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ORIGINAL ARTICLE

Extended endoscopic approaches for midline skull-base lesions

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Abstract The endoscopic transsphenoidal approach has been reported in the literature as a useful tool to treat sellar and parasellar lesions. The endoscope permits a panoramic view instead of the narrow microscopic view, and it allows the inspection and removal of the lesions of sellar, parasellar, and suprasellar compartments by angled-lens endoscopes. On the basis of the experience gained with the use of the endoscope, we have performed extended endoscopic endonasal transsphenoidal approach in 13 of 200 (total endoscopic transsphenoidal approaches since September 1997) patients for the last 5 years. Extended endoscopic transsphenoidal approach was performed for three patients with pituitary adenoma, two patients with craniopharyngioma, one patient with metastatic lesion, one patient with anaplastic germinoma, two patients with chordoma, one patient with chondrosarcoma, one plasmocytoma, and two patients with tuberculum sella meningioma. Total removal of the tumor was achieved in nine patients and subtotal removal was achieved in four patients. Extended approaches are essential for reaching the area from lamina cribrosa to the cranio-cervical junction. Endoscopic approach permits reaching the lesion without brain retraction and with minimal neurovascular manipulation. The main problems are related to the hemorrhage control of intracranial vessels and to the closure of the dural and bony defects, with subsequent increased risk of postoperative cerebrospinal fluid leak, tensive pneumocephalus, and/or meningitis.

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Introduction

Recently, endoscopic endonasal transsphenoidal surgery has been progressively accepted by neurosurgeons. In many centers throughout the world, this technique is now routinely used under the same indications as conventional microsurgical technique. In 1963, Guiot et al. first proposed the use of the endoscope as a part of transnasorhinoseptal microsurgical approach. Some authors have described an endoscope-assisted technique, to complement the microscope in the early or late stages of a traditional procedure. “Pure” endoscopic endonasal transsphenoidal surgery has been described in detail by Jho et al. [24]. Extended transsphenoidal approach and originally described by Weiss in 1987 [41]. Expanded and extended endoscopic approaches were reported overtime [2–5, 7, 10–14, 17–20, 29–32, 36, 39]. Extended approaches are essential for reaching the area from lamina cribrosa to the cranio-cervical junction.

Materials and methods

Retrospective analysis was performed for 200 endoscopic transsphenoidal approaches in our department between September 1997 and May 2008. We have performed only standard endoscopic approach for the first 40 cases, since endoscopic transsphenoidal surgery requires a learning curve [37]. On the basis of the experience gained with the use of the endoscope, we have performed extended endoscopic endonasal transsphenoidal approach in 13 of 200 patients for the last 5 years.

Extended endoscopic transsphenoidal approach was performed for three patients with pituitary adenoma, two patients with craniopharyngioma, one patient with metastatic lesion, one patient with anaplastic germinoma, two patients with chordoma, one patient with chondrosarcoma, one plasmocytoma, and two patients with tuberculum sella meningioma (TSM) (Table 1). All the patients have been treated at Kocaeli University, Department of Neurosurgery. Each patient was examined preoperatively with 1.5-T contrast-enhanced magnetic resonance imaging (MRI).

The extent of surgical removal was evaluated on the basis of postoperative magnetic resonance imaging scans obtained in the immediate postoperative period and 3 months later. The extent of surgical resection was determined radical, subtotal (the clear presence of residual tumor but with resection of more than 80% of the tumor), and partial (the clear presence of residual tumor but with resection of less than 80% of the tumor). Tumor pathological type was confirmed by the department of pathology. Ophthalmological examination was performed with Humphrey perimetry for visual field function, and Hess chart evaluation for ocular motility. Minimum follow-up time was 2 months and maximum follow-up time was 44 months (Table 1). We performed electrophysiological detection of oculomotor, trochlear, and abducens nerves using intraoperative monitoring (Nim-Plus Xomed). The cranial nerves were stimulated with a monopolar stimulator electrode and eye movements evoked by the stimulation were monitored with an auditory signal.

Equipment A 0° endoscope, 4 mm in diameter (Karl Storz Endoscopy, Tuttlingen, Germany), was used during the whole surgical procedure. Angled endoscopes have been used to allow a panoramic view on the lesion and on the surrounding neurovascular structures, with a 0° endoscope. Intraoperative micro Doppler system (Mizuho America, Beverly, MA) is also a useful tool to render the procedure safer because it helps in preventing vascular injury to the intracavernous carotid artery and other intracranial vessels, especially during use of microdrill for the lateral borders of the tuberculum sellae fenestration and before the dura opening. We used not only standard endoscopic transsphenoidal surgical instruments but also specially designed instruments like curved aspirators.

Surgical approaches

Extended endoscopic transsphenoidal surgical techniques were described by several authors in the literature [10–13, 18, 20, 29–32, 36]. Herein, basic steps of surgical approaches were explained briefly. Surgical approaches were performed through both nostrils in all cases. After removing the middle turbinate of appropriate nasion (mostly preferred right nasion) the posterior nasal septum was removed. Mucosa of nasal septum was incised to form a flap with its pedicle for closure. The middle turbinate of the contralateral nostril was pushed laterally providing binostril access.

Extended approach was performed by two surgeons through both nostrils providing the surgeons to use two or three more surgical instruments together with the endoscope. This provides the surgeons with a deep perspective and a closer view during the intradural maneuvers. Wider anterior sphenoidotomy than a standard sellar lesion have been performed to reach to the suprasellar area. In our cases, resection of anterior and posterior ethmoid cells, total or partial removal of middle turbinate with medial pterygoid process resection has been performed according to tumor localization and requirements. Surgical procedures have been continued according to the lesion localization.

