Case Report

The Bilateral Supraorbital Minicraniotomies for Total Removal of Giant Suprasellar-Subchiasmatic Tumors

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Minimally invasive supraorbital approach through minicraniotomy have been proposed and developed for the treatment of anterior cranial fossa pathology and lesions around sellae. The author has used this concept of smaller operative corridors to treat the suprasellar tumors. In cases of large suprasellar tumors, mainly of subchiasmatic location, that radical removal could not be achieved with unilateral approach, an additional contralateral supraorbital approach was proceeded to accomplish radical removal. Through bicoronal incision, approach via bilateral supraorbital minicraniotomies was used to treat three cases of giant suprasellar-subchiasmatic tumors, with the greatest dimension of more than 4 cm, between 2005 and 2010. The result of treatment is satisfactory. There was no operative mortality or new major neurological deficit. All tumors were totally removed with marked improvement of visual deficit in two patients. No adjuvant radiotherapy was given. All were recurrence free 18 months, 4 years, and 5 years after the surgery. The major advantage of this approach is the excellent visualization and identification of the plane between the tumor and contralateral optic nerve through each corridor. This will facilitate complete decompression of both optic nerves and enhance radical removal of the tumor while avoiding risk of injury to the nearby neurovascular structures. However, the approach-related disadvantage is the risk of olfactory dysfunction from bilateral olfactory nerve damage, which can be further improved by a refinement of the techniques.

Keywords: *Bilateral subfrontal approach, Bilateral supraorbital approach, Bilateral supraorbital minicraniotomies, Giant suprasellar-subchiasmatic tumors*

J Med Assoc Thai 2012; 95 (5): 730-8
Full text. e-Journal: *http://www.jmat.mat.or.th*

With improvement of microneurosurgical techniques and refined instrumentation, anterior cranial fossa and perisellar tumors traditionally approached by a conventional large frontotemporal or bifrontal craniotomy are now often accessed through smaller operative corridors[1-4]. A minimally invasive supraorbital keyhole or minicraniotomy has been proposed for approaching to the sellar, suprasellar, and perisellar regions[5-8]. The supratentorial aneurysms and tumors are the common lesions that treated by this approach. The author has used this concept of smaller craniotomy window to treat some selected suprasellar tumors with an attempt of total removal. In cases of large suprasellar tumors, mainly of subchiasmatic location, that radical removal could not be achieved with unilateral approach, an additional contralateral supraorbital approach was performed through the prepared bicoronal exposure. Similar to other combined approach, bilateral approach and working significantly promotes more radical resection than unilateral approach. Three cases of giant suprasellar-subchiasmatic tumors, approached by bilateral supraorbital minicraniotomies, are reported. Each tumor has the greatest dimension of more than 4 cm. Total tumor removal was accomplished in all cases without new major neurological deficit. Two patients had marked visual improvement. Neuroimaging follow-up did not show any evidence of residual or recurrent tumor. No adjuvant postoperative radiotherapy was given in all.

The objective of the present article is to propose a relatively simple and less invasive combined approach via bilateral supraorbital minicraniotomies for giant suprasellar-subchiasmatic tumors with special attention to its advantages of enhancing total tumor removal and complete decompression of optic apparatus while risk of injury to the adjacent neural and vascular structures is avoided. The surgical technique is described. Its advantages and disadvantages are discussed.

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Case Report

Between December 2005 and January 2010, three patients harboring giant suprasellar-subchiasmatic tumors were operated on at Rajavithi Hospital, Bangkok, Thailand, by the author using bilateral supraorbital minicraniotomies. Each patient had tumor with maximum dimension of more than 4 cm. Two were nonfunctioning pituitary adenomas and the other was tuberculum sella meningioma. All were females with their age range from 23 to 29 years.

