endoscope together with the progress in diagnostic imaging modalities and the availability of intraoperative neuronavigation systems has allowed a further broadening of the indications for endoscopic endonasal procedures. In this way, during the past few years the use of extended endoscopic endonasal approaches for lesions involving the cavernous sinus, the clivus, or the planum sphenoidale have been reported from different centers around the world.\(^{3,10,12}\)

The extended endoscopic endonasal approach to the pterygopalatine fossa that is described here has been proposed as a new, minimally invasive surgical approach to this deep location. Because of the communication of this region with different intra- and extracranial areas, there are several entities of neurosurgical interest that could be approached via this route.

There are only a few reports in the literature involving the use of the endoscopic endonasal approach for the removal of pterygopalatine fossa lesions. Klossek, et al.,\(^{13}\) have reported one case of schwannoma of the pterygopallatine fossa, and Pasquini, et al.,\(^{14}\) described a benign schwannoma of the sinonasal tract involving the pterygopallatine fossa. In both cases, the lesions were successfully removed via an endoscopic endonasal approach.

Recently, Alfieri, et al.,\(^1\) in an anatomical study, described three different endoscopic endonasal approaches to the pterygopallatine fossa: 1) the endonasal middle meatal transpalatine approach; 2) the endonasal middle meatal transantral approach; and 3) the endonasal inferior turbinectomy transantral approach. In their results they found the first approach suitable for medial exposure of the pterygopallatine fossa contents and the second was useful to obtain a lateral view of the fossa, whereas the third approach offered the widest view and room for surgical maneuvering in the medial and lateral compartments of the pterygopallatine fossa.

We have used a variation of the first two approaches depending on the extension of the lesion. The removal of the inferior turbinate has not been performed because this structure plays an important role in the maintenance of the physiological turbulence of the nasal airstream, which provides warmed, humidified, and filtered inspired air.

In our experience we found some advantages in using the endoscopic approach. With the standard microscopic transmaxillary–transantral route the surgeon has an excellent three-dimensional view on one face of the region, whereas with the endoscope he has only two-dimensional vision, but the view is dynamic. This means that it is possible to look all around the surgical field. The third dimension can be simulated by the active movement of the endoscope, which provides a sense of depth. In addition, the proximity to the active portion of surgical dissection achieved with endos-
copy cannot be recreated with the operating microscope. This active endoscopy does require “four-hand” surgery, with the otolaryngologist maneuvering the endoscope. Furthermore, with the endoscope it is possible to use the same access (for example, the nostril) to expose regions contiguous with the pterygopalatine fossa, either to uncover further landmarks, for a better surgical orientation, or to extend the exposure and resection even further, with the goal of accomplishing a more complete lesion removal with less morbidity.

Even though this region is relatively small and its location is deep, in the presence of tumors, especially benign ones, all the neurovascular structures are displaced by the lesion itself, which creates or enlarges some corridors that otherwise could be difficult to access through the endonasal route. Under these conditions, it is relatively easy to manipulate the blood vessels or the nerves within these spaces.

To permit adequate presurgical planning for lesions involving this region, a detailed knowledge of the appearance of the pterygopalatine fossa and its communications on computerized tomography scans is needed, and dedicated instrumentation and tools for the surgical manipulation of the anatomical structures located in this region are also required.

**CONCLUSIONS**

Based on our cadaveric study we think that the endoscopic transnasal approach to the pterygopalatine fossa could be considered an effective method for the removal of benign tumors in the deep region. This approach improves access and visualization of the pterygopalatine fossa and has the potential to reduce complications and length of hospitalization compared with open approaches. The endoscopic approach could be a valid alternative to the standard

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**Fig. 7.** Photographs showing the transsphenoid–transpterygoid approach. A: The anterior and inferior walls of the sphenoid sinus have been removed. The right vidian nerve has been cut at the level of its entrance into the pterygopalatine fossa. B: The pterygopalatine fossa contents enclosed in its fascia have been lateralized and the anterior face of the pterygoid process has been exposed. C: The exposed bone of the pterygoid process has been removed and the lateral wall of the sphenoid sinus is now visible. D: The vidian nerve and the maxillary branch of the trigeminal nerve have been exposed. ICA = intracavernous carotid artery; lwSphS = lateral wall of the sphenoid sinus; PF = contents of the pterygopalatine fossa enclosed in its fascia; PG = pituitary gland.
microscopic transmaxillary–transantral route, in which a gingival–buccal incision is performed.

Image guidance systems and dedicated surgical instruments and tools are needed to perform this procedure in a safe and effective way. The operation should only be performed by experienced surgeons who are well trained in the use of the endoscope through the nasal and paranasal cavities. We expect that an increasing number of pathological conditions will be treatable by using this minimally invasive endoscopic approach.

References


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