Table 1 Characteristics of the patients

Number of the patient	Age and sex	Pathologic type	Follow-up time	Resection volume
1	43 M	Chondrosarcoma	44 months	Subtotal
2	42 M	Chordoma	29 months	Total
3	55 M	Chordoma	25 months	Total
4	53 F	Metastasis	29 months	Total
5	65 F	Plasmocytom	19 months	Total
6	53 F	Invasive adenoma	7 months	Total
7	45 F	Tuberculum sella meningioma	2 months	Total
8	47 F	Tuberculum sella meningioma	10 months	Subtotal
9	55 F	Craniopharyngeoma	29 months	Total
10	43 F	Craniopharyngeoma	22 months	Total
11	43 F	Prolactinoma	6 months	Subtotal
12	13 M	Anaplastic germinoma	2 months	Subtotal
13	54 M	Invasive adenoma	7 months	Total

For tuberculum sella meningiomas The bone of tuberculum sellae was thinned using a diamond drill and the upper half of the sella was removed. Opening of the planum has been extended in a posteroanterior direction about 1.5 cm, lateral extension of the opening is limited by the protuberances of the optic nerves (Fig. 1a,b). For the cases with plasmacytoma, invasive adenoma, chordoma (Fig. 2a,b), and chondrosarcoma, we extended the bone removal to the posterior portion of the vomer and the sphenoidal floor to access the lower clivus. The anterior intercavernous sinus should be controlled before the dura is opened. The sinus mostly runs within the dura of the upper part of the sella. Dural incision was performed horizontally and is then enlarged. After viewing the lesion, an ultrasonic aspirator was used in most of the cases especially for tuberculum sella meninigioma to decrease the lesion in volume; thus, tumor removal is performed avoiding injury of the surrounding structures. Tumor removal has been performed by fine and meticulous dissection from the surrounding structures. We have used combined approaches rather than defined standard cavernous sinus approaches for the cases with giant adenoma extending suprasellar and parasellar and craniopharyngiomas. In these approaches, after middle turbinate resection on one side, the middle turbinate of the other side was pushed laterally. We have removed the posterior part of the nasal septum and rostral part of the vomer, thus, single a widened operative area has been provided allowing usage of two or three surgical instruments (curets, ultrasonic aspirator, bipolar; Fig. 3).

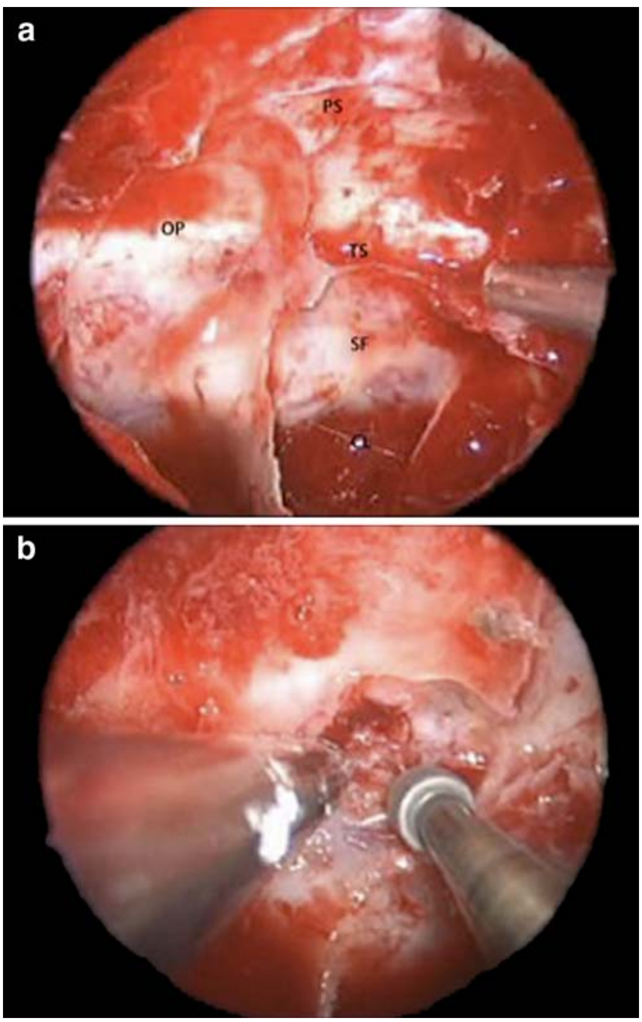

Fig. 1 a,**b** A 45-year-old female with tuberculum sella meningioma (PN: 7). **a** Intraoperative view of posterior sphenoid sinus wall after removal of anterior sphenoid wall. **b** The bone of tuberculum sellae was thinned using a diamond drill. *PS* planum sphenoidale, *TS* tuberculum sella, *SF* sphenoid wall, *OP* optic protuberance, *C* clivus

After removing sellar component, we have removed the tumor localized in cavernous sinus using medial and lateral corridors. The dissection and the removal of the lesion in the suprasellar and parasellar area were performed using specifically designed instruments and bipolar forceps. Tumor-removal planning was modified for each lesion, thus it will be different in craniopharyngiomas, pituitary adenomas, metastatic lesions. Micro Doppler was used before and after dural incision verifying carotid artery localization and during the tumor removal in all cases (Fig. 4). Tumor removal was performed by careful dissection from the chiasm, the stalk, and the superior hypophyseal arteries (Figs. 5 and 6). The anterior communicating artery complex, located above the chiasm, is protected by an arachnoidal sheet (Fig. 7). At the end of the tumor resection, the surgical cavity was inspected with 0° and 30° endoscopes to check the entirety of the removal and to control any bleeding. In our cases with craniopharyngiomas, lesions were prechiasmatic with intrasellar cystic components and removal of these difficult lesions is safer and more effective than transcranial approaches (Fig. 8). In the case with anaplastic germinoma, the patient underwent operation for three times; once, microscopic transsphenoidal, two times, transcranial approach in another center and subtotal resection was performed. Also, the patient had received gamma knife surgery. We have performed extended endoscopic transsphenoidal approach for this case and reached to pons passing through the clival dura and observed vascular structures and subtotal resection has been performed (Figs. 9 and 10). Following this approach, the patient underwent transcranial approach and resection of the lesion was continued.