Case 1

A 29-year-old woman presented with severe headache and impaired vision in the left eye of three weeks duration. She also had a history of amenorrhea for one year. Neurological examination was positive for decreased vision (20/50) in the right eye with temporal hemianopia and only hand motion with primary optic atrophy in the left eye. Magnetic resonance image (MRI) revealed a 4.4 cm sellar-suprasellar tumor with hemorrhagic component at the upper part. The tumor had anterior extension and showed dumbbell-shaped appearance in coronal view (Fig. 1 upper). Through bilateral supraorbital approach, the well capsulated tumor was radically removed. Histological examination revealed that the tumor was pituitary adenoma. After operation, there was no new neurological deficit but bilateral anosmia. She was discharged from the hospital on the eleventh postoperative day with improved vision but sustaining diabetes insipidus. Postoperative MRI showed no residual tumor (Fig. 1 lower). Five years after surgery she had visual acuity of 20/20 in the right eye and 20/200 in the left eye with right homonemous hemianopia. She is independent but requires full hormonal replacement and still has anosmia. Recent follow-up MRI shows no recurrent tumor.

Case 2

A 23-year-old woman began to have a symptom of decreased vision in the left eye and the deficit progressed to involve both eyes in two weeks. She had missed one cycle of her menstruation two months before. Neurological examination was positive for decreased vision, only hand motion in both eyes, bilateral optic atrophy, bilateral ptosis and lateral rectus palsy with diminished facial sensation on the left side. Hormonal testing showed only hypothyroid. MRI demonstrated a 5 cm sellar-suprasellar tumor with lateral extension to both cavernous sinuses (Fig. 2 upper). She was operated on via bilateral supraorbital approach and the tumor was radically removed. Histological examination revealed that it was pituitary adenoma. Postoperatively, she performed well and had no new neurological deficit except bilateral anosmia. She had temporary diabetes insipidus and was discharged from the hospital on the sixteenth postoperative day with marked improvement of her vision and other preoperative neurological deficits. Follow-up MRI revealed no residual tumor (Fig. 2 lower). Four years after surgery the patient is independent with normal visual acuity and minimal temporal visual

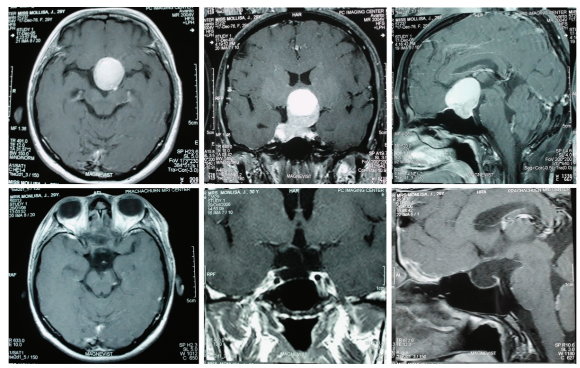

Fig. 1 T_1-weighted contrast enhanced MRI in axial, coronal, and sagittal view of case 1
Upper: Preoperative image showing giant sellar-suprasellar tumor with anterior extension and dumbbell configuration in coronal view
Lower: Postoperative image confirming total tumor removal

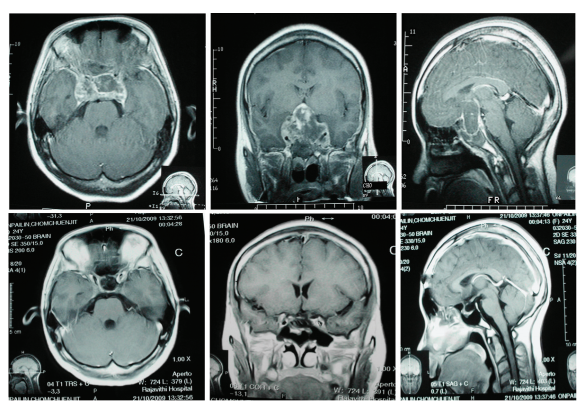

Fig. 2 T_1-weighted contrast enhanced MRI in axial, coronal, and sagittal view of case 2
Upper: Preoperative image showing giant sellar-suprasellar tumor extending to both cavernous sinuses
Lower: Postoperative image revealing no residual tumor

field defect of both eyes but her anosmia persists. She requires hormonal replacement except for diabetes insipidus. Recent MRI demonstrated no recurrent tumor.

