12 Supraorbital Approach

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Abbreviations

CSF	Cerebrospinal fluid
EEA	Endonasal endoscopic approach
ICA	Internal carotid artery
MRI	Magnetic resonance imaging
SO	Supraorbital eyebrow approach
SRT	Stereotactic radiotherapy

12.1 Introduction

Craniopharyngiomas represent one of the most challenging brain tumors to treat. Surgical removal is the primary treatment, but complete removal is possible in only 50–70 % of cases. The surgical goal is maximal safe tumor removal with reversal of neurological deficits and complication avoidance. In recent years, minimally invasive keyhole approaches have been increasingly used to remove these tumors that may arise in the sellar, suprasellar, and parasellar regions. Of these approaches, the two most commonly used are the extended endonasal endoscopic transsphenoidal route and the supraorbital (SO) eyebrow craniotomy. Although both approaches may be appropriate for a given patient, in many cases, one route offers a better opportunity for safe and maximal tumor removal.

The most common growth pattern of craniopharyngiomas is into the retrochiasmal suprasellar space with displacement of the optic chiasm into a prefixed or superior location; this pathoanatomy facilitates endonasal endoscopic removal by allowing one to pass under the chiasm directly into the retrochiasmal space. In contrast, for craniopharyngiomas with extrasellar extensions lateral to the supraclinoid carotid arteries and/or into the anterior cranial fossa, a transcranial approach may be required. Given that a majority of craniopharyngiomas arise in the retrochiasmal space, the endonasal endoscopic route is our most commonly used approach for craniopharyngiomas. However, for craniopharyngiomas that require a craniotomy, the SO approach offers a potentially less-invasive alternative to the traditional pterional, cranio-orbito-zygomatic or bifrontal approaches. In our series of craniopharyngioma surgeries over the last 7 years, approximately 25 % had an SO approach while the remainder had an endonasal endoscopic approach.

Using an incision within the eyebrow and a small craniotomy that is flush with the orbital roof, the SO approach offers a direct anterolateral

Electronic supplementary material The online version of this chapter (doi:10.1007/978-3-319-21533-4_12) contains supplementary material, which is available to authorized users.

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© Springer International Publishing Switzerland 2016
P. Cappabianca et al. (eds.), *Midline Skull Base Surgery*, DOI 10.1007/978-3-319-21533-4_12

subfrontal trajectory to the ipsilateral frontal fossa, orbitofrontal lobe, a wide medial portion of the contralateral frontal fossa, parasellar and suprasellar regions, Sylvian fissure, and the anterior aspect of the medial temporal lobe. The SO approach abides by the keyhole principle, of a small well-placed craniotomy that allows relatively wide access to deeper lesions with minimal need for fixed brain retraction. The potential advantages of this approach over conventional transcranial approaches include shorter operative times, reduced extent of scalp, muscle and bone dissection, reduced postoperative pain, a shorter hospital stay, and satisfactory cosmetic outcomes. Despite these potential benefits, the SO approach is technically demanding and poses similar risks and some additional challenges compared to conventional craniotomies and skull base approaches. There are some limitations in terms of exposure and maneuverability that are particularly important to consider before using this approach. With those cautions, the SO approach is considered ideal for removal of many suprasellar craniopharyngiomas, particularly those with extrasellar far lateral and anterior extensions. The use of endoscopy in addition to microscope further extends the range and versatility of this keyhole approach and is considered an essential adjunct for allowing safe and maximal tumor removal.

Herein, we discuss the key selection factors for using the SO approach in patients with a craniopharyngioma and detail technical aspects of the approach, highlighting potential pitfalls and methods of complication avoidance. The endonasal endoscopic and other approaches to craniopharyngiomas are discussed in other chapters in Part II.

12.2 Indications for Supraorbital Approach

The choice of a specific approach takes into consideration numerous factors including the tumor size, location, invasiveness, prior treatments, and the symptom of the patient [1, 2]. Based on our experience and others, the endonasal route is preferred for most retrochiasmal craniopharyngiomas and those lesions that are predominantly sellar [1–3] (Fig. 12.1). In contrast, for those craniopharyngiomas that are predominantly prechiasmal or with prominent lateral extensions, the supraorbital route may be preferred [1–3]. The SO approach provides excellent access for tumors that extend well lateral to the supraclinoid carotid arteries, an area that is difficult to safely access with the endonasal route. In some complex tumors with both prechiasmal and retrochiasmal extensions, either route may be appropriate. In addition, performing simultaneously an SO and an endonasal approach can be considered for lesions in which residual tumor would be anticipated if only one or the other approach were done [4]. The SO approach may also be used in young children with small nasal cavities and poorly pneumatized sinuses. Extremely narrow bilateral internal carotid artery (ICA) distance, the presence of severe sinusitis, and the presence of cavernous ICA aneurysms are relative contraindications of endonasal endoscopic approach and favor the SO approach (Fig. 12.2).

In patients with prior surgery with or without radiation, the SO approach may offer a more favorable route for recurrent craniopharyngiomas than the endonasal approach (Fig. 12.2) [5]. In addition to providing a trajectory that potentially avoids or minimizes dissection through scar tissue, the SO approach has the advantage of a simplified skull base reconstruction with a lower risk of postoperative CSF leak in the setting of recurrent tumors. The extensive scar tissue from the prior endonasal route or a nasoseptal flap in previously irradiated patients in whom the risk of postoperative CSF leak was thought to be relatively high can weigh favorably toward use of the SO approach (Table 12.1).

Regarding the side of approach, preoperative visual assessment and tumor location are key factors guiding the side of surgical approach. In general, if the tumor is predominantly located eccentrically to one side, approaching from that ipsilateral side is recommended. However, if the tumor is predominantly medial to an optic nerve in the prechiasmatic space, or under an optic nerve, approaching the lesion from the contralateral eyebrow may be advantageous.