Closure method Following tumor removal, effective dural closure should be performed to avoid postoperative CSF fistula in extended approaches [6, 23, 28, 40]. In our cases, a multilayer technique has been used to close the suprasellar defect following the closure of the sella floor and posterior sphenoid sinus wall. After the removal of the lesion, a single layer of surgical and fat graft was positioned inside the residual cavity. A dural graft was covered over the fat graft

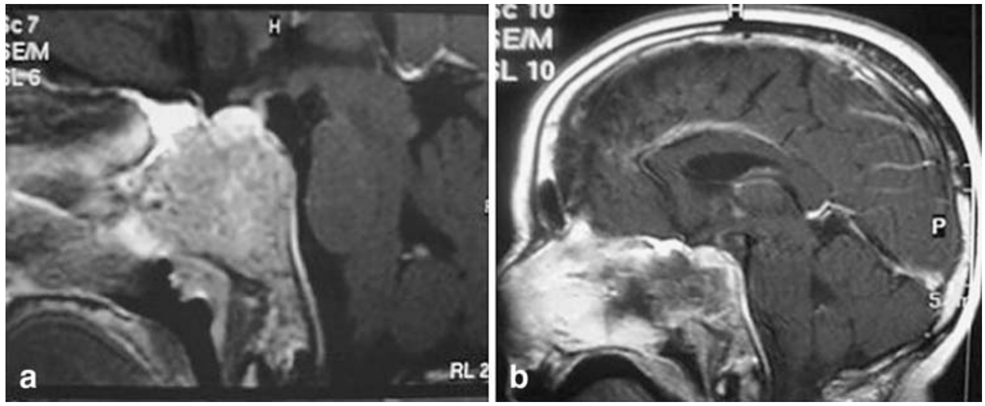

Fig. 2 a,b Preoperative and postoperative sagital MRI of a 55-year- old female with chordoma (PN: 3). Total resection has been performed

and positioned in the intradural space and a bone graft was used considering the borders of bone which is the solid barrier between the intra- and extradural compartments. Reconstruction have been continued by multiple layers of dural grafts and by mucosal flap with its pedicle slipped from the original nasal septum. Surgical glues have been used to fill the sphenoid cavity and hold the repair in place. A Fogarty catheter (12–14 French) was inflated in the posterior nasal cavity just in front of the opened sphenoid sinus in cases where a flap with pedicle was used.

Results

The follow-up period was between 2 and 44 months (median: 17.76 months) Postoperative CSF fistula was observed in five patients and lumbar drainage was performed for those patients. CSF leakage stopped in four of five patients by lumbar drainage and one of them needed reoperation (7.7%) due to CSF fistula.

The extent of surgical removal was evaluated on the basis of postoperative magnetic resonance imaging scans obtained in the immediate postoperative period and 3 months later.

Total removal of the tumor was achieved in nine of 13 patients and subtotal removal was achieved in four patients. A patient with anaplastic germinoma died due to hemorrhage on the postoperative period during the course of intensive care. Transient diabetes insipidus was seen in three patients and permanent diabetes insipidus was seen in none of the patients.

Discussion

During the past few years, the transsphenoidal approach for removal of extrasellar lesions has been reported with increased frequency. Tumors located in the anterior cranial

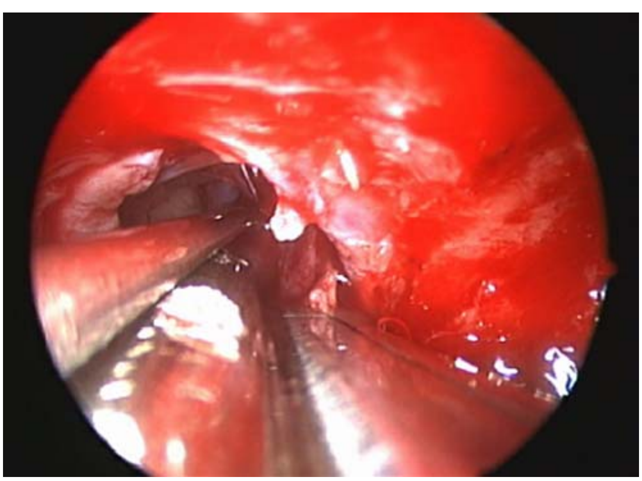

Fig. 3 Intraoperative view of 45-year-old female with tuberculum sella meningioma (PN: 7). After removal of posterior part of the nasal septum and rostral part of the vomer, single widened operative area has been provided allowing usage of two or three surgical instruments (curets, ultrasonic aspirator, bipolar)

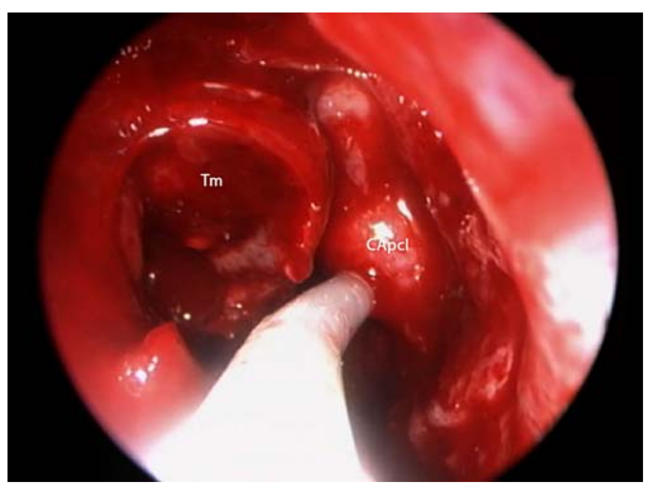

Fig. 4 Intraoperative view of micro Doppler usage to verify carotid artery localization during the tumor removal of a 53-year-old female with invasive adenoma (PN: 6) *CApcl* paraclival carotid artery, *Tm* tumor