Case 3

A 25-year-old woman presented with an episode of seizure one week before admission. She had progressive decrease of vision for eight months. On neurological examination, she was drowsy and confused. Testing of visual acuity showed no light perception of both eyes. Ophthalmoscopy revealed bilateral primary optic atrophy. MRI showed an enhanced suprasellar mass with greatest dimension of 4.6 cm. The tumor based on the whole sella with posterior and superior extension causing hydrocephalus (Fig. 3 upper). On operation, the external ventricular drainage was done first and through bilateral supraorbital approach, gross total removal of the tumor was performed and the dural attachment around tuberculum sella was coagulated. Histological examination reported that the tumor was meningioma. After surgery, she was confused for a few days and developed temporary diabetes insipidus. Apart from bilateral anosmia, she had no new neurological deficit. She was discharged from the hospital on the twenty-seventh postoperative day without improvement of her vision. Follow-up MRI showed no residual tumor or hydrocephalus (Fig. 3 lower). Eighteen months after surgery her vision has not improved as well as her anosmia. She is partially dependent resulting from blindness and requires hormonal replacement except for diabetes insipidus. Last follow-up MRI demonstrates no recurrent tumor.

Surgical technique

Operation was performed under general anesthesia with use of the operating microscope and microsurgical instrumentation. Each patient was operated on with supine position with the neck slightly extended. The head was fixed in a head holder without rotation of head to the side but the operating table was tilted to each side according to the surgeon's preference during the procedure. Intravenous osmotic diuretic (mannitol) was given before making a cosmetic bicoronal incision. The incision extended behind the hairline from the level of one eyebrow to the other (Fig. 4). The scalp was dissected through the loose aereolar layer and turned. The galeal layer was elevated along with the scalp anteriorly, while leaving the pericranium and temporalis muscle and fascia attached to the skull. The superficial temporal fat pad was elevated up with the galeal skin flap, by using the interfascial dissection technique, to preserve the frontotemporal branch of the facial nerve. Care was taken to preserve the supraorbital nerve and artery as the galeal elevation approached near the supraorbital rim. The supraorbital craniotomy was intended to be started on the right side in all patients, so a small incision on the right temporalis muscle just above and parallel to the zygomatic process of frontal bone was made and extended superiorly and curved medially in such a fashion to make a supraorbital pericranial flap

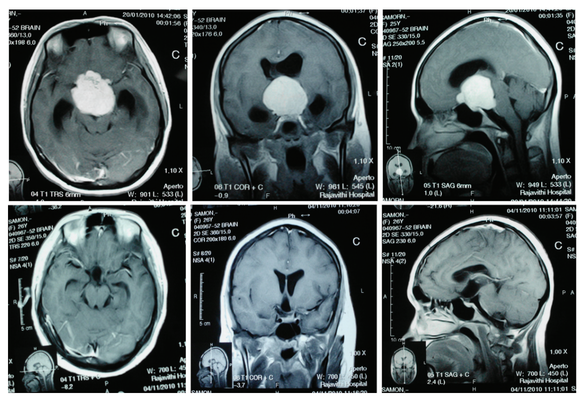

Fig. 3 T_1-weighted contrast enhanced MRI in axial, coronal, and sagittal view of case 3
Upper: Preoperative image showing giant suprasellar tumor locating on the entire sella with retrochiasmal extension and enlarged ventricles
Lower: Postoperative image showing total tumor removal and resolved hydrocephalus