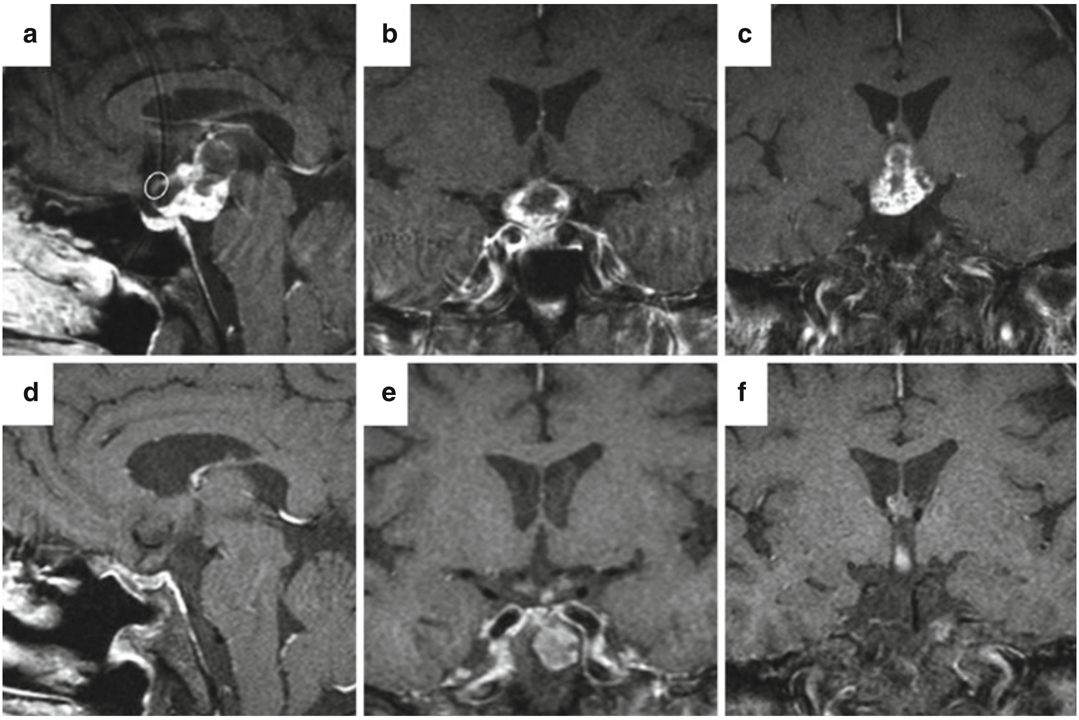

Fig. 12.1 MRI of a 52-year-old man with a visual loss and panhypopituitarism with a typical retrochiasmal craniopharyngioma. He underwent uneventful endonasal endoscopic gross total tumor resection. He is currently doing well more than 2 years after surgery with improved vision and on full pituitary hormone replacement therapy. *Top row*: Preoperative sagittal (**a**), and coronal (**b**, **c**) post-gadolinium MRI scans showing large cystic tumor extending into retrochiasmal and suprasellar space. *Circle* in **a** indicates position of the optic chiasm. *Bottom row*: Images **d**–**f** show corresponding 1-year postoperative sagittal and coronal MRIs confirming gross total tumor resection without evidence of recurrence.

This contralateral trajectory may avoid scar tissue from an original craniotomy and gives better access to the inferomedial aspect of the contralateral optic nerve. If there is prior severe or complete loss of vision in one eye, the approach may be optimally performed on this side in order to preserve the remaining eye. As detailed below, the size and extent of frontal sinus pneumatization is also a consideration in choosing the best side of approach with the choice being preferably to avoid entering the frontal sinus.

From 2007, we had 33 operations for 30 patients with craniopharyngiomas. Among the 33 operations, 9 operations were performed by the SO approach for 7 patients (27 % of total operations and 23 % of total patients). The remaining 23 operations were done by endonasal endoscopic approach and 1 operation by temporal craniotomy. Among the seven patients treated by SO approach, two patients had an SO for their first and only operation, and the remaining five patients had a previous endonasal endoscopic approach or a previous craniotomy. Two patients had a repeat SO approach.

12.3 Neuroradiology

Prior to surgery, the preoperative MRI including sellar/pituitary protocol must be carefully studied to determine which approach, endonasal endoscopic, SO, or alternative approach, is most suitable. The key anatomical relationships and structures to ascertain are the locations of the optic chiasm and nerves, the infundibulum, the pituitary gland, the circle of Willis vessels, and whether the tumor reaches the hypothalamus. The location and extent of the tumor will dictate

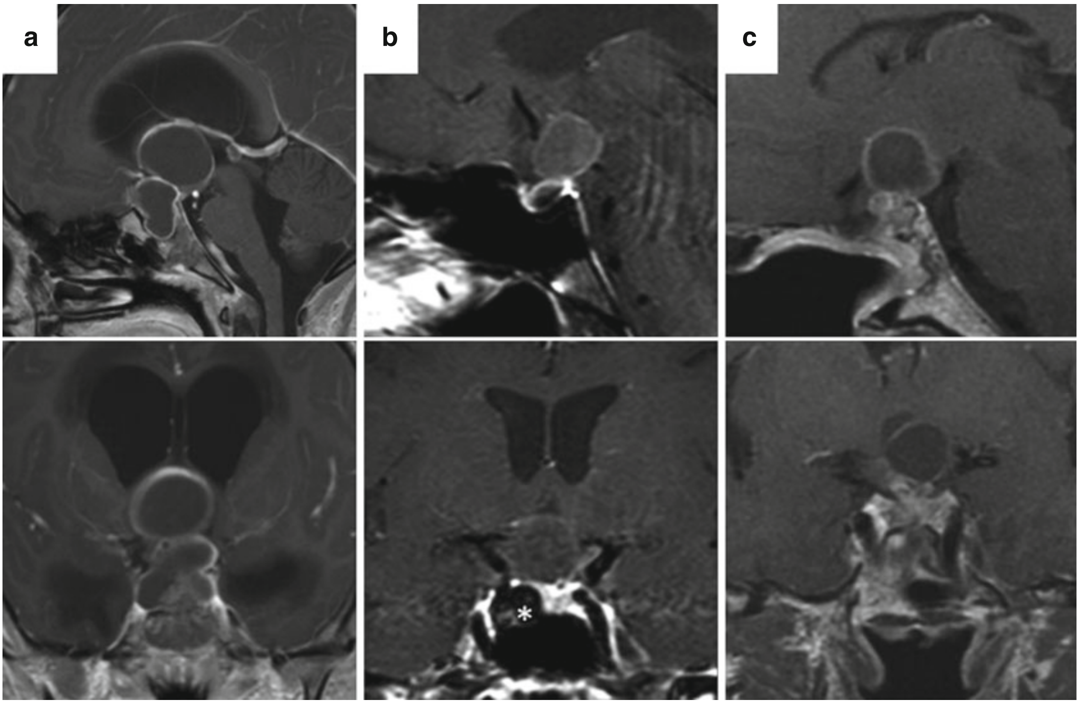

Fig. 12.2 Examples of MRIs of three patients who underwent the SO approach: (**a**): 6-year-old pediatric patient with small nostrils, and extensive cystic and solid craniopharyngioma with suprasellar and suprachiasmatic extension. (**b**) A 71-year-old woman with coexisting cavernous sinus and sellar aneurysm (*asterisk*) (**c**): A 51-year-old man who underwent prior endonasal endoscopic surgery and radiation with residual tumor and growing suprachiasmatic tumor cyst

Table 12.1 Advantages, disadvantages, and possible indications of the SO approach versus the endonasal route

	SO approach	Endonasal
Advantages	Enhanced exposure of lesions lateral to ICA Simplified skull base repair with reduced postoperative CSF leak	Enhanced exposure of sella and retrochiasmal area No brain retraction Enhanced view of the superior hypophyseal arteries
Disadvantages	Limited access to the retrochiasmal area compared to endonasal Brain retraction (rarely)	Restricted lateral access beyond ICAs and optic nerves Narrower surgical corridor More demanding skull base repair
Possible indications	Prechiasmal and suprachiasmal craniopharyngiomas Craniopharyngiomas with prominent lateral extension beyond ICAs Prior history of transsphenoidal surgery, transcranial surgery, and/or radiotherapy in whom there is extensive scar tissue and possibly limited endonasal options for skull base repair Young pediatric patients (<5 years old) with small nostrils and poorly pneumatized paranasal sinuses Cavernous sinus/intrasellar aneurysm	Most retrochiasmal craniopharyngiomas Sellar craniopharyngiomas

the likelihood of success with an SO approach or the potential need for a larger alternative craniotomy or endonasal route. Axial, coronal, and sagittal MRI sequences should be carefully reviewed to determine the lateral and anterior extent of the lesion. Probably the most important factor in choice of approach is the tumor location in relation to the optic chiasm and optic nerves (Figs. 12.1 and 12.2). This anatomical relationship is typically best appreciated on sagittal sellar images and T2-weighted coronal sellar images, but all sequences should be reviewed to provide the best possible three-dimensional understanding of the tumor. Although a pre-fixed optic chiasm may be a relative contraindication to the SO approach, in such cases, the SO approach still allows access through the lamina terminalis to tumor within the retrochiasmal space and third ventricle. Craniopharyngiomas with lateral extension beyond the supraclinoid carotid arteries or large anterior extensions are often best approached via the SO approach or the pterional route. Extension into the middle cranial fossa may necessitate a traditional pterional or mini-pterional craniotomy; however, in most cases, the SO route allows excellent access to the Sylvian fissure and the medial temporal lobe region.