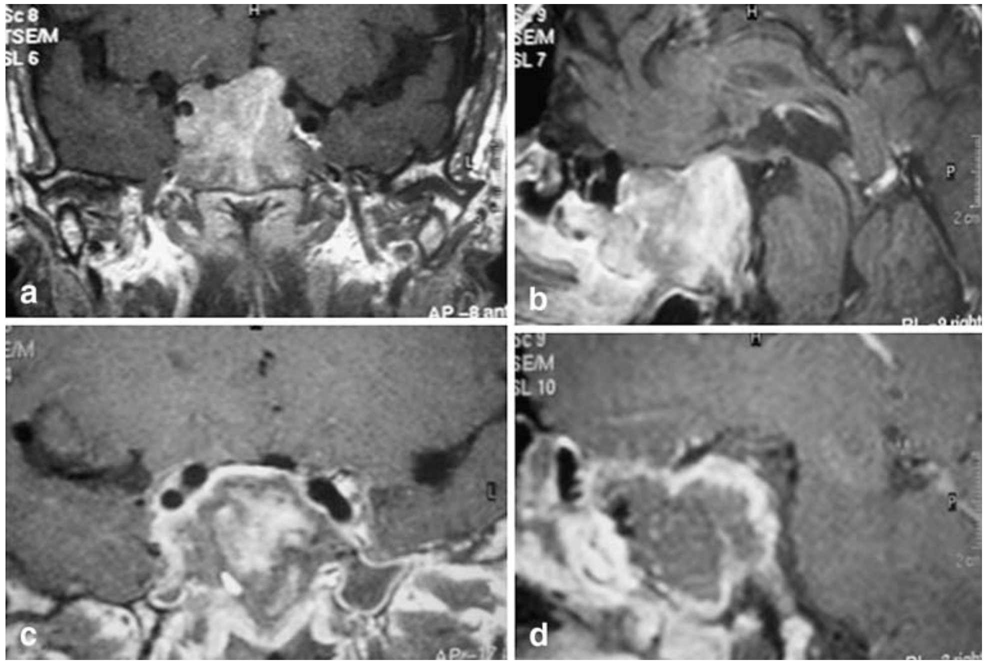

Fig. 5 Preoperative and postoperative sagittal and coronal MRI of a 53-year-old female with invasive adenoma (PN: 6). Total resection has been performed

base that were thought to be accessible only from the transcranial approaches are now being approached through a so-called extended transsphenoidal route, a modification of the more routine standard transsphenoidal exposure, sublabial or endonasal, microscopic, or endoscopic.

Lesions located in the suprasellar area are commonly removed by transcranial approaches, through a pterional or subfrontal route [11, 22, 38]. Transcranial approaches carry risks, mainly related to the brain retraction and manipulation of the neurovascular structures.

The craniopharyngiomas were classified as prechiasmatic or retrochiasmatic; they were classified as supradiaphragmatic or sellar and suprasellar according to radiological and intraoperative findings [18]. In our cases, lesions were prechiasmatic with intrasellar cystic components. Removal of this type of lesions through the endoscopic extended transphenoidal approach is safer and more effective than standard transcranial approaches.

Surgical excision of chordomas and chondrosarcomas has been performed using various approaches ranging from the transsphenoidal approach to craniotomy open approaches [20]. The choice of the surgical approach of these tumors depends on the extension and on the anatomic location. Until today, only a few articles have described the

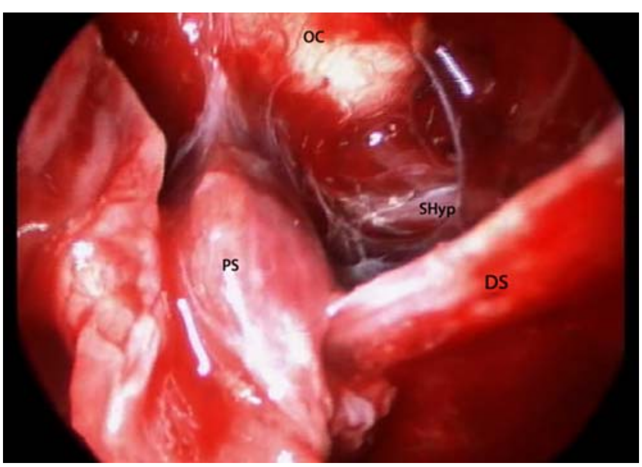

Fig. 6 A 53-year-old female with invasive adenoma (PN: 6). Intraoperative view of the chiasm, the stalk, and the superior hypophyseal arteries after cutting out stalk and removal of the tumor. *OC* optic chiasm, *PS* pituitary stalk, *Shyp* superior hypophysial artery, *DS* diaphragma sella

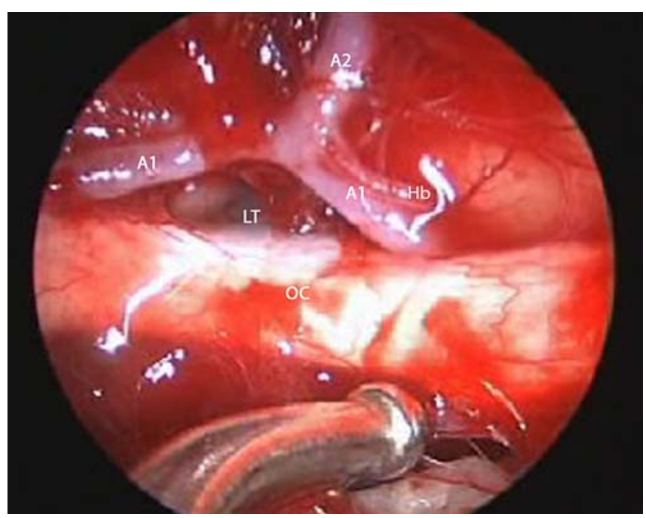

Fig. 7 A 45-year-old female with tuberculum sella meningioma (PN: 7). Intraoperative view of anterior communicating artery complex (*A1*, *A2*), located above the chiasm. *OC* optic chiasm, *LT* lamina terminalis

