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Surgical Experience of Transsphenoidal Supradiaphragmatic Intradural Approach to Presellar and Suprasellar Lesions

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Objective : In selected cases, the transsphenoidal approach(TSA) can be extended anteriorly to the tuberculum sellae, chiasmatic sulcus, and planum sphenoidale to obtain direct exposure of the suprasellar cisterns and its contents. We applied this modification of the TSA to various lesions of the presellar and suprasellar areas. We evaluate our clinical experience of this technique and review the related literature.

Methods : From 1999 to 2004, we used the transsphenoidal supradiaphragmatic intradural approachs(TSIAs) in 9 patients who had various lesions at the pre- and suprasellar regions. Concomitant presellar extension of the bone window was performed with the sublabial or transnasal transseptal transphenoidal techniques. After removal of the lesions, sellar or anterior cranial floor was repaired with silicone plate substitute.

Results : The TSIAs have been applied in the following cases : four tuberculum sellae meningiomas, two craniopharyngiomas, two Rathke's cleft cysts, and one non-functioning macroadenoma. The complications were one case of visual acuity decrease and one cerebrospinal fluid rhinorrhea.

Conclusion : The TSIA is easily applicable through a minor modification of the standard TSA. It is suitable for removing lesions located in the presellar and suprasellar area adjacent to the pituitary stalk with minimal brain manipulation and decreased morbidity.

KEY WORDS : Transsphenoidal supradiaphragmatic intradural approach · Presellar region · Suprasellar region · Craniopharyngioma · Tuberculum sellae meningioma.

Introduction

Since popularization of the transsphenoidal approach(TSA) by Guiot and Thibaut[7], and Hardy[8], the TSA is the gold standard for treatment of most sellar tumors. However, the approach to lesions extending beyond the limit of the sella turcica remains still problematic[13]. Up to date, tumors and other lesions mainly located in the presellar and suprasellar regions have been removed by the transcranial approach[4,6,9]. Recently, a surgical technique that extends the standard TSA to the suprasellar cistern via the anterior cranial fossa, to remove tumors which are confined to the pituitary stalk itself or extended superiorly into the stalk from intrasellar origin, was firstly proposed by Mason et al.[18].

The presellar extension of the bone window combined with opening of the sellar floor results in the transsphenoidal supradiaphragmatic intradural approach(TSIA)[12,14]. Through the division of the anterior circular sinus, this presellar extension of the TSA affords unbelievable exposure of the pituitary stalk and other neurovascular structures in the supradiaphragmatic intradural space[3,11,13,14,18]. Two routes of TSIA to suprasellar cisterns are one is transsellar, and the other is the transtuberculum sellae or transplanum sphenoidale route.

In this study, we review our clinical experiences with these extensions of the TSAs to a variety of lesions of the presellar and suprasellar regions.

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Table 1. Clinical characteristics of the patients who underwent TSIA*

Case No.	Age /sex(yrs)	Symptoms /signs	Extent of removal	Complications	Follow-up (months)	Pathology
1	63/F	VFD	subtotal	(-)	66	tuberculum sella meningioma
2	41/F	incidental	partial	(-)	65	Rathke's cleft cyst
3	24/M	VFD	total	CSF rhinorrhea	62	macroadenoma
4	9/F	VA↓	total	(-)	40	craniopharyngioma
5	41/F	headache	partial	VA↓	33	Rathke's cleft cyst
6	15/F	headache vomiting	total	(-)	15	craniopharyngioma
7	65/F	VFD	total	(-)	15	tuberculum sella meningioma
8	61/F	VA↓	total	(-)	14	tuberculum sella meningioma
9	69/F	VA↓	subtotal	(-)	13	tuberculum sella meningioma

*CSF : cerebrospinal fluid, F : female, M : male, TSIA : transsphenoidal supradiaphragmatic intradural approach, VA : visual acuity, VFD : visual field defect

Materials and Methods

Patient population

Between January 1999 and July 2004, total 46 patients who underwent surgical resection of sellar and parasellar lesions were retrospectively reviewed. Data was obtained through review of medical records and operative video recordings. Among them, nine TSIAs were performed by one surgeon in our institute.