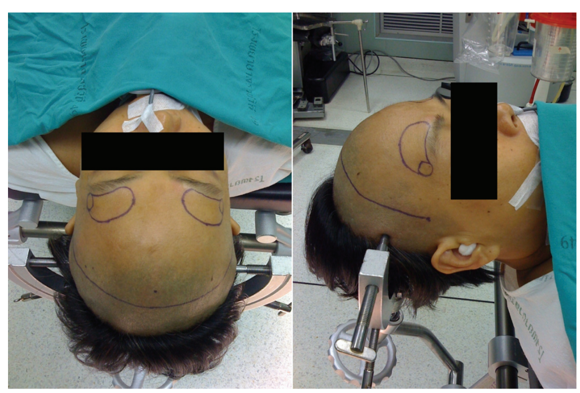

Fig. 4 Preoperative views showing the position of the head and the line of bicoronal skin incision extended just behind the hairline from the level of eyebrows with the proposed burr hole and bone flap

which was then retracted inferiorly to expose the supraorbital rim. A burr hole was placed under the incision of temporalis muscle just posterior to the anterior temporal line. An approximate 4cm by 3 cm craniotomy was performed close to the supraorbital rim (Fig. 5). The dura was opened in a semicircular-shaped fashion and reflected anteriorly with tack-up sutures. The frontal lobe was gently elevated and the cerebrospinal fluid was drained from the basal cistern to obtain brain relaxation except case 3 that needed external ventricular drainage from ventriculostomy done via right frontal burr hole. Self-retaining retractors were placed to expose the tumor and the ipsilateral optic nerve. The anterior part of the tumor, which was seen bulging between both optic nerves, was then resected and debulked in a piecemeal fashion via prechiasmatic space (Fig. 6). From the angle of view through the first craniotomy, the contralateral optic nerve was seen displaced and lateral to the tumor. Therefore, the plane between the tumor and contralateral optic nerve was well visualized and this part of the tumor could then be accessed and radically resected out of the contralateral optic nerve and internal carotid artery (Fig. 6B). On the other hand, the tumor part behind the ipsilateral optic nerve was difficult to access and resect due to the overlying optic nerve and internal carotid artery (Fig. 6C). Access to the tumor through the opticocarotid and carotidoculomotor spaces or lamina terminalis was not performed. The part behind the ipsilateral optic nerve and the superior part was left when a significant amount of tumor remained and could not be resected further. The same approach and procedure was then performed on the left side (Fig. 7, 8). After the basal part of the tumor behind both optic nerves was substantially removed then the superior part could be mobilized down. The maneuver of mobilizing the superior part of tumor down into view and resecting it via prechiasmatic space were alternately repeated. Entire removal was attempted. Ultrasonic aspirator was also used for resection and curette was used for the intrasellar portion. After hemostasis was confirmed, the dura was closed in water-tight fashion. If the frontal sinus was entered during craniotomy, the mucosa was exenterated and the sinus was packed with a piece of pericranium or temporalis muscle then closed with supraorbital pericranial flap if needed. The craniotomy and wound were closed in the usual way.

The surgical technique can be summarized as the following steps:

Step 1. Through the first craniotomy, removing the contralateral basal part of the tumor, including the accessible intrasellar part.

Step 2. Through the second craniotomy, removing the contralateral basal part of the tumor, including the remaining intrasellar part.

Step 3. Through the second craniotomy, removing the remaining superior part of the tumor.

Discussion

In 1900, Krause first demonstrated supraorbital subfrontal approach on cadaver with a rather large craniotomy over the supraorbital rim, then eight years later he reported the first resection of skull base meningioma through this approach[9]. In 1913, Frazier reported the first case of a patient operated on via supraorbital approach, in order to treat a pituitary adenoma[10]. Jane et al used the supraorbital approach to treat orbital tumors, anterior communicating artery aneurysms, pituitary adenomas, craniopharyngiomas, and parasellar or olfactory groove meningiomas[7]. However, this approach, restricted at that time by both instrument availability and level of understanding, was not widely accepted until the 1990s[11,12].

Now this approach has developed and employed through the smaller craniotomy so that it can be performed via incision on the eyebrow[2,3,4,13]. It is applied to treat various pathologies of the anterior cranial base and around sellar region. The major drawback of the approach is the potential for limited maneuverability caused by the small bony opening[1,2,6,13]. Recently Nakamura M et al reported a retrospective analysis of patients with tuberculum sellae meningiomas operated by one surgeon using three different transcranial approaches[14]. They reported that a small frontolateral (supraorbital) approach provided better results concerning visual outcomes than the pterional and bifrontal approaches, with similar results regarding rates of total tumor removal. The frontolateral approach represented the least invasive surgical approach.