Coronal and sagittal MRI sequences demonstrate the superior extent of the lesion, as well as involvement of the sella and sphenoid sinus. Craniopharyngiomas with significant sellar expansion are typically best approached via an endonasal endoscopic approach. Likewise, lesions with significant superior extension that extend into the third ventricle typically require the inferior-to-superior trajectory provided by the endonasal corridor; rarely such tumors can also be approached via an interhemispheric transventricular approach. Significant superior midline extension is a relative contraindication to the SO approach, as the flat trajectory along the floor of the frontal fossa may not provide access to the superior extent of the tumor.

Finally, the size and lateral extent of the frontal sinus should be considered in the approach decision. A large lateral extension of the frontal sinus may discourage one from using the SO approach, but in general this is only an issue in a minority of cases. If the planned craniotomy will likely enter the lateral edge of the sinus, then one should plan accordingly by prepping the patient for a possible abdominal fat graft or, less frequently, use of a pericranial flap to rotate over the defect.

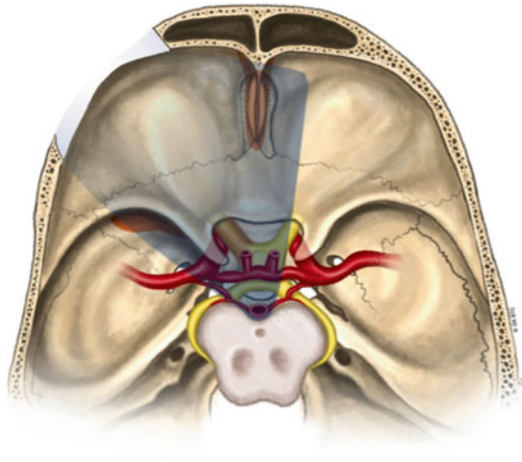

Fig. 12.3 Artistic drawing showing the extent of exposure of the SO approach: *shaded areas* including cribriform plate area, inferior space directly under ipsilateral optic nerve, ipsilateral medial middle fossa, and medial temporal lobe are difficult to visualize without endoscopy

12.4 Anatomy of the Approach

12.4.1 Anatomical Studies on SO Approach

By the SO approach, the field of view includes the ipsilateral frontal fossa, including the olfactory groove and planum, a portion of the medial contralateral frontal fossa, ipsilateral basal frontal lobe and frontal pole, the ipsilateral proximal Sylvian fissure, the medial temporal lobe, the lateral wall of cavernous sinus, the ipsilateral third nerve, the optico-carotid cistern, the suprasellar region including the optic chiasm and nerves (but only the medial and superior aspect of the contralateral optic nerve), the suprachiasmatic cistern, the perimesencephalic/interpeduncular cistern, the lamina terminalis, both supraclinoid carotid arteries, both A1 segments, the anterior communicating artery, both A2 segments, and the pituitary stalk (Fig. 12.3).

Additional dissection through the optico-carotid or carotid-oculomotor windows will expose the ventral brainstem, the basilar artery and ipsilateral posterior cerebral artery, and posterior communicating arteries and perforators.

Fig. 12.4 Intraoperative photo showing a two-surgeon team using a rigid endoscope in the SO approach for visualization; the endoscope is being “driven” by an assistant allowing two-handed surgery by the primary surgeon

When necessary, the SO approach can be used to reach as far posteriorly and inferiorly to the ventral brainstem and top third of the clivus.

Recent anatomical studies have compared the surgical exposure afforded by the keyhole SO approach to standard transcranial approaches [6, 7]. Results showed that the working space deep within the surgical field obtained with the keyhole SO approach is similar to [7] or greater than [6] that obtained by the standard pterional approach. In contrast, the angular exposure appears to be increased with the orbitozygomatic approach or pterional approach due to the more extensive bony removal obtained [7]. Indeed, the pterional and orbitozygomatic craniotomy were able to offer significantly better angles of work in both the vertical and horizontal planes [7]. Similarly, other authors have shown that removal of the orbital rim in the transorbital keyhole approach increases the inferior projection of the inferior boundary of the craniotomy [6].

However, these measurements were performed using the surgical microscope. The introduction of the rigid endoscope to the SO approach either as an adjunctive visualization technique [1, 8, 9] or as the sole imaging modality [10] appears to broaden the surgical exposure without the need for additional bony removal or brain retraction (Fig. 12.4). The panoramic and multidirectional view obtained with the endoscope appears to lessen the need for the larger external openings afforded by conventional craniotomies [8, 10] (Fig. 12.5). With the use of a 30° or 45° angled endoscope, one can also visualize into areas not well seen with the microscope, including the cribriform plate region, under the ipsilateral optic nerve, along part of the ipsilateral medial sphenoid wing, over the tuberculum sellae into the pituitary fossa, and over the dorsum sellae into the prepontine cistern.

12.5 Surgical Technique

12.5.1 Overview, Instrumentation, and Monitoring

Several authors, including our group [1, 2, 5], have previously described the technical steps of the SO approach with subtle variations [3, 4, 11–14]. For all cases of craniopharyngiomas, intraoperative neuronavigation and evoked potential monitoring are used. Image guidance is helpful in evaluating the anticipated surgical trajectory and in mapping the frontal sinus. Evoked potential monitoring is helpful for cranial nerve monitoring and to monitor for any potential vascular compromise during surgery. The Doppler probe should also be available for all cases, as many if not most craniopharyngiomas will often abut or

