Endoscopic assisted Supraorbital Approach for Tumors of Anterior and Middle Skull Base

Abstract

Background data: The supraorbital eyebrow approach is a minimally invasive keyhole technique that offers wide access to the anterior skull base and parasellar region using the subfrontal corridor, with assistancesof neuroendoscopy The approach through the eyebrow permits access to a number of lesions in the subfrontal corridor with minimal brain retraction and a much smaller area of potential injury of main structures.

Study Design : This study is a follow up study.

Objective: to evaluate the role of supraorbital endoscopic approach for tumors of anterior and middle skull base.

Patients and Methods: All the operations were performed at Suez Canal University hospitals , In about 24 months, the first 30 patients having tumors of anterior and middle skull base fulfilling the inclusion criteria were included in this prospective study

Results:

Endoscopy can play an important role in improving visualization through the keyhole corridor. With the use of neuroendoscopy, the reach of this approach may be extended even further to include the pituitary fossa, the top third of the clivus, the interpeduncular cistern, the anterior third ventricle, and the medial and anterior temporal lobe and middle fossa.

The major advantage of the supraorbital over the endonasal route is a simplified skull base closure and reduced risk of postoperative CSF leak. It is a valuable approach for selected patients. Neuromonitoring may further increase surgical safety

Conclusion: The approach through the eyebrow permits access to a number of lesions in the subfrontal corridor With the use of the assisstence of neuroendoscopy ,with minimal brain retraction and a much smaller area of potential injury of superficial structures.

Keywords: Minimally invasive neurosurgery ,Neuroendoscopy , Skull base surgery ,Supraorbital approach, eyebrow approach

Introduction: Access to tumors of the anterior and middle cranial base has traditionally required aggressive trans-cranial approaches such as the frontotemporal, pterional, Cranio-orbito-zygomatic or bifrontal. These wide exposures, however, often come at the expense of a significant degree of frontal and/or temporal brain retraction and involve unnecessary surgical dissection, which in turn may result in undesirable perioperative morbidity 1.The supraorbital eyebrow approach is a minimally invasive keyhole technique that may be used to access surgical lesions located at the anterior skull base and within the parasellar region 2.Relying on an eyebrow incision and a small anterolateral craniotomy, the supraorbital route is a workhorse-type approach in minimally invasive neurosurgery that offers excellent exposure of a number of anatomic locations and structures, including the anterior fossa floor, the optic apparatus, the lamina terminalis, the ipsilateral and contralateral internal carotid arteries, the proximal Sylvian fissure, medial temporal lobe, the circle of Willis, the basal frontal lobe, and the interpeduncular cistern (3).The small opening and wide surgical reach of this approach make it minimally invasive yet maximally effective. The reach and visualization of the supraorbital approach can be enhanced by endoscopy, which allows better views and access to the pituitary fossa, the region under the ipsilateral optic nerve (ON), contralateral segments of the circle of Willis, the anterior third ventricle, the anterior interhemispheric fissure, the upper third of the clivus, the interpeduncular cistern, and the medial aspect of the ipsilateral middle cranial fossa and temporal lobe (3). To minimize the injurious effects of frontal and temporal lobe retraction and to avoid the use of potentially disfiguring skin incisions, approaches to tumors of the middle cranial base have become progressively less invasive. The strategic placement of "keyholes" eliminates the need for excessive surgical manipulation without sacrificing exposure or outcome. Furthermore, with the introduction of fully endoscopic approaches to the skull base, these tumors have now become amenable to endoscopic resection with a minimum of deleterious consequences (3).The most commonly encountered surgical lesions amenable to the supraorbital approach are the tuberculum sellae, planum and anterior clinoid meningiomas, some olfactory groove meningiomas, craniopharyngiomas, and intra-axial tumors of the orbitofrontal region, frontal pole, and medial temporal lobe, such as metastases and gliomas (4).Less commonly encountered neoplastic lesions that are ideally treated via the supraorbital approach include the rare pituitary adenoma with a far lateral or anterior extension, gliomas involving the optic apparatus or suprasellar compartment, and other tumors of the anterior third ventricle, such as hypothalamic hamartomas with inferior extension. In addition, tumors of the orbit that are superior and lateral to the optic nerve are ideally accessed by this subfrontal craniotomy followed by opening of the roof of the orbit (3). In addition, the adaptation of rigid endoscopy to the supraorbital approach broadens the available surgical exposure, thus providing extended access to the middle and not only the anterior cranial fossa without additional dissection or retraction. Using the endoscopic supraorbital approach to access the anterior and middle cranial base, we found that the endoscope enhanced our ability to respect the anatomy of this area because of its superior visibility, therefore enabling a more complete excision of middle cranial base tumors (3).