Criteria included in this study were the patients who needed the presellar extensions of the standard TSAs for removal of the presellar and suprasellar lesions which were beyond the surgical limit of the standard TSAs. There were eight females and one male whose ages ranged from 9 to 69 years (mean; 43.1 years). The clinical characteristics of patients who underwent the TSIAs were summarized (Table 1).

Operative technique

The patient was placed in the supine position with the head was elevated approximately 10 degrees and tilted 10 degrees to the left side on a horseshoe headrest. This maneuver was preferred than the rigid pin fixation, which limited intraoperative manipulation of the patient's head to improve visualization. A C-arm fluoroscope was equipped to get a lateral image of the sphenoid sinus and sellar turcica. The standard transnasal or sublabial transseptal precedure to the floor of the sphenoid sinus was performed by the otolaryngologist (co-author). After introduction of the operative microscope, the anterior portion of the floor of the sphenoid sinus was carefully rongeured to improve the strategy to the planum sphenoidale.

After entering the sphenoid sinus, the sphenoidal septum was removed to expose the anterior wall of the sella. When the important surgical bony landmarks : including sellar prominence, carotid prominences, opticocarotid recess, and tubercular recess were identified (Fig. 1), the anterior wall of the sella was opened with microdrill and microcurette, and then enlarged with micro-Kerrison rongeur.

The posterior part of the planum sphenoidale and tuberculum sellae were removed by drilling with a diamond burr on the telescopic attachment (Midas Rex®; Medtronic, Fort Worth, TX, USA) and rongeuring with a 2-mm thinfoot plate Kerrison rongeur. After completion of opening of the bone window, the anterior circular sinus and the anterior leaf of the diaphragma sellae were divided in the midline with a bipolar coagulator and oxidized regenerated cellulose (Surgicel®; Ethicon, Cornelia, GA, USA) or microfibrillar collagen hemostat (Avitene®; CR Bard Inc, Murray Hill, NJ, USA) for meticulous bleeding control. The dura mater covering the planum sphenoidale was incised in a cruciate fashion. After opening the dura, the intradural part of the lesions was evacuated.

Sometimes the angled curette was used to scrape the tumor remnant, which adhered to the tumor capsule and situated beyond the surgical field. Some pieces of abdominal fat were plugged into the empty cavity created by the mass removal. The fibrin glue (Green plast®; Green Cross Co., Yongin-si, Gyeonggi-do, Korea) was used as a dural sealant just before and after implantation of a silicone plate (Pharm Elast®; SF medical, Hudson, MA, USA) as a substitute for autologous bone splint for reconstruction of the bone window. The silicone plate for implantation was cut to a size slightly larger than that of bone window, and then pricked with a threepronged fork and snapped into the bony defect.

Results

By use of these TSIAs, various lesions were operated during 66 months (Table 1) : 4 cases of tuberculum sellae meningiomas; 2 craniopharyngiomas; 2 Rathke's cleft cysts; and 1 nonfunctioning macroadenoma. All lesions were studied preoperatively with computed tomography and/ or magnetic resonance(MR) image. Among the lesions, gross total resection was achieved in 5 cases. The complications which related to surgery were one decreased visual acuity, and cerebrospinal fluid(CSF) rhinorrhea, respectively. One CSF rhinorrhea was resolved after plugging of abdominal fat between the anterior