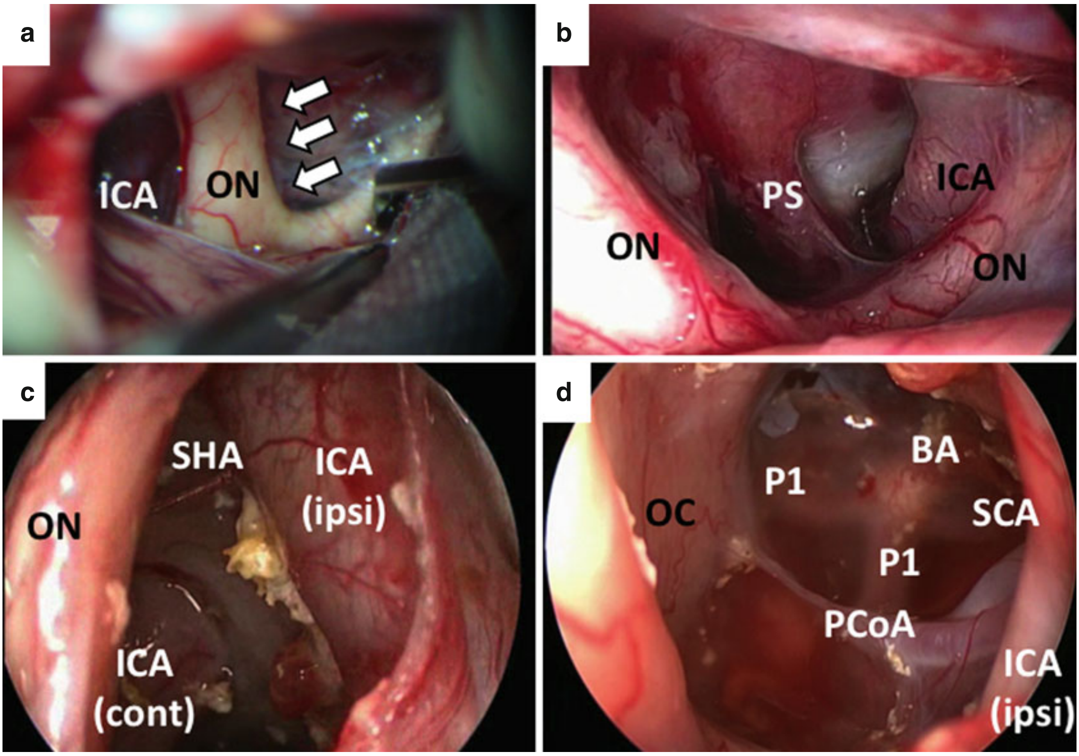

Fig. 12.5 Operative views of SO approach: (**a**) Right SO approach with microscope. *Arrow* indicates the blind spot under the ipsilateral optic nerve. (**b**) Endoscopic view of the right SO approach. Note the contralateral ICA and the PS though the prechiasmal space. (**c**, **d**) Endoscopic view of the left SO approach through the ipsilateral optico-carotid space after subtotal removal of recurrent suprasellar craniopharyngioma. In **c**, blind area behind the ipsilateral optic nerve by microscope is well visualized by endoscope. In **d**, deeper endoscopic view is provided through optico-carotid space. Posterior circulation is well visualized. The area under the optic chiasm is also visualized. *SHA* superior hypophyseal artery, *BA* basilar artery, *ICA* internal carotid artery, *OC* optic chiasm, *ON* optic nerve, *PCoA* posterior communicating artery, *PS* pituitary stalk, *P1* P1 segment of posterior cerebral artery, *SCA* superior cerebellar artery

encase at least one of the circle of Willis vessels [15]. Low-profile micro-instrumentation is essential to allow maximal maneuverability through the relatively narrow SO corridor. Most instruments should be bayoneted or pistol grip in design. Finally, 0°, 30° and 45° 4 mm rigid endoscopes should be available on all cases.

12.5.2 Positioning and Preparation

Proper positioning is necessary to optimize the reach of the SO approach. As previously described, the patient is placed in the supine position and the head fixated in a Mayfield head holder [3]. The table is placed in mild reverse Trendelenburg, and the head is elevated above the level of the heart to enhance venous drainage. The neck is slightly extended with the head above the heart level, and the head is rotated to the contralateral side between 20° and 30° depending on the location of the tumor and its pattern of extension. Head extension, with the vertex angled back toward the floor, is an important maneuver that allows gravity to work in the surgeon's favor and obviates the need for fixed retraction in opening the subfrontal corridor through which the surgeon will operate [3].

Once the patient is positioned, neuronavigation is registered and the location of the frontal sinus relative to the eyebrow incision and the planned craniotomy is determined. In planning the eyebrow incision, the lateral aspect of the frontal sinus is marked with a surgical pen and the supraorbital notch is palpated. The incision is then marked within the eyebrow extending from

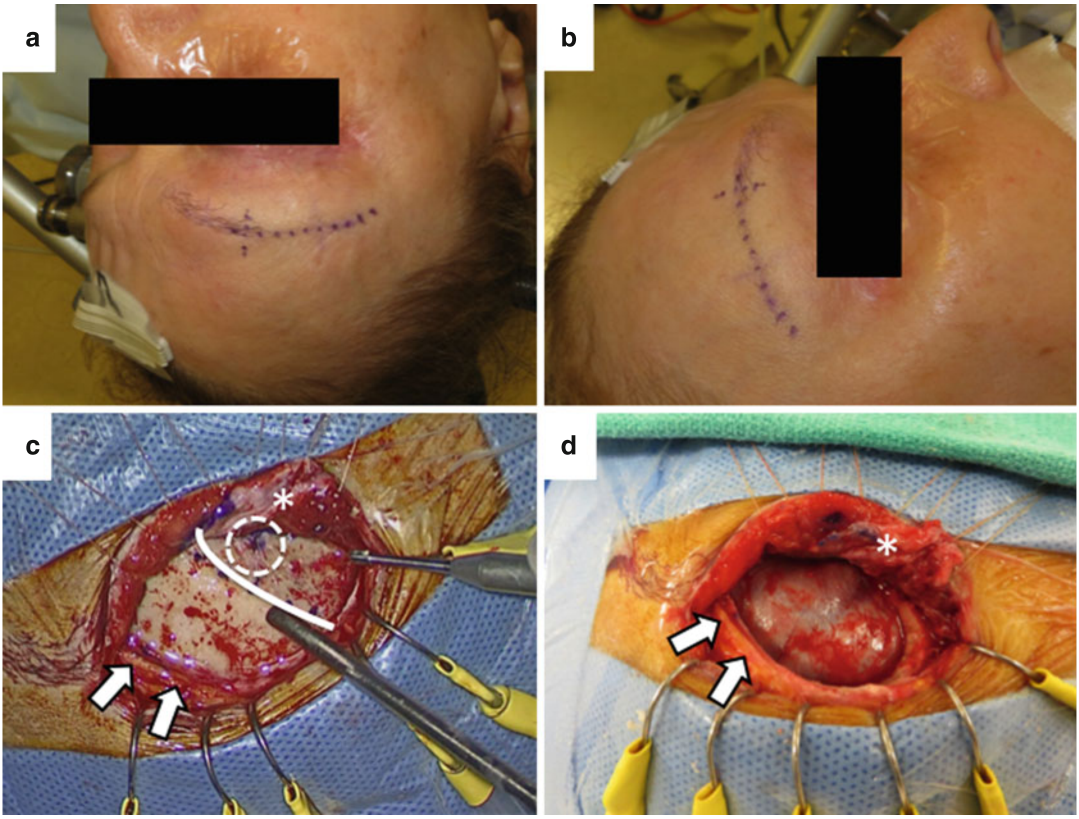

Fig. 12.6 Skin incision and craniotomy of right SO approach: (**a**, **b**) Eyebrow incision is marked from just medial to supraorbital notch extending laterally to eyebrow termination. (**c**) *Asterisk* indicates the pericranial flap reflected with sutures. *Arrow* indicates the course of the exposed supraorbital nerve. *White line* shows the superior temporal line. *Dotted circle* indicates the position of the keyhole. (**d**) Craniotomy showing dural exposure. The inner table of the inferior edge of the craniotomy and any protuberances of the orbital roof are drilled flat prior to dural opening

just medial to the supraorbital notch and coursing laterally to the lateral termination of the eyebrow. Note that the exposure must allow access to the area immediately below the superior temporal line since that is where the burr hole will be placed.

12.5.3 Skin Incision and Craniotomy

The skin incision is made within the middle of the eyebrow, and care is taken to identify and preserve the supraorbital nerve at the medial aspect of the opening (Fig. 12.6). In patients with relatively short eyebrows, the lateral extent of the incision may need to extend up to 1 cm beyond the eyebrow in a skinfold along the frontozygomatic process. The incision extension should not extend more than 13 mm lateral to the zygomatic process in order to prevent injury to the frontalis muscle branch of the facial nerve [16]. If the eyebrow is very thin, the skin incision can be made in a crease or a previous scar of the supraorbital area [17]. In general, to maximize preservation of the supraorbital nerve, the supraorbital notch represents the medial extent of the incision. As the medial extent of the incision is taken deeper toward the pericranium, the supraorbital nerve should be anticipated and protected. In some cases, careful drilling of the nerve's bony encasement can be performed, thus allowing the surgeon to gently mobilize it medially and away from the main operative field.