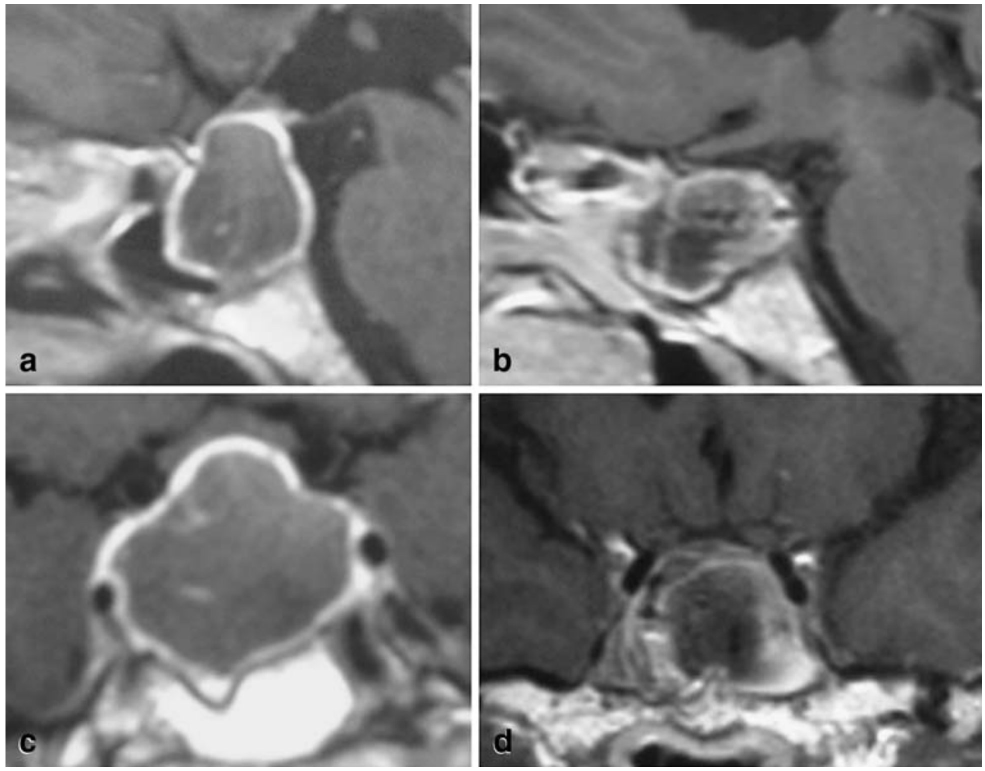

Fig. 8 Preoperative and postoperative sagittal and coronal MRI of 55-year-old female with craniopharyngeoma (PN: 9). Total resection has been performed

usefulness of the endoscopic transsphenoidal approach for the treatment of cranial base chordomas [20, 25]. For clival lesions, it is easier to work on the midline projection due to absence of vascular structures and wide surgical corridor can be exposed by removing the posterior part of the vomer.

Three different types of extended transsphenoidal techniques are currently used for TSM: microsurgical, with its variations (sublabial, transrhinoseptal, and direct endonasal), endoscopic endonasal, and endoscope-assisted microsurgery [1, 8, 9, 13, 24, 26, 27, 34, 35, 39].

de Divitiis et al. classified the tuberculum sella meningiomas based on Yasargil's criteria as measuring up to 2 cm (Type I), measuring 2 to 4 cm (Type II) and more than 4 cm (Type III).which can be approached endoscopic transsphenoidally as small or medium sizes with limited dural attachment and without vascular encasement, calcification [13]. In our first case, the tumor size was 4 cm and had cisternal invasion so following partial resection of the lesion we have used transcranial approach and resection of the tumor was performed. In the second case, the tumor size was about 2 cm (type 1) and was limited dural attachments and without vascular encasement thus total resection could be performed (Fig. 11a,b,c,d). For tuberculum sella tumors with type II and type III or/and with vascular encasement and cisternal invasion, transcranial approach should be done. Although it is still not a standardized procedure, in carefully selected cases (i.e., small midline lesions, without major vessel encasement, or parasellar extension and type I lesions and in experienced hands), endoscopic transsphenoidal approach can be considered an alternative choice for tuberculum sella meningiomas.

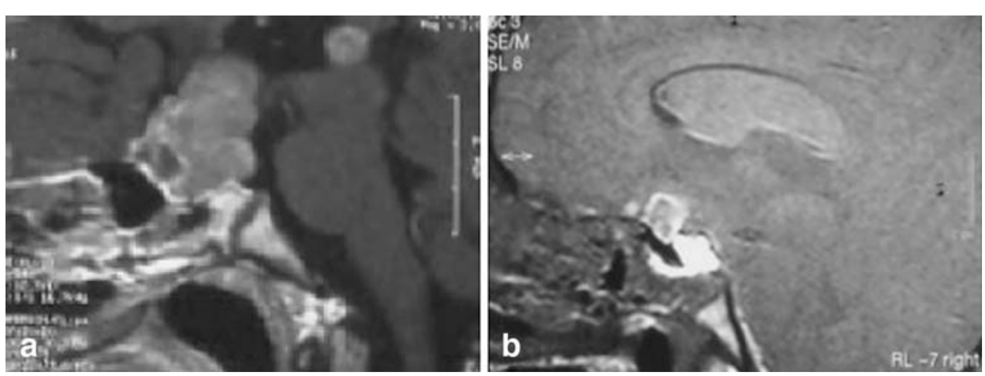

Fig. 9 Preoperative and postopertive sagital MRI of a 13-year-old male patient with anaplastic germinoma (PN: 12). Subtotal resection has been performed after endoscopic transsphenoidal approach and transcranial approach

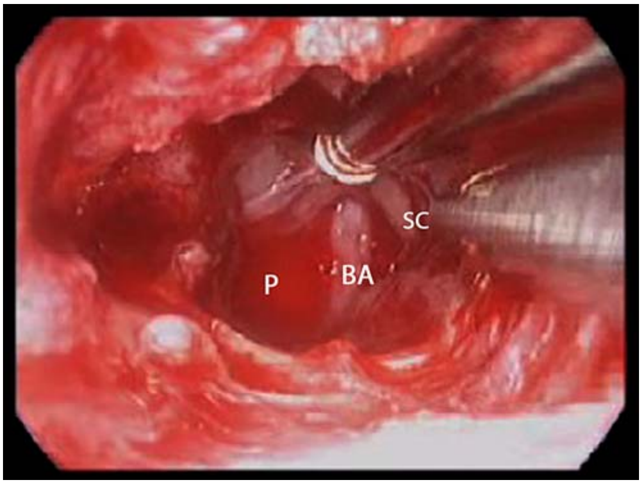

Fig. 10 Intraoperative view of 13-year-old male patient with anaplastic germinoma (PN: 12). Vascular structures have been observed after removal of the tumor. *P* pons, *BA* baillary artery, *SC* superior cerebellar artery

The main complications are related to the hemorrhage control of intracranial vessels and to the closure of the dural and bony defects, with increased risk of postoperative cerebrospinal fluid (CSF) leak, tensive pneumocephalus, and/or meningitis.