The author has used supraorbital mini-craniotomy for treatment of selected suprasellar tumors and found some limitations of unilateral approach for giant suprasellar tumors with subchiasmatic location. The problem was that it was very difficult to see and identify the plane between the tumor and the inferior surface of the ipsilateral optic nerve and internal carotid artery. Therefore, trying to clear the tumor from underneath the ipsilateral optic nerve was difficult and the nerve was more prone to surgical trauma. On the

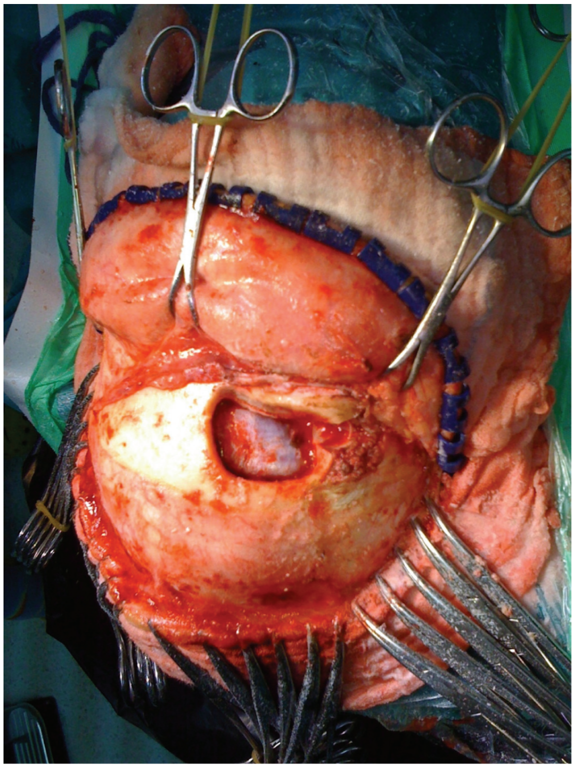

Fig. 5 Operative view of right supraorbital craniotomy

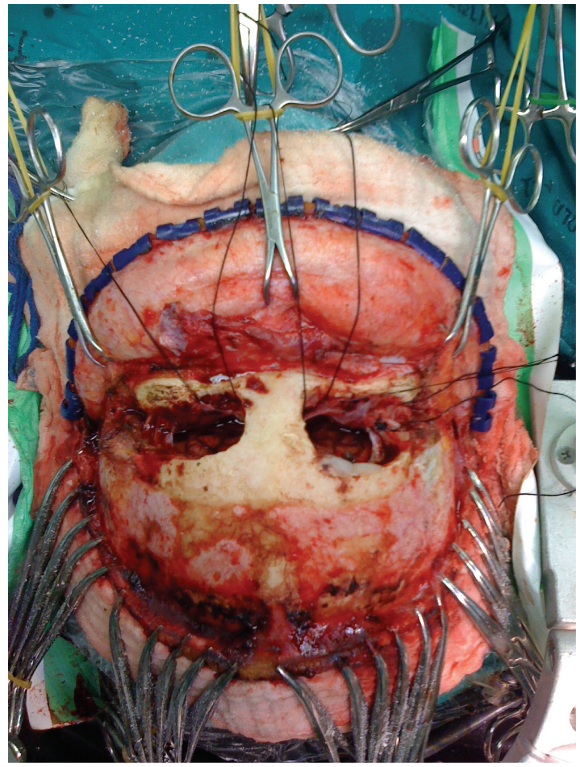

Fig. 7 Operative view of subsequent left supraorbital approach

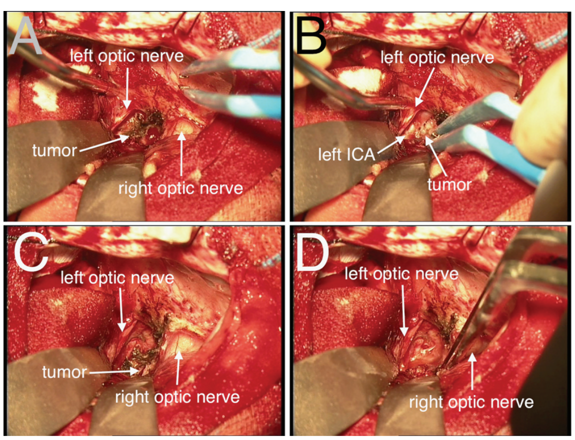

Fig. 6 Illustration through right supraorbital approach in case 3
A: Initial resection of tumor between both optic nerves
B: The tumor was debulked and dissected from the left optic nerve and internal carotid artery (ICA)
C: The part behind the left optic nerve was totally resected while the part behind the right optic nerve was difficult to see and access
D: The tumor was cleared out of view

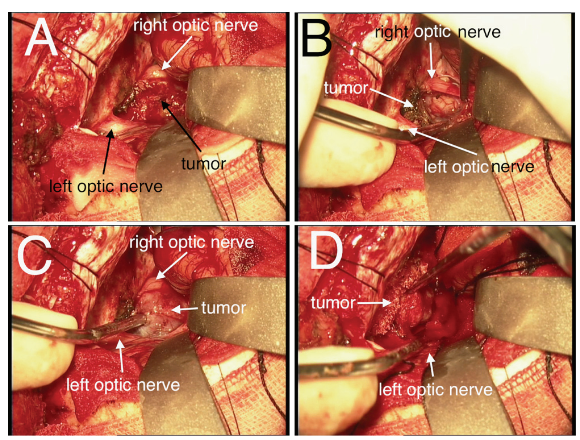

Fig. 8 Illustration through left supraorbital approach in case 3
A: The bulging right optic nerve compressed by the tumor underneath
B: The tumor was cleared from the right optic nerve
C: The superior part of the tumor was mobilized down to prechiasmatic space
D: Removing of the last bulky piece of tumor

contrary, visualization and identification of the plane between the tumor and contralateral optic nerve and internal carotid artery was much better.