The subgaleal plane is then dissected superiorly while preserving the underlying pericranium. The skin flap is reflected superiorly and is maintained in position with multiple fishhooks to evenly distribute the pressure on the superior skin edge. Inferior reflection of the frontal and orbital muscles should be sufficient to expose the supraorbital rim but gentle enough to prevent periorbital hematoma. The pericranium is incised as superiorly as possible to fashion a U-shaped pericranial flap that extends laterally over the superior temporal line and into temporalis fascia. This flap is reflected inferiorly along the supraorbital rim and is kept tense with sutures and humid with a wet cloth to prevent shrinkage and desiccation. In preparation for the burr hole, a short segment of temporalis fascia and muscle are released at the superior temporal line and then retracted inferiorly and laterally with fishhooks to expose the keyhole below and posterior to the frontozygomatic process.

A single burr hole is placed below the superior temporal line and posterior to the standard keyhole. A supraorbital half-moon-shaped bone flap measuring approximately 20 mm in height by 20–25 mm in length is made which is flush with the orbital roof but does not include the orbital rim (Fig. 12.6c, d). Once the bone flap is removed, the underlying dura is dissected from the orbital roof. Prior to dural opening, the inner table of the inferior edge of the craniotomy and any protuberances of the orbital roof are drilled flat with a high-speed drill. This maneuver is essential to optimize the flat surgical trajectory along the frontal floor, as even small boney ridges may significantly impair the line of sight to deeper regions. For cosmetic reasons, care must be taken not to drill up to the superficial cortical bone on the inferior craniotomy border. If the frontal sinus is entered, it is not cranialized and can be covered with Gelfoam® (Pfizer) during the tumor removal.

12.5.4 The Dural Opening and Approach to the Lesion

The dura is opened in a C-shape manner with its base toward the orbital rim and reflected inferiorly. The dural flap is kept moist and under tension throughout the case to prevent shrinking and allow for a watertight closure.

The rest of the procedure is performed under microscopic visualization and intermittent use of endoscopy. The frontal lobe is protected with strips of Telfa® (American Surgical Company). The main anatomical structure at this point becomes the olfactory tract on the inferior surface of the frontal lobe, and it is followed back to the ipsilateral optic nerve. The arachnoid overlying the optic, opticocarotid, and carotid cisterns is sharply opened with egress of CSF and further brain relaxation. A brain spatula may be placed initially over the frontal lobe to gently retract the frontal lobe. With egress of CSF, the brain rapidly becomes well relaxed and the retractor is generally not needed. This step of CSF drainage may require patience, particularly if the brain is "full." However, as CSF egress proceeds, the surgical corridor will open. Any forceful retraction of the frontal lobe is to be avoided. Additional dissection of the arachnoid at the base of the frontal lobe over the interface with the optic chiasm and within the proximal Sylvian fissure will further free the frontal lobe from the basal cisterns and temporal lobe and allow it to fall away with gravity.

12.5.5 Tumor Removal

Depending upon the location of the craniopharyngioma, tumor in the suprasellar space, prechiasmatic space, the optico-carotid cistern region, or further laterally along the Sylvian fissure should all now be accessible. Tumor in these areas is then approached, and surgery proceeds using standard microsurgical technique depending on the site and size of the craniopharyngioma. For large craniopharyngiomas with multiple cystic components, draining the cysts as an initial part of the procedure will help reduce pressure on the optic apparatus and aid with brain relaxation and exposure. In general, care must be taken in assessing tumor involvement of any of the number of surrounding neurovascular structures mentioned above. Of particular concern are the carotid artery and its branches and the optic apparatus. To anticipate and preserve bilateral superior hypophyseal arteries arising from medial supraclinoid carotid arteries is mandatory.

The position of the optic chiasm and pituitary stalk must be carefully assessed. Craniopharyngiomas often are very adherent to the optic apparatus and pituitary stalk, and a workable surgical plane between the tumor and hypothalamus is often not present. If tumor is located in predominantly retrochiasmal region, trans-lamina terminalis route can also be used to access tumor in this region and the third ventricle. Proximal Sylvian fissure dissection is done as needed when the lateral extension of the tumor extends to the middle fossa, requiring dissection of the capsule and the medial temporal lobe. Dense adhesion to the hypothalamus is saved.

In cases of prior transsphenoidal or transcranial surgery, significant scar tissue in the arachnoid over the optic apparatus is often noted, requiring careful dissection using microsurgical techniques and the frequent use of Doppler ultrasound to confirm the surrounding vessels that might be hidden under the scar tissue. Anterior cerebral arteries are often elevated and pushed posteriorly. If significant scarring around the optic apparatus exists, approaching the tumor through the gyrus rectus may sometimes be needed.

The 0° and 30° endoscopes are used intermittently to provide a panoramic perspective of the surgical anatomy. The endoscope often allows one to better define tumor-vascular relationships along the outer recesses of the suprasellar space. Small tumor remnants or infiltration directly visualized by endoscopy may be missed on intraoperative MRI or may be considered as postoperative changes on follow-up imaging [18]. Therefore, endoscopic visualization is strongly encouraged for all SO cases. Visualization of more lateral areas is improved, without the need of additional dissection or retraction. Particularly in the setting of craniopharyngiomas, assessment of the surgical field for tumor remnants with the endoscope gives the best chance of identifying residual tumor that can be addressed before terminating the procedure [9, 10]. The endoscope is particularly helpful for visualizing tumor remnants under the ipsilateral optic nerve and tract which is a relative “blind spot” of the SO approach given that its trajectory is in direct alignment with the optic nerve [1, 8]. In case of an extremely narrow corridor, the 2.7 mm endoscope may be useful to inspect the area.

One important caveat, however, is that unlike in endonasal surgery in which the operating corridor is the nose and sinuses, in the SO approach, the corridor is the frontal fossa with all its critical neurovascular structures. It is critical in intracranial skull base endoscopy to be constantly mindful of the endoscope and instrument locations. Wielding the endoscope and multiple instruments safely in this confined space must be done with utmost caution and care, as the endoscopic view is blind behind the lens.

12.5.6 Closure

Due to the unique location of the eyebrow incision, a cosmetically pleasing closure is essential. After tumor removal and hemostasis is achieved, the dura is closed in a watertight fashion. The medial bone edge of the craniotomy is inspected to confirm that the frontal sinus has not been entered or that a frontal sinus breach has been adequately repaired. A large piece of collagen sponge (Helistat® or Duragen® – Integra LifeSciences) is placed over the dura with redundant collagen extending over the bony edges. The bone flap is repositioned and secured with a lateral burr hole cover and a straight plate spanning the medial edge of the craniotomy (Fig. 12.7). When replacing the bone flap, the more cosmetically noticeable gap at the superior aspect of the craniotomy should be minimized. Gaps between the bone flap and calvarium are filled with collagen sponge in order to minimize visible scalp depressions in the supraorbital region. Temporalis muscle and fascia and the attached pericranial flap are reflected back into anatomical position and reapproximated over the bone flap with absorbable sutures. Similarly, scalp incision is closed with absorbable galeal and subcutaneous stitches. A final running 5-0 absorbable subcuticular skin stitch is then placed to evenly approximate the skin edges. After undraping, pressure is applied over the incision until the patient is extubated and breathing comfortably to prevent the formation of a pseudomeningocele.