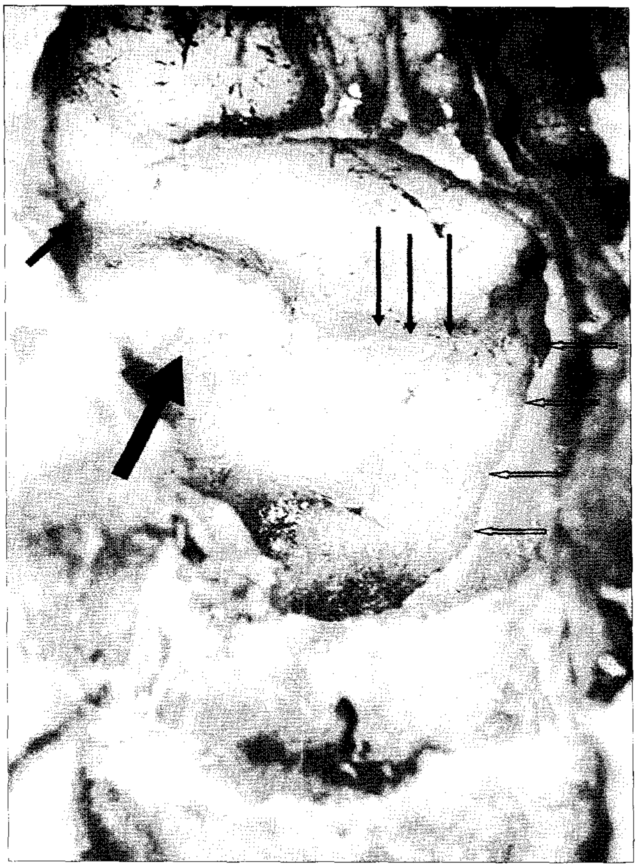

Fig. 1. Photograph of the inner view of the sphenoid sinus which the bony septum (open arrows) extremely deviates to the left side. There are several prominent landmarks in the roof of the sphenoid sinus : Carotid prominence (black large arrow) corresponds to the cavernous and clinoid segment of the internal carotid artery, sellar turcica prominence at the center, tubercular recess (thin arrows) that responds intracranially to the tuberculum sellae and the chiasmatic sulcus, and opticocarotid recess (black small arrow) which is a small recess between the optic canal and the carotid prominence.

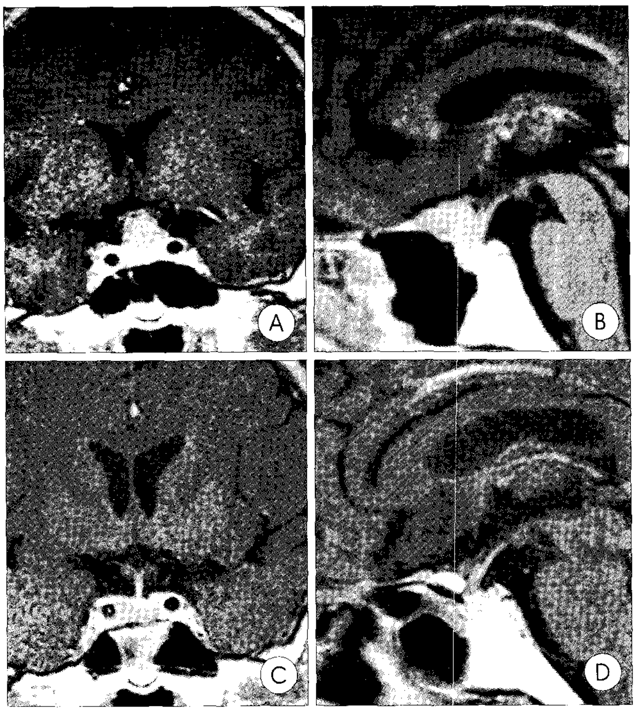

Fig. 2. A, B : Preoperative coronal (A) and sagittal (B) sections of T1-weighted magnetic resonance images after gadolinium administration shows a tuberculum sellae meningioma. C, D : Postoperative gadolinium enhanced coronal (C) and sagittal (D) sections of T1-weighted magnetic resonance images demonstrating complete resection of the tumor. The arrow indicates the low signal in the area of the anterior sellar wall, which represents the silicone implant. The grafted fat upon it reveals high signal intensity.

margin of the previous silicone plate and planum sphenoidale and repositioning the silicone plate with three-pronged fork at the second operation. There was no mortality in our study.

Illustrative Cases

Case 1 : Tuberculum sellae meningioma

A 65-year-old woman presented with progressive visual field defect that was right temporal hemianopsia. MR images revealed a pre- and suprasellar mass lesion, which was strongly enhanced after gadolinium infusion, based on the tuberculum sellae (Fig. 2A, B). The tumor was totally removed via TSIA. After opening of the bone window, the meningioma bed directly came into view. The tumor feeding vessels were easily coagulated with bipolar coagulator. An early devascularization at its base resulted in the easy removal of the tumor. The tumor was gently removed, and a small piece of fat was plugged into the intradural space.

The bone window was repaired with the silicone plate, finally. Postoperative MR images, which were obtained 3 months after operation revealed complete removal of the tumor with the reconstructed silicone plate as a black signal void just in front of the sellar turcica, and the grafted fat upon it (Fig. 2C, D). The patient's visual field immediately improved after removal of the tumor.