CSF leakage is one of the main problems in extended approaches. Although free grafts or flaps with pedicle have been used for closure, CSF fistula rate is still high in the literature [6, 23, 28]. CSF leakage rate is 38.46% (five of 13) in our series with a small number of patients. Lumbar drainage was used for those five patients and CSF leakage stopped in four of five patients, only one patient needed reoperation (7.7%).

Usage of free fascia lata graft for tuberculum sella lesions and mucosal flaps with pedicle for clival lesions and application of lumbar drainage for 5–7 days can be an important advance in decreasing CSF leakage.

There are some advantages and disadvantages of endoscopic extended transsphenoidal approach.

This approach allows reaching the lesion without brain retraction and with minimal neurovascular manipulation. Endoscopic extended approaches are mainly for reaching the area from lamina cribrosa to the cranio-cervical junction and require a wider surgical corridor to expose in the different sellar areas. A binostril approach provides not only a wide surgical area but also for hand maneuverability and allows usage of two or three instruments together through both nostrils.

Several authors report using the endoscope-assisted microsurgical technique for extended approaches using the endoscope as an adjunct visualizing tool [9, 10, 15, 16]. In cases of residual tumor observed in lateral corners, they usually need to remove the endoscope and continue the operation with a microscope, and manage the remnant in a blind fashion. Transsphenoidal microsurgical approach has been performed through the sublabial or endonasal route [13, 15, 27, 33, 34]. The nasal speculum is essential in all types of microscopic approaches, and this causes restriction of the microinstruments usage in the limited area created by the speculum [10]. Sometimes, wide spreading of the transsphenoidal retractor at the anterior wall of the sphenoid sinus can carry some risks of optic nerve damage, facial swelling, and nasal pain [10, 21]. These risks can be increased in the extended microsurgical approaches, because it requires a wider exposure compared with the standard approach. The majority of microscopic procedures are performed via a sublabial or transseptal route with dissection of the mucosa to expose the anterior face of the sphenoid. If endoscopic endonasal approach is used, nasal packing is not required. This helps to minimize patients' breathing difficulties, headache, and dryness of the oral mucosa and is associated with excellent patient compliance [16]. The disadvantages and limitations of endoscopy should be considered. The endoscopic system gives computer-processed bidimensional image on the video monitor, which is a problem for depth perspective; besides, binocular stereoscopic vision of the operating microscopes is superior to endoscopic systems.

Endoscope lens produce images with maximal magnification at its center and contraction at its periphery, and the nearest images are disproportionally enlarged, while remote images are falsely miniaturized [10]. This limit can be overcome with continuous in-and-out movements of the endoscope. Handling dedicated endoscopic instruments and the associated different and variably angled tips is challenging when working in the tight corners that the angled endoscopes are designed to expose [10]. One surgeon alone can continue the procedure in microsurgical technique, while endoscopic technique requires two surgeons with experience in the use of the endoscope in standard transsphenoidal surgery [10].

Some pitfalls of extended endoscopic transsphenoidal surgery can be described considering our experience with 13 patients:

- Wide resection of middle/suprema turbinate and anterior and posterior ethmoid cells can cause lamina cribrosa injury and therefore CSF leakage.
- Wide medial pterygoid resection extending to vidian canal in lesions with clival extension can cause vidian nerve and anterior genu of petrous carotid artery injury.
- Tumor extending to clival region can invade paraclival carotid tubercule and after anterior sphenoidotomy, tumor and paraclival carotid artery can be encountered directly together (Fig. 4).

Although the anterior intercavernous sinus is usually compressed in meningiomas but especially in craniopharyngiomas, profuse bleeding may present and force the