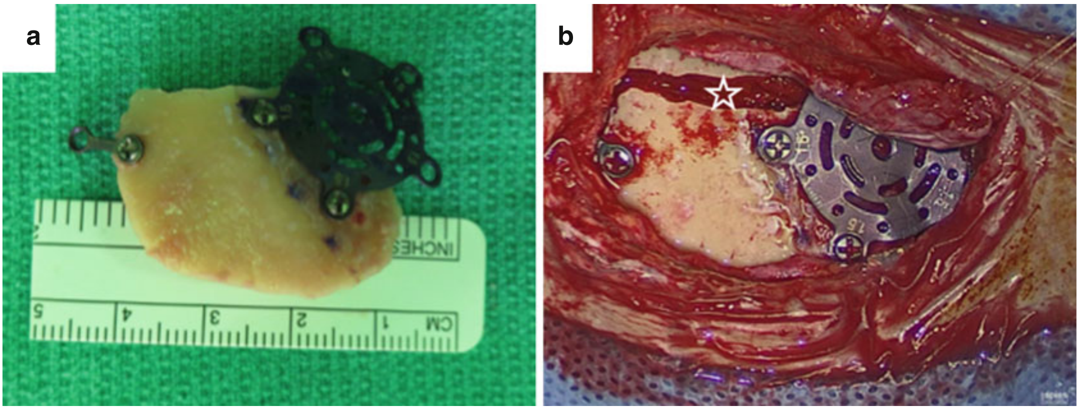

Fig. 12.7 Bone flap and closure: (**a**) A right-sided bone flap with titanium plates. (**b**) A right-sided bone flap is positioned and secured with a lateral burr hole cover and a straight plate spanning the medial edge of the right-sided craniotomy. Note that for cosmesis, the bone flap is pushed superiorly, so it is flush with supraorbital calvarium leaving no gap along the forehead; the bone gap (*star*) on the inferior edge of the craniotomy is generally well-hidden by the eyebrow. This gap can also be filled in with collagen or bone cement

In cases where the frontal sinus has been breached, closure can be performed in three ways depending upon the size of the defect. For small defects, placement of collagen sponge against the opening with the bone flap directly opposed against the defect is typically effective. For larger defects, abdominal fat should be placed within sinus opening and the lateral aspect of the sinus, and reinforced with collagen, tissue glue, and the bone flap. Alternatively for larger defects, the repair with fat can be further reinforced with the pericranial flap rotated over the defect. This last option is less desirable from a cosmetic standpoint. After addressing the frontal sinus, the closure then proceeds as described above.

12.6 Possible Complications and Their Avoidance

While the SO approach carries little approach-related morbidity, it is associated with a unique set of potential complications. Transient forehead numbness from injury to the supraorbital nerve is a common event in the early postoperative period but is rarely permanent, being reported in up to 7.5 % of patients in some series [3]. Transient frontalis weakness from injury or stretching of the frontalis branch of the facial nerve can be seen immediately after surgery and is also typically transient, although lasting frontalis paresis has been reported in up to 5.5 % of patients [3]. Both of these complications may be avoided by careful planning of the incision and meticulous soft tissue dissection. The supraorbital nerve is readily identifiable as it courses from the orbit through the supraorbital notch at the medial aspect of the eyebrow incision. Although the frontalis branch of the facial nerve may be more difficult to identify, the risk of injury can be reduced by minimizing the lateral extent of the incision.

CSF rhinorrhea may occur if the frontal sinus is violated and inadequately repaired. This complication has been reported in up to 4 % of patient [3] and can [3] be avoided by carefully planning the craniotomy lateral to the lateral-most edge of the frontal sinus. However, if the sinus is entered, it should be carefully repaired. In all cases, the medial aspect of the craniotomy should be thoroughly inspected to determine if there is sinus entry. As mentioned above, a small frontal sinus breach may be repaired with bone wax with an overlay of collagen sponge. Larger frontal sinus breaches may require packing with fat or muscle as well as with a pericranial flap and collagen sponge reinforcement. Because the soft tissue dissection of the eyebrow approach does create a small potential space low over the frontal bone, postoperative pseudomeningocele formation is a possible complication if a watertight dural closure is not achieved. Application of pressure over the incision while the patient is being extubated may reduce the incidence of this potential complication.

Overall, because the SO approach utilizes a small incision and involves minimal temporalis dissection, scalp pain, temporalis atrophy, and difficulty with mastication are rarely observed.

12.7 Illustrative Cases

Case 1

A 71-year-old woman reported a 3-month history of progressive peripheral visual loss and headache. MRI revealed a 16×18 mm retrochiasmal suprasellar cystic lesion causing severe compression of the optic chiasm and posterior displacement of the infundibulum (Fig. 12.8). The patient's pituitary hormonal studies were normal except for mild hyperprolactinemia. There was evidence of a right cavernous flow void; MRA confirmed a right cavernous carotid artery aneurysm which appeared to be entirely contained within the cavernous sinus and sella. To avoid the potential manipulation of the cavernous sinus aneurysm, a left SO approach was chosen. Pseudocapsule of the lesion was entered with large windows made into it. However, there were multiple perforators adherent to the tumor capsule. Considering the patient's age and perforators, no attempt was made for complete removal. The pathological diagnosis was craniopharyngioma. Postoperatively her visual fields were full. She subsequently had stereotactic radiotherapy (SRT). Two years after craniotomy and SRT, the residual mass has shrunken and remains stable in size.

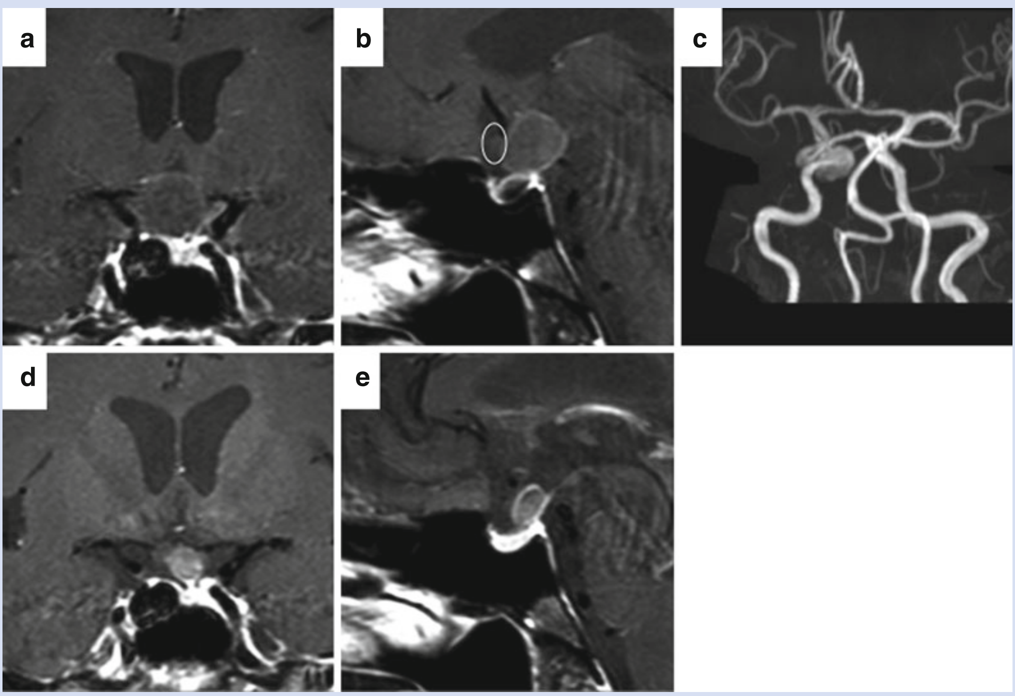

Fig. 12.8 Case illustration 1. Craniopharyngioma in a 71-year-old woman with progressive visual loss. Preoperative coronal (**a**) and sagittal (**b**) postgadolinium MRI scans showing large cystic tumor in suprasellar area. Note the flow void in the right cavernous sinus and sella (the *circle* represents the location of the optic chiasm). MR angiography (**c**) reveals right cavernous sinus ICA aneurysm. Two-year postoperative coronal (**d**) and sagittal (**e**) postgadolinium MRI showing persistent regression of cystic craniopharyngioma. See text for additional clinical history

Case 2

A 46-year-old woman developed progressive loss of vision and worsening headaches over 2 months. MRI of the brain showed a heterogeneously enhancing and partially cystic suprasellar tumor attached to the pituitary stalk, which was pushed posteriorly. The cystic lesion was multi-lobulated, being larger anteriorly and optic chiasm was markedly compressed (Fig. 12.9). She underwent a left SO craniotomy, cyst decompression, and tumor debulking. The tumor was partially calcified and densely adherent to the left aspect of the chiasm and left optic nerve and tract. She did well after surgery with visual improvement and no new endocrinopathy. She underwent SRT and at 5 years after surgery has a stable small residual tumor.