Case 2 : Craniopharyngioma

A 15-year-old girl presented with severe headache and vomiting. There was obstructive hydrocephalus by tumor blockage. Pituitary endocrine studies showed no abnormal findings. Sellar MR images revealed a huge cystic tumor with pre-and suprasellar extension (Fig. 3A, B).

Tumor had various consistencies such as solid, cystic, and calcified parts on operation. The fluid within cyst appeared oily and dark brown color. The tumor had been resected gross totally through the TSIA (Fig. 3C, D). Transient diabetes insipidus, which occurred postoperatively resolved with short-term use of pitressin. Follow-up MR images have revealed no evidence of recurrence with disappearance of obstructive hydrocephalus, and also well preserved pituitary gland during 15 months of follow-up.

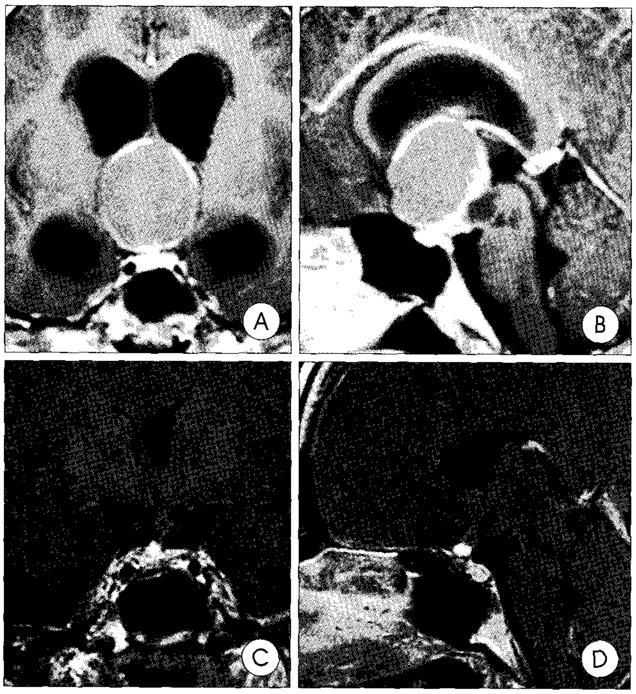

Fig. 3. A, B : Preoperative coronal (A) and sagittal (B) sections of T1-weighted magnetic resonance images after gadolinium administration shows a huge cystic craniopharyngioma, which compressing optic chiasm. Severe obstructive hydrocephalus is also seen. C, D : Postoperative gadolinium-enhanced coronal (C) and sagittal (D) T1-weighted magnetic resonance images taken 15 months after surgery demonstrating total resection of the tumor with evidence of complete resolution of the obstructive hydrocephalus. The grafted fat upon silicone plate reveals high signal intensity.

Discussion

Saito et al.[21] reported 100 cases (16%) of suprasellar extension in their series of 610 pituitary tumors. Until new millennium, a standard TSA was commonly used to treat suprasellar extension of pituitary tumors, supported by maneuvers that facilitated the descent of the tumor into the sella (e.g. Valsalva maneuver[2,19], jugular vein compression, lumbar infusion[21]). Other treatment options for significant suprasellar extension of tumor include a staged transsphenoidal removal with or without the utilization of the open sella method, a combined transsphenoidal and intracranial approach, and a transcranial approach only. However after new anterior extended TSA technique to remove lesions at the level of the pituitary stalk introduced by Mason et al.[18], this anterior extended modifications of standard TSAs have been developed by some interested surgeons[3,11,14]. Rostrally extended bone removal to standard TSA affords additional exposure of the suprasellar region. These anterior extended TSAs have progressively applied to a variety of lesions such as tuberculum sellae meningioma, suprasellar craniopharyngioma, and Rathke's cleft cyst, etc[3,11,14,18].