Furthermore, other deficiencies have been previously pointed out. Access to the tumor through the ipsilateral opticocarotid and carotidoculomotor corridors is narrow. The optic nerve, internal carotid artery, and oculomotor nerve can only be mobilized a few millimeters (1-2 mm) to reveal underlying structures and dissection beyond this is blind(15). The lateral view through the opticocarotid space may be obstructed by perforating arteries therefore when faced with large retrosellar tumors, working through these corridors is limited, and gross total removal of tumors cannot be accomplished(16).

Due to aforementioned limitations, in cases of large suprasellar-subchiasmatic tumors, removing part of the tumor behind and lateral to the ipsilateral optic nerve was not effective and could be partially done. Only the contralateral basal part of the tumor could be substantially removed, owing to the better view to access and identify the plane. This made further removal of the superior part of the tumor very difficult because the bulky remaining ipsilateral basal part of the tumor precluded mobilization of the superior part down to subchiasmatic area. To obtain more radical removal of the tumor, an additional contralateral supraorbital approach was performed. Bilateral approach provided additional line of surgical vision and working corridors. This enabled radical removal of entire basal part of the tumor and subsequently allowed mobilizing the superior part down to be removed through prechiasmatic space and achieving total removal.

Consequently, some benefits of this bilateral supraorbital approach are proposed. The distinction is that it facilitates radical removal of large suprasellar-subchiasmatic tumors with relatively less invasive approach. This promotes a good long-term clinical outcome and obviates the need for radiation therapy particularly in total removal of benign tumors. Several studies have reached the similar conclusions that surgical outcome and recurrence are dependent on the degree of resection(17-25).