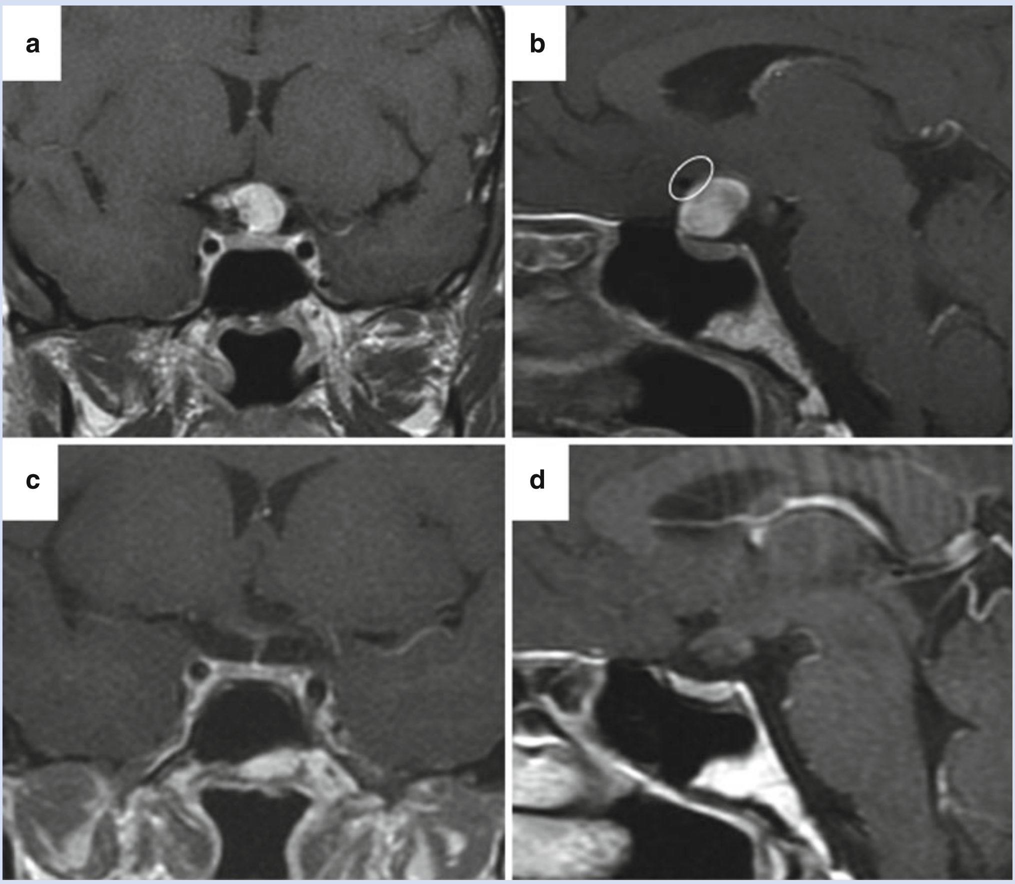

Fig. 12.9 Case illustration 2. Craniopharyngioma in a 46-year-old woman with progressive visual loss. Preoperative coronal (**a**) and sagittal (**b**) postgadolinium MRI scans showing large cystic tumor in suprasellar area (the *circle* represents the location of the optic chiasm). Five-year post-surgery and post-SRT, coronal (**c**), and sagittal (**d**) post-gadolinium MRI showing persistent cyst regression. See text for additional clinical history

Case 3

A 51-year-old man with multiple previous therapies for a retrochiasmal craniopharyngioma treated elsewhere including endonasal resection and postoperative CSF leak repair with a ventriculoperitoneal shunt. He had developed craniopharyngioma cyst progression in the retrochiasmatic and third ventricular space. His visual fields had progressively deteriorated. Considering the scar tissue from his previous endonasal approach, he underwent left SO approach. There was significant scar tissue around the optic nerves and chiasm. He had a trans-lamina terminalis decompression of the craniopharyngioma cyst. Given the multiple dense adhesions to the optic apparatus and hypothalamus, no attempt was made to remove a significant portion of the cyst wall. He had an uneventful postoperative course. His initial postoperative MRI showed good decompression of the large tumor cyst (Fig. 12.10 and Video 12.1).

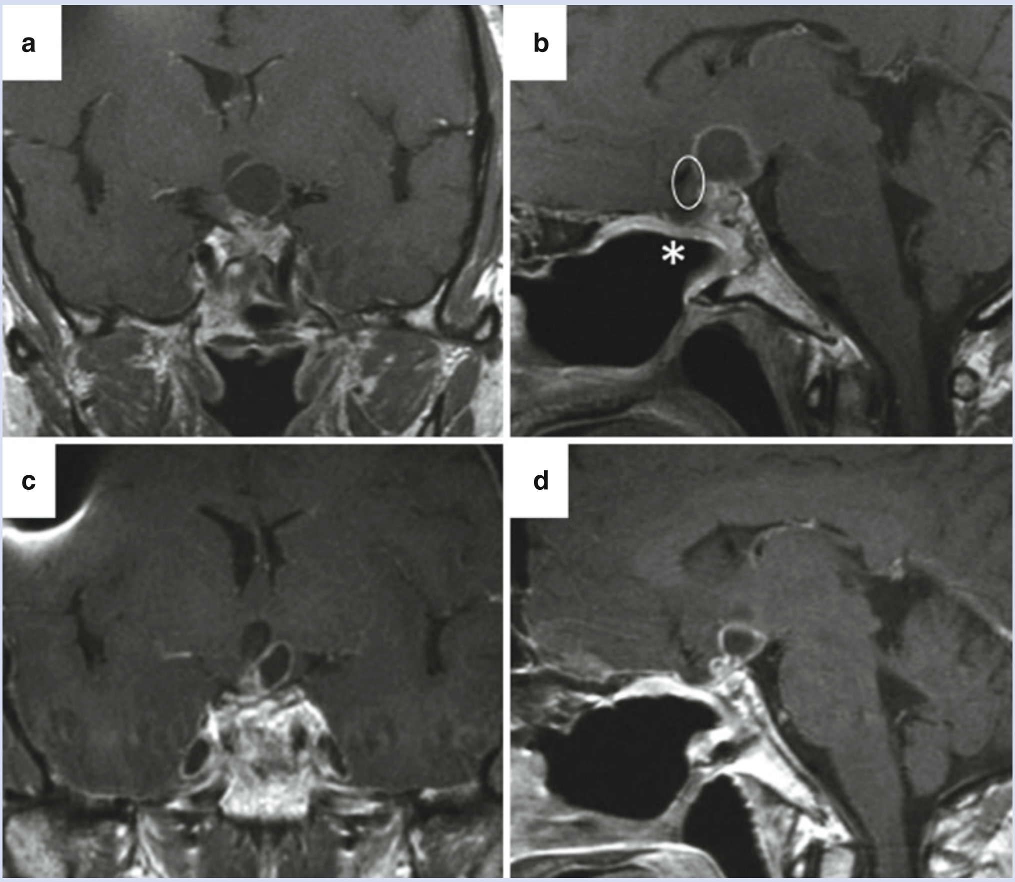

Fig. 12.10 Case illustration 3. Recurrent craniopharyngioma in a 51-year-old man. Preoperative coronal (**a**) and sagittal (**b**) postgadolinium MRI scans showing large cystic tumor in suprasellar area. *Asterisk* indicates the nasal septal flap utilized for the previous endonasal endoscopic surgery (the *circle* represents the location of the optic chiasm). Postoperative day 1 coronal (**c**) and sagittal (**d**) postgadolinium MRI showing cyst collapse. See text for additional clinical history