This series aims for evaluating of the surgical management of anterior and middle skull base tumors by a minimal invasive endoscopic supraorbital procedure.

Patients and Methods This study is a follow up study to evaluate the role of supraorbital endoscopic approach for tumors of anterior and middle skull base.
All the operations were performed at Suez Canal University hospitals , In about 24 months, the first 30 patients having tumors of anterior and middle skull base fulfilling the inclusion criteria were included in this prospective study. **Inclusion criteria : I** Anterior and middle skull base small and medium sized lesions, II Both sexes were included**, III** Age 16-70 yrs. **Exclusion criteria:**. I Recurrent cases**, II** Cranial Congenital anomalies, III Previous trauma affecting anterior or middle base, IV Large extended tumors (closely related to carotid artery or its branches and/or fibrous expected neoplasms), V Cranial infections.

Preoperative evaluation: History: Personal history was taken from the patients or the relatives including sex, age, occupation, special habits, and co-morbid medical conditions. Present history data concerning the presence of neurological symptoms (onset, course, duration) like visual symptoms, olfaction, and hormonal dysfunction. Past history of any previous cranial surgery or cranial trauma, **Examination:** General examination with detailed neurological examination, which also used as measurements for assessment the clinical progress **Investigations** including Preoperative CT-brain and MRI brain with contrast, Hormonal profile may be needed and Visual perimetry may be needed. if lesions are closely related to carotid artery or its branches: CT-angiography should done.

Operative Data: The mean operative time, the mean blood loss, the intra operative complications, was estimated.

Operative technique:

- The patient was placed supine on the operating room table, and the head of the bed was slightly raised to improve venous drainage.
- After the induction of general anesthesia, the patient's neck was extended approximately 15º-30º so that the frontal as well as the temporal lobes were relaxed and retracted downward with gravity away from the orbital roof and the floor of the skull base once CSF is drained.
- This position facilitates access to middle cranial fossa tumors from an anterior trajectory.
- Once positioned, the head was fixed in place using a 3-pin clamp, and the frontal and Para nasal areas were cleansed with an aqueous antiseptic solution and then draped.

- The base of a pneumatically powered endoscope holding arm was fastened to the operating room table opposite the surgeon; the arm extended to hold the endoscope firmly.
- A 4.0-mm 08 rigid endoscope (Karl Storz) was attached to the holding arm.
- A standard skin incision was placed within the hair of the eyebrow a few millimeters above the orbital rim according to each patient's individual anatomy that has to be respected.
- The incision was bounded medially by the supraorbital notch and laterally by the lateral end of the eyebrow just anterior to the frontozygomatic suture.
- There was no standard position for the skin incision because it had to vary slightly according to each patient's individual anatomy and skull shape.
- Subsequent to skin and soft tissue incision, a 1.5-cm supraorbital craniotomy was performed with its lower end flush with the skull base.
- The dura was incised, and CSF was slowly drained under microscopic visualization without traction.
- A combination of mild hyperventilation, positioning, and CSF drainage opened a space as the frontal lobe relaxed away from the anterior cranial base downward facilitated by gravity.
- At this point, the monitor becomes literally the surgeon's eye.
- The endoscope was introduced through the keyhole and advanced between the frontal lobe and the floor of the anterior cranial base, closely sliding over the superior wall and the lesser wing of sphenoid bone all the way to the middle cranial fossa.
- A panoramic view of the tumor was displayed on a flat screen.
- Endoscopic survey revealed the degree of intracranial tumor spread.
- Using a combination of custom-designed bipolar electrocoagulation and micro-CUSA (if available), the tumor was gradually resected.
- Once the tumor was thought to be completely removed, the zero degree endoscope was withdrawn, and the 30degree endoscope is introduced and rotated in a clockwise and anticlockwise direction to conduct a survey of the middle cranial fossa and to look for any residual tumor out of the straight view of the 0degree endoscope.
- Any tumor remnants were removed, assuring that the tumor had been totally excised.