Effective decompression of both optic nerves is also a significant advantage of this approach because it gives the better identification of the plane between the tumor and both optic nerves. This will promote the improvement and recovery of visual function of both eyes. The reported case 1 and case 2 have satisfactory and good visual outcome respectively. The case 3, who had visual symptoms for 8 months and had no light perception before surgery, had no improvement of visual deficit. The duration of visual deterioration before surgery is considered as one of the main factors influencing the visual outcome. Some authors reported that patient with a duration of visual symptoms less than 6 months had a better chance of postoperative improvement of vision, whereas patients with symptoms lasting longer than 24 months had a higher risk of visual deterioration(26,27). Other authors found that visual prognosis was affected favorably when preoperative visual loss was less than 50%(28).

Another advantage of this approach is that access to the lateral part of the large subchiasmatic tumor through the opticocarotid and carotidoculomotor corridors can be obviated. Manipulation through these corridors is limited and potentially blind, due to the restriction among neurovascular structures(15,16). Contralateral approach via prechiasmatic space will provide better view and access to the tumor behind these structures. Therefore, the risk of injury to the ipsilateral optic nerve, internal carotid artery, oculomotor nerve, and the perforating arteries can be avoided. Besides, owing to the increased facility of mobilizing the tumor down, translamina terminalis access might not be needed as well. This can avoid the possibility of damage to the optic pathways during manipulation through lamina terminalis(16). However, according to the operative findings, these corridors can still be useful and can be used if needed. Moreover, this approach is less invasive compared with the larger exposure, bifrontal interhemispheric approach, which may need to cut the draining veins and superior sagittal sinus. This maneuver, combined with brain retraction, may cause venous infarction and fatal brain edema(14,29).

On the basis of bilateral trajectory lines through the prechiasmatic space, the profit is the wide angle of viewing and access into the subchiasmatic space. Therefore, the bilateral supraorbital approach is then suitable for large suprasellar-subchiasmatic tumors with less intrasellar extension. These tumors will push up the chiasm and open the prechiasmatic space, which is necessary for working through this space. The tumors should also be well-circumscribed, not a kind of invasive or infiltrative to the brain substance, so that they can be mobilized down. In mainly prechiasmatic placed tumors, unilateral approach is usually adequate for good visualization and access, because the optic nerves do not conceal the tumors. While purely retrochiasmatic tumors, with prefixed chiasm, are not accessible between the optic nerves at the beginning of the procedure[30].

Location of anterior optic pathways in sellar and parasellar tumors can be evaluated and predicted preoperatively by use of MRI[31,32]. Studying with heavily T2 weighted MRI, Saeki et al reported the 95% detectability rate of anterior optic pathways in suprasellar tumors and found that the optic chiasms were most commonly superoposterior in pituitary adenomas, posterior in meningiomas, and anterior (prefixed) in craniopharyngiomas[32]. However, even if the prefixed chiasms are faced either preoperatively or intraoperatively, the primary supraorbital approach can still be used, by access through lamina terminalis for suprasellar part or removal of tuberculum sellae for access to intrasellar part of tumors[33,34]. If additional surgical trajectory is needed, the secondary contralateral supraorbital approach can be considered as well.

Owing to the need of bilateral craniotomies, the bicoronal skin incision is used. This is for cosmetic reason and, in addition, the craniotomy size will not be limited by the incision, contrasted with those made through the eyebrow incision. Therefore, with bicoronal incision, the craniotomy is more flexible and comfortable depending on the surgeon's preference and the encountered situations.

The disadvantage related to this approach is the risk of bilateral olfactory dysfunction. All of the three cases reported here had bilateral anosmia after surgery. Postoperative anosmia is a well-known complication after subfrontal approach. It results from damage to the olfactory nerve that may be pulled out of the cribiform plates as a result of excessive frontal lobe retraction or damaged by the ischemic effects of retraction pressure[35-37]. To reduce the incidents of this complication, meticulous dissection and separation of the nerves or cautious frontal retraction of not more than 15 mm must be employed[38]. Furthermore drilling of the supraorbital rim and orbital roof can reduce the need of frontal retraction[1].