Case 4

A 6-year-old boy with progressive visual loss and lethargy was found to have left optic atrophy and right-sided papilledema. MRI showed a large 4 cm multilobulated cystic and solid craniopharyngioma arising from the suprasellar cistern with sellar extension. A larger retroinfundibular cystic component obliterated the third ventricle and caused severe obstructive hydrocephalus. Preoperatively he had low thyroid and cortisol levels consistent with secondary hypothyroidism and adrenal insufficiency. Given his small nostrils and sinonasal corridor, he underwent right SO approach with temporary external ventricular drainage. At surgery, after opening the large suprasellar and retrochiasmatic tumor cysts, a near complete removal of the tumor capsule was accomplished with preservation of the infundibulum. Postoperatively, he had a marked improvement in vision and overall alertness and well-being. He did require full anterior and posterior pituitary hormone replacement. His postoperative MRI 3 months after the surgery showed no obvious residual tumor and resolution of obstructive hydrocephalus (Fig. 12.11).

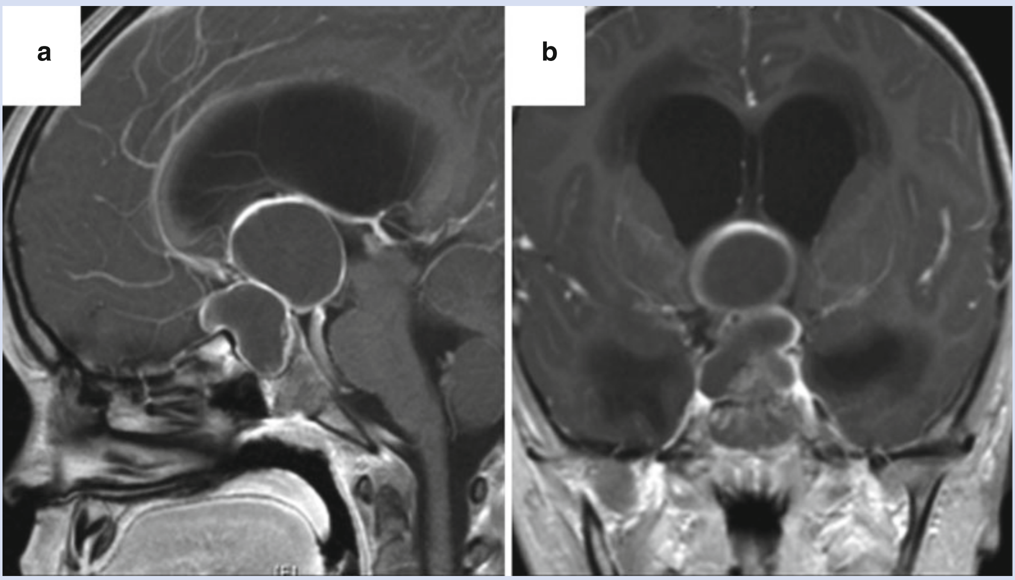

Fig. 12.11 Case illustration 4. Six-year-old patient with small sinonasal structures and extensive cystic and solid craniopharyngioma with suprasellar and retrochiasmatic extension. Preoperative sagittal (**a**) and coronal (**b**) post-gadolinium MRI scans showing large multicystic tumor in suprasellar and retrochiasmatic area with obstructive hydrocephalus. Three-month postoperative sagittal (**c**) and coronal (**d**) post-gadolinium MRI after right SO craniotomy showing no obvious residual tumor and resolution of obstructive hydrocephalus. See text for additional clinical history

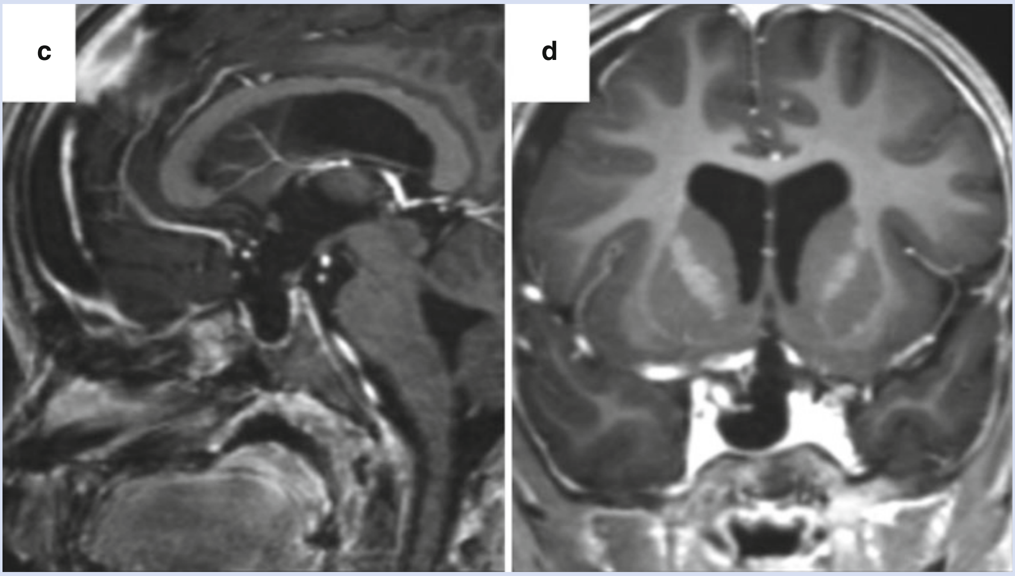

Fig. 12.11 (continued)

12.8 Additional Therapy for Residual or Recurrent Craniopharyngioma

Although total resection of craniopharyngiomas has been advocated by some, it is associated with a higher morbidity and mortality [19, 20]. Consequently, we opt for subtotal removal if dense adhesions to neurovascular structures and hypothalamus are present [21–23]. Given the effectiveness of stereotactic radiotherapy (SRT) and stereotactic radiosurgery (SRS), these modalities are frequently employed for residual and/or recurrent craniopharyngiomas; these modalities are further discussed in Chap. 14.

Conclusions

The SO approach is a minimally invasive keyhole technique that offers wide access to the anterior skull base and parasellar region by exploiting the subfrontal corridor. Endoscopy expands the reach of this approach by providing a more panoramic assessment of the parasellar space and maximizing safe tumor removal. The SO approach is an excellent alternative to the endonasal approach for certain craniopharyngiomas, particularly those with frontal and lateral extensions. The major advantage of the SO approach over the endonasal route is a simplified skull base closure and reduced risk of postoperative CSF leak. It should also be considered as an effective alternative route for recurrent or residual suprasellar craniopharyngiomas previously treated by conventional craniotomy or transsphenoidal surgery. The unique location of the eyebrow incision demands meticulous cosmetic closure. With proper technique, excellent cosmetic results are routine.

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