An exact knowledge of anatomical landmarks is the most important point to perform this TSIA technique. Some landmarks should be kept in mind and are essential to avoid unnecessary injury to important neurovascular structures. From the view point of the roof of the sphenoid sinus, the sella turcica is recognized as a prominence and the carotid prominence can be identified on the anterolateral side of the sella turcica[14]. The bony structures between the planum sphenoidale and the anterior portion of sella turcica are the limbus sphenoidalis, prechiasmatic sulcus, and tuberculum sellae in the anteroposterior dimension[14,20]. Anterior and superior to the sella turcica prominence in the roof of the sphenoid sinus, there is a recess that corresponds intracranially to the tuberculum sellae and chiasmatic sulcus. Lateral to the recess the optic canals traverse the most anterior portion of the sphenoid sinus roof bilaterally. Resection of the planum sphenoidale is limited laterally by the optic canal[14,20]. The mean distance between the optic nerves at the entrance to the optic canals is 14mm[20]. The bony window created by resection of the tuberculum sellae and planum sphenoidale that enables the TSA to enter the supradiaphragmatic intradural space is limited laterally by the carotid arteries and optic canals to the dimensions given above.

Venous channels that occupy the space between two dural layers of the dura mater in the sella turcica communicate between the two cavernous sinuses. These venous channels are known as coronary sinuses[5] and composed of the anterior and posterior circular sinuses. The anterior circular sinus is present in 76% of cases according to Renn and Rhoton[20]. It is requisite to divide this sinus just before entering the suprasellar cistern. The use of Surgicel or Avitene with a bipolar coagulator can easily control bleeding from the sinus. Kato et al.[11] warned that deep coagulation of the lateral cut edges of the divided sinus may cause damage to the optic nerve. On the basis of thorough anatomical study[14], we have applied these anatomic principles to maximize the visualization of the tuberculum sellae, planum sphenoidale, and suprasellar cistern. Anteriorly extended modifications of the standard TSAs have been used for a variety of pathological lesions in our series.

For patients in whom one would prefer to avoid prolonged surgery, such as elderly patients and those with medical comorbidities, the TSIA provides an especially attractive alternative. This approach can be applied to the selected small meningioma of the midline tuberculum sellae/planum sphenoidale region[3,11,14]. Surgical management of craniopharyngiomas can be achieved with many different approaches and techniques, according to the localization and expansion of the tumor. Classically, a TSA is considered only in cases of intrasellar infradiaphragmatic lesions or in intrasuprasellar lesions with enlarged sella, preferably cystic[22]. Laws[17] reported the merits of the transsphenoidal route in the removal of craniopharyngiomas previously. The additional bony exposure with the standard TSA (TSIA) allows excellent midline access and visibility to the suprasellar space while obviating brain retraction in our series. Craniopharyngiomas, Rathke's cleft cysts, which extended to suprasellar portion, are also suitable to treat in our cases. With respect to the pituitary macroadenomas with marked suprasellar extension, we think that more complete resection of adenomas may be achieved, reducing the need for blind curettage of tumor in the presellar space. Different to other lesions, in the case of meningioma removal, the bone which covers the anterior sellar wall, tuberculum sellae, and posterior planum sphenoidale may be hyperostotic and frequently require the use of high-speed drill. Especially, in cases of tuberculum sellae meningioma and craniopharyngioma, these lesions generally displace the optic apparatus and pituitary stalk away from the surgeon. Therefore, tumor removal can begin immediately after opening the dura, resulting in prompt chiasmal decompression. And also in case of the small sized meningioma, the the arachnoid membrane, which served as external capsule, separates the tumor from the surrounding neurovascular structures. However, there is vascular encasement in MR images in these tumors, this TSIA should be avoided because the possibility of serious vascular injury is too high. The superior hypophyseal arteries arose from the posteromedial surface of the ICA distally to the distal dural ring, and supply the optic chiasm and pituitary stalk are most vulnerable to tumor dissection[13)]. In addition, as with the suprasellar exposure, the extent to exposure obtained may be enhanced with the endoscopic apparatus.