Conclusion

Bilateral subfrontal approach through bilateral supraorbital minicraniotomies is a less invasive exposure compared with the conventional large frontotemporal or bifrontal craniotomy. It is proposed for the treatment of a well-circumscribed giant suprasellar-subchiasmatic tumor with less intrasellar extension. It offers additional line of surgical vision and working corridors to the tumor part behind both optic nerves. This enables complete decompression of the optic apparatus and total tumor removal, which will promote visual improvement and better long-term clinical results of the patients. It can also avoid the risk of injury to adjacent neurovascular structures, which is more prone in pterional approach. However, the approach-related risk is bilateral olfactory dysfunction. The ways to preserve the olfactory function can be further improved by a refinement of the techniques. Nevertheless, its utilities and benefits will justify the approach in this group of patients.

Potential conflicts of interest

None.

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การเปิดกะโหลกศีรษะขนาดเล็กเหนือเบ้าตาทั้งสองข้างสำหรับการผ่าตัดเนื้องอกขนาดใหญ่เหนือ sella ใต้ chiasm

พรินทร์ มหัทธโน

จากที่ได้มีการเสนอวิธีการรักษาพยาธิสภาพบริเวณฐานกะโหลกศีรษะด้านหน้าและรอบ sella ด้วยการผ่าตัดเปิดกะโหลกศีรษะขนาดเล็กเหนือเบ้าตา และมีการพัฒนามาเป็นลำดับ ผู้นิพนธ์ได้ใช้แนวคิดนี้ในการรักษาเนื้องอกเหนือ sella แต่ในรายที่เนื้องอกมีขนาดใหญ่มาก จนไม่สามารถผ่าตัดออกได้หมด การเปิดกะโหลกเหนือเบ้าตาเพิ่มขึ้นอีกข้างหนึ่งเพื่อเพิ่มช่องทางเข้าสู่เนื้องอก จะช่วยให้สามารถผ่าตัดเนื้องอกออกได้มากขึ้น รายงานนี้ได้เสนอการรักษาเนื้องอกเหนือ sella ใต้ chiasm ที่มีขนาดใหญ่มากกว่า 4 เซนติเมตร จำนวน 3 ราย ในระหว่างปี พ.ศ. 2548 ถึง พ.ศ. 2553 โดยการผ่าตัดเปิดแผลแบบ bicoronal และเปิดกะโหลกศีรษะขนาดเล็กเหนือเบ้าตาทั้งสองข้าง ผลการรักษาเป็นที่น่าพอใจ ไม่มีผู้ป่วยรายใดเสียชีวิต หรือ เกิดภาวะแทรกซ้อนทางระบบประสาทอย่างรุนแรง ทุกรายได้รับการผ่าตัดเนื้องอกออกได้หมด โดยไม่ต้องให้การรักษาทางรังสีเพิ่มเติม สองรายมีการมองเห็นดีขึ้นมาก ในผู้ป่วยทั้งสามรายไม่พบเนื้องอกกลับเป็นใหม่ภายหลังการผ่าตัด 18 เดือน 4 ปี และ 5 ปี ตามลำดับ ข้อดีของการเปิดกะโหลกสองข้างแบบนี้คือ สามารถมองเห็นและแยกแนว (plane) ระหว่างเนื้องอกกับเส้นประสาทตาทั้งสองข้างได้ดีผ่านช่องทางแต่ละข้าง ช่วยให้ผ่าตัดเนื้องอกออกได้มากขึ้นจนหมดได้ แก้ไขการกดทับเส้นประสาทตาได้อย่างสมบูรณ์ และยังลดโอกาสเสี่ยงต่อการบาดเจ็บของเส้นประสาทตาและหลอดเลือดข้างเคียง แต่ข้อเสียคือความเสี่ยงต่อการสูญเสียการได้กลิ่น จากการบาดเจ็บต่อเส้นประสาทการได้กลิ่นทั้งสองข้าง ซึ่งสามารถปรับปรุงให้ลดลงได้ต่อไป