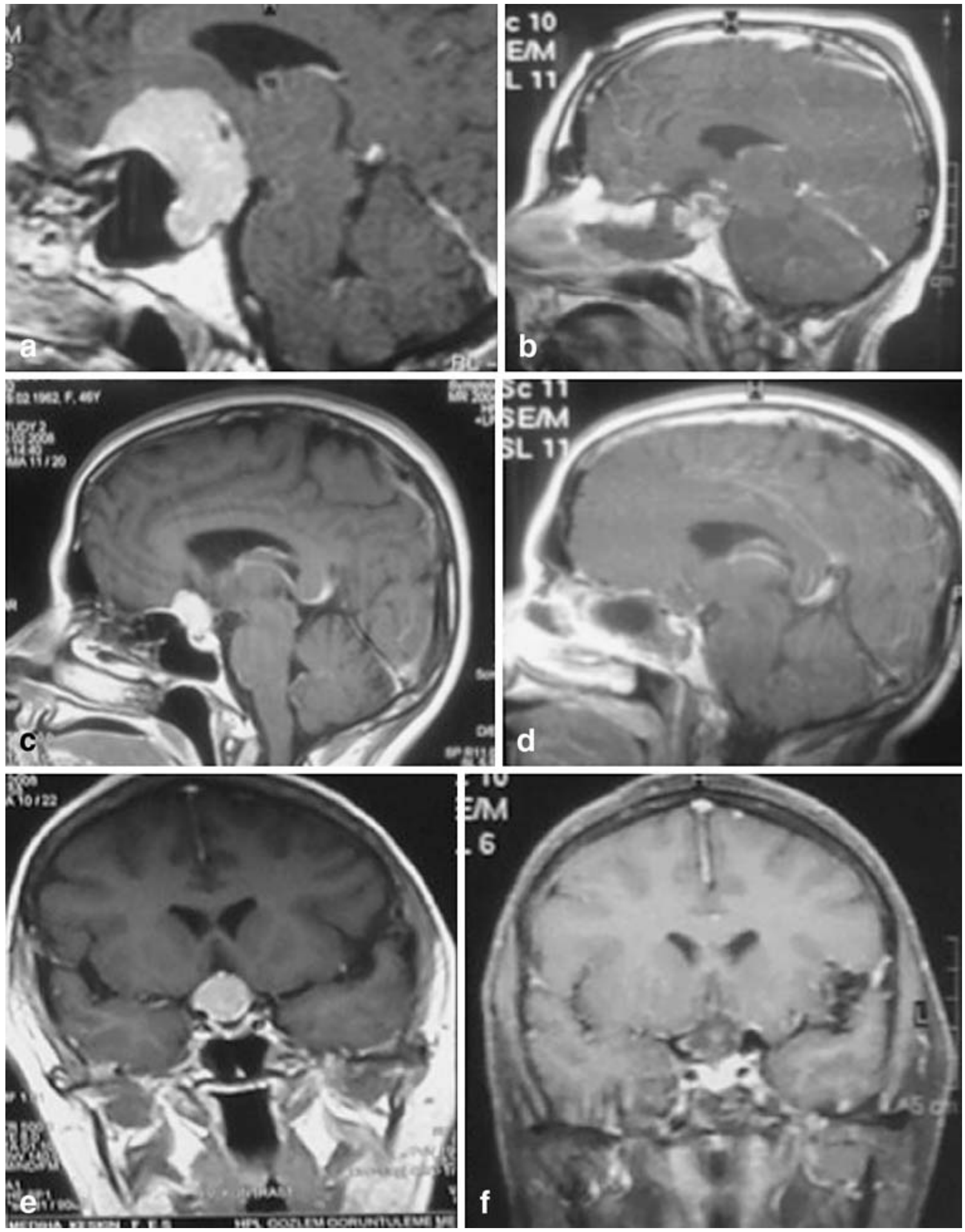

Fig. 11 a, b, c, d, e, f Preoperative and postoperative MRI of two cases with tuberculum sella meningiomas; first case, Sagital MRI: 47-year-old female (PN: 8), tumor size was 4 cm and had cisternal invasion so following partial resection of the lesion, we used a transcranial approach and subtotal resection of the tumor was performed (**a**, **b**). Second case, sagittal and coronal MRI: 45-year-old female (PN: 7), the tumor size was about 2 cm (type 1) and was limited dural attachments and without vascular encasement, thus total resection could be performed (**c**, **d**, **e**, **f**)

surgeon to abort the procedure. The anterior cavernous sinus should be coagulated and cut. The lateral edges of the sinus are coagulated but should not be extended too far laterally to avoid intracavernous carotid arteries injury

Conclusion

Using endoscope for extended transsphenoidal surgery improves postoperative comfort and recovery time as a result of its minimally invasive characteristics. The most important point is to define limitations and cases. The endoscopic transsphenoidal approach is a useful tool to treat sellar and parasellar lesions. The endoscope permits a panoramic view instead of the narrow microscopic view, and it allows the inspection and removal of the lesions of sellar, parasellar, and suprasellar compartments by angled-lens endoscopes. When an endoscope and surgical instruments are inserted without the use of retractor, the flexibility of the surgical trajectory and the maneuverability of the surgical instruments improve significantly.

The main problem in extended approaches is CSF leakage. The rate of CSF leakage should be decreased by improving the surgical technique. Extended approaches are essential for parasellar and anterior cranial base lesions reaching the area from lamina cribrosa to the cranio-cervical junction. Experienced neurosurgeons in endoscopy with the proper surgical tools, and in selected cases, extended endoscopic transsphenoidal surgery, can be expected to have better results than conventional microscopic techniques. Further studies should be performed to correspond to these techniques.

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Comments

Luis A Borba, Curitiba, Brazil

I believe that this kind of approach may not be necessary in some cases; an example is the radical removal of plasmocytoma or anaplastic germinomas that could have an increased risk of CSF leakage in the post-RT period, which certainly will need an adjuvant RT or CT, increasing the risk of CSF leakage after the post-RT period.

− Case of chordoma: a MRI in coronal view can demonstrate the “advantage” of the approach, not the sagittal view.

− Case of invasive pituitary adenoma. I cannot see the advantage over the pure endonasal-assisted or not by endoscope, the false invasion of the cavernous sinus (Fig. 5) may be an issue of confusion.

− The meningioma cases: I believe that the first (Fig. 11a) case is a contraindication to the endoscopic procedure, because the tumor is encasing the basal arteries, and I am not surprised about the impossibility to remove the tumor. The second case (Fig. 11c) may be a good candidate.

During the last decade, the utilization of endoscopic approach to sellar and parasellar lesions has increased. The high quality of illumination and the fish-eye view are the greatest advantage of the endoscope. A 30° or 45° scope allows the visualization of corners unreachable by microscopic view. Despite this very important progress, the pure endoscopic technique has several limitations including the 2D view, the utilization of long and unstable instruments, and, in some situations, a one-hand dissection. The endoscope is very welcome in neurosurgery, but it is not a substitute for microsurgical techniques. The need to push new techniques can be, in the future, responsible for its death.

In the present paper and in the literature, the utilization of pure endoscopic approach does not prove to be superior to directly endonasal approach combining microsurgery and assisted endoscope-associated or not to minimal maxillary osteotomes.

The management of frontal base meningiomas through endonasal approach is a new and brave surgical technique. In my opinion, the removal of meningioma through the nose, makes a simple surgical procedure a more dangerous and unsafe method.

I believe that anterior approaches (endoscopic or not) are reserved to midline lesions (medial to both ICA), extradural, with or without intradural extension. A purely intradural lesion must be removed through an intradural approach.

What is new does not mean that it is better; many times it is more dangerous and unsafe.

Robert Reisch, Zurich, Switzerland

In this paper, Ceylan et al. describe their experiences with endoscopic transsphenoidal approaches treating midline skull-base lesions. Extended approaches were performed for 13 of 200 endoscopically treated patients during a period of 5 years.

Endoscopic techniques offer several advantages in transsphenoidal surgery. Advantages in visualization are the increased light intensity in the deep-seated surgical field and the clear representation of patho-anatomical details. The extended viewing angle of endoscopes enables surgeons to observe hidden parts of the surgical field. Advantage in surgical manipulation is the unhindered maneuverability of the micro-instruments. Without using a nasal speculum, surgical dissection is not impeded and the instruments are freely mobile allowing unrestricted approach to the clearly visualized structures.