Although TSA is relatively safe procedure, sometimes its postoperative course can be dangerous if the sellar floor is not reconstructed appropriately. The complications resulting from an inappropriate sellar floor reconstruction are empty sellar syndrome, hemorrhage, infection, pneumocephalus, and CSF rhinorrhea[12)]. Among these complications, the CSF rhinorrhea occurs as an immediate or delayed postoperative complication in 3 to 6.4% and requires re-operation in 1.5 to 2%[23)]. Generally, the goals of sellar reconstruction are hemostasis, reduction of intrasellar dead space, support for suprasellar structures, prevention of CSF leakage, and maintenance of the integrity of sellar floor[22)]. The most common method that has widely adopted to obtain these purposes is the extradural packing technique with autologous bone splint after packing the intradural dead space with fat graft. Since Kubota et al. used the silicone plate as a substitute during TSA because of its greater elasticity and maneuverability than bone or cartilage[10,16)], we have used to use the silicone plate for sellar floor resconstruction[12)]. We have gotten a suitable silicone plate from a 2-mm thick large-sized silicone plate with scissors in a rectangular shape. The edge of the silicone plate was inserted into extradural space between the bone and dura in an orderly fashion, and adjusted with a three-pronged fork or dissector into a final adequate position in our series. This technique is easier, faster than any other techniques that used a variety of substitutes[1,15)], and reduces operation time. If there is a small gap between the substitute and the sellar floor, it is obliterated by packing with oxidized regenerated cellulose and fibrin glue in our study.

Conclusion

There are several advantages of the TSIA from the authors' experience, as well as review of the literature. First, it is easily applicable through a minor modification of the standard TSA. Second, it provides excellent anatomical exposure of the structures located in the supradiaphragmatic suprasellar cistern with minimal brain manipulation, decreased morbidity. Third, an early devascularization at its base in the case of tuberculum sellae meningioma, results in the easy removal of the tumor. Finally, it is suitable for removing small lesions located in the presellar and suprasellar areas adjacent to the pituitary stalk. We recommend these TSIAs in the selected diseases, which mainly occur at the pre- and suprasellar regions. However the recent and increasing interest in the extended TSAs is currently reserved to selected suprasellar lesions, the greater care should be paid in the hands of experienced neurosurgeons.

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Commentary

The authors described the experiences of extended transsphenoidal approach for various suprasellar or presellar lesions. Extended TSA technique has been carefully applied suprasellar and parasellar tumors by several experienced neurosurgeon who had a lots of experience on the standard TSA technique. This technique would be indicated for the large suprasellar extended pituitary tumor which had tight diaphragm and relative small sellar. Also, craniopharyngioma which had relatively prefixed chiasm and growing into interpeduncular cisternal space would be indicated for this approach. The authors applied this technique for the tuberculum sellae meningiomas. But, in my opinion, tuberculum sellae meningioma had different tumor configuration to compare with pituitary tumor and craniopharyngioma in several point. The first point is the tuberculum sellae meningioma has origin of tumor from the dura over the tuberculum sellae and there are relatively broad dural attached tumor base which cannot be completely resected out through even extended TSA surgical corridor. If the dural attachment of tumor is remained, it can be the source of tumor recurrence in the future. The second point is most of the tuberculum sellae meningioma has tumor growing between the optic nerve and internal carotid artery on both parasellar direction. Superior hypophyseal artery and very tiny P-com perforators would be engulfed inside of the tumor in most cases. Probably, some readers of this paper have experiences how difficult to preserve the superior hypophyseal artery and P-com perforators completely during resection of tuberculum sellae meningioma in transcranial approach. The injury to superior hypophyseal artery can cause the visual problems and injury to P-com perforators can cause tremendous neurological problems. The pituitary tumor and the craniopharyngioma has relatively well preserved arachnoid dissection plane between tumor capsule and the adjacent neurovascular structures, such as optic nerve and P-com perforators. I had personal experience of extended transsphenoidal approach for 24 cases of giant pituitary tumor and 19 craniopharyngioma (9 pure suprasellar, 10 intrasellar and suprasellar location). But, I never applied this technique for the tuberculum sellae meningioma with those reasons.

Another weak point of this technique is to prevent postoperative CSF leakage. This technique open the CSF space intentionally to exposed the tumor and neurovascular structures in quite different pattern with standard TSA technique. So, after removal of tumor, CSF leakage repair requires water tight closure of dural defect, it cannot be done with conventional intrasellar packing technique, such as fat or muscle packing.

I comment one more point as the conclusion. If someone consider this technique in suprasellar and parasellar lesions, it should be consider the possibility of their own and confidence to preserve the tiny perforators around the tumors and CSF leakage repair in small, deep transsphenoidal route before thinking about the advantage of this technique to compare with transcranial route.

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