According to these clear benefits, I obviously recommend the use of endoscopes in transsphenoidal surgery, especially for pituitary tumors and extradural clival lesions of the central skull base. However, in treating intradural lesions, some main problems should be critically discussed:

1. The endoscopic extended transsphenoidal way offers manifest-approach-related traumatization of the nasal cavity. Removal of the middle and superior turbinates, creation of a mucosal septal flap, removal of the posterior septum and wide sphenotomy often cause postoperative nasal fetor and anosmia with long-term problems among patients. In comparison, a supraorbital keyhole craniotomy and transcranial dissection presents a minimal invasive way, approaching similar intracranial lesions.
2. Maneuverability of the instruments through the transnasal way is limited; the often-used “pulling” of the tumor can never be compared with safe microsurgical dissection. Resection of a 4-cm-large meningioma with incorporation of main cerebral vessels is for me a clear contraindication for transsphenoidal surgery.
3. After tumor removal, reconstruction of the cranial base is mandatory and very problematic. The authors describe this problem accurately reporting a CSF leak in 38.46% (five of 13) of patients.

I strongly believe that extradural lesions should be removed via an extradural transsphenoidal way and intradural lesions via an intradural way using minimally invasive endoscopic techniques.

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Hae-Dong Jho, Pittsburgh, US

Ceylan et al. reported their experiences with endoscopic endonasal approaches for midline skull-base lesions that are located beyond the pituitary fossa. Over 5 years, they operated on 13 patients; three with pituitary adenomas, two with craniopharyngiomas, two with meningiomas, three with chordomas or a chondrosarcoma, one with metastasis, one plasmocytoma, and another with a germinoma. They claimed that nine patients had total tumor removal and four, subtotal. One patient died of postoperative hemorrhage. Five out of thirteen patients developed postoperative CSF leakage of which four were treated with lumbar drainage and one required surgical repair. They used a two-nostril technique with two operating surgeons. They used intraoperative neuromonitoring for cranial nerves and intraoperative Doppler for carotid artery localizations. Their patient follow-up was 2–44 months.

I congratulate their successful transition from microscopic transsphenoidal surgery to endoscopic endonasal surgery over the past 10 years. Certainly, there is a steep learning curve for neurosurgeons to perform endoscopic endonasal surgery because neurosurgeons usually do not have formal endoscopic endonasal training during their residency period. Although neurosurgeons perform endoscopic ventricular procedures, endoscopic techniques for endonasal approaches are quite different from endoscopic ventricular surgery. Although the number of cases they have is small and their follow-up period is short, I believe that this paper deserves to be published in order to have readers understand the technical difficulties, potential problems, and intrinsic complications. The endoscope is simply another surgical tool that surgeons can utilize to achieve surgical goals.

The endonasal route is simply another surgical corridor that can be adopted if necessary. However, when surgeons try to use new tools or attempt to perform new techniques, technical difficulties and associated complications are inevitable.

For surgical indications, I agree with them that very select cases of meningiomas at the tuberculum sella, planum sphenoidale, and olfactory groove can be approached with endoscopic endonasal routes. Although I perform endoscopic endonasal approaches for those meningiomas occasionally, I prefer to perform endoscopic transcranial approaches with a mini-incision for meningiomas. Meningiomas usually have a wide tumor base and a wider involvement of the dura mater. Thus, a transcranial route provides better exposure to the whole spectrum of the tumor and its attachment. Occasionally, I still perform endoscopic endonasal approaches for menigiomas, particularly when total resection is certainly feasible in MR findings, or if main mass removal of the tumor alone is sufficient for patients, particularly for very elderly patients. Otherwise, I prefer to perform transcranial endoscopic approaches for meningomas.

Indications for endoscopic endonasal approaches for craniopharyngiomas are also limited to particular cases like the case described in this paper. Whether craniopharyngiomas should be approached through transcranial routes or endonasal routes will be determined by tumor location and its relationships with surrounding tissues. Most pituitary adenomas that require surgery can be approached through endonasal routes. One exception would be a tumor that extends to the middle cranial fossa. Pituitary adenomas that are involving the cavernous sinus can be approached with endonasal routes. However, I have been cautious in approaching the cavernous sinus for pituitary adenomas because radiosurgery is an available treatment option. Surgical attempts also carry higher cranial nerve morbidities. Endoscopic endonasal approaches will be excellent indications for petrous tip cholesterol granulomas, clival chordomas, or chondrosarcomas. Even if total tumor removal is not achieved for clival chordomas or chondrosarcomas, repeated endonasal endoscopic operations in intervals can prolong patient survival quite long following the initial operation and radiation treatment.

S. Ceylan et al., also mention the use of intraoperative neuromonitoring, intraoperative Doppler scanning, and other surgical tools. Although they did not mention it, an image-guiding tool is another tool neurosurgeons are fond of using for complex skull-base surgery. However, we have to balance between what is and is not necessary. Simplifications versus safety have to be judiciously guided. Authors used a two-nostril technique. I prefer to do a one-nostril technique. While the authors like to have two operating surgeons, I prefer one surgeon with endoscope anchored to the endoscope holder. However, the preservation of the nasal anatomy is more important. Surgical approach itself in the nasal cavity should not destroy the normal nasal and paranasal anatomy unnecessarily. As the authors described, skull-base reconstruction is still a main hurdle for endoscopic endonasal approaches to the intracranial pathologies. Although various surgical glues are introduced, they are not yet sufficient to seal the skull base. Various surgical techniques for skull-base reconstructions are still not good enough to prevent postoperative CSF leakage. Although the authors used lumbar drainage in five cases, I personally do not like to use lumbar drainage. When a patient leaks CSF significantly, I prefer to surgically repair it immediately. That hastens the patient's recovery, shortens their hospital stay, and reduces the chance of developing other complications such as meningitis, pneumonia, or venous thrombosis, and pulmonary embolism.

Again, I praise the authors that they share their experiences with others. I have no doubt that they will continually improve their surgical skills and patient outcomes.