- Of note, the sphenoid ridge and/or the superior orbital roof were drilled away to either give a better basal view or better access to the tumor.
- After tumor removal, Dura was tightly closed and the keyhole bone flap was repositioned using micro plates and screws.
- The skin incision was closed with careful attention to the aesthetic repair.
- If the frontal sinus was accidentally opened during the bony work, the mucosa was stripped, the naso-frontal duct was obliterated, and the sinus was dealt with.
- Most patients undergoing these procedures were monitored overnight in the intensive care unit and thereafter transferred to the ward for 24 hours until discharge from the hospital.

Postoperative evaluation

Post-Operative Data:

- Time of stay in hospital, post-operative complications were estimated.
- Post-operative CT-brain.

Follow up evaluation

Clinical examination, hormonal investigations and brain image if needed were carried out at the out-patient clinic at 1, 6 and 12 month after the surgery.

Assessment of clinical outcome

We considered the following variables as primary outcomes:

- Total removal of tumors without neurological deficit.

Second outcomes

We also considered the following variables as second outcomes:

- Complications of surgery, including mortality and common thrombosis, surgical site and other infections.
- Duration of hospital stay.
- Surgical cost, and
- Operation time.

Statistical Data Analysis

Data was analyzed with the statistical package of social science (SPSS), statistical software program version 18.

Statistical data analysis was accomplished using the chi-square test and the Student t test. P value of 0.05 was used to define statistical significance.

Results

30 patients(12 males and 18 females) were recruited for this study after exclusion of who have lost during the follow up. Demographic data and age distribution are shown in table 1

93.33% were complaining of headache. **Distribution of symptoms & signs among study population is showen in table2** &3

The smallest lesion operated upon in this study was 2cm while the largest was 8cm.

Radiologic analysis of lesions(nature, size, site &enhancement) were illustrated in table4 and figure 1,2&3

❖ **Surgical findings**

The selected approach among the 30 patients was as follows:

- 10 patients (33.33%) were operated via the right supraorbital endoscopic assisted trans eyebrow approach.
- 20 patients (66.67%) via the left supraorbital endoscopic assisted trans eyebrow approach.
- The lesion was found to be firm and tough in 19 patients (63.33%), soft and suckable in 7 patients (23.4%), cystic in 1 patients (3.3%), mixed cystic and solid in 3 patients (10%). Attachment of the lesions to the surroundings was illustrated in table5

Extent of surgical excision

The lesions were totally removed in 24 cases:

- 17 meningiomas (12 convexity meningiomas and 5 frontobasal meningioma -planum sphenoidal, and olfactory grooves-).
- 4 metastesis.
- 2 gliomas.
- 1 pituitary adenoma.

The lesions were subtotally removed in 5 cases:

- 2 meningiomas (diaphragm sellae& planum).
- 2 gliomas.
- 1 metastesis.

The lesions were partially resected in one case only:

- Pituitary adenoma.

The mean blood loss was 850 ml± 215 ml & the mean operative time was 300± 150 minutes

- ➢ All patients were given antibiotics for at least first postoperative week and antiepileptic drugs were given to all patients intraoperative and continued for at least first 3months post-operative.
- ➢ ***Adjuvant therapy*** (chemotherapy, radiotherapy and radiosurgery) proceeded according to histopathological analysis. Different pathological lesions were treated: There were 19 meningiomas, 5 metastasis, 4 GBM and 2 pituitary adenomas.

Patient's admission ranged from 2-6 days, only one patient stayed at hospital for two weeks. ICU admission lasted for 12hrs in 14 patients and lasted for 24 hours in 15 patients (50 %).

All patients were assessed clinically and by radiological imaging immediately postoperative and at 3 months, 6 months and 1 year after surgery to evaluate:- Extent of lesions resection, Related complications& Post- operative scar.

- ➢ Postoperative **visual evaluation** showed that:
- In 80% of patients with preoperative visual problems, the vision improved.
- The vision stayed the same in 20% of patients.
- The vision did not deteriorate in any patient.

Postoperative **endocrinal evaluation** showed:

- Improvement in 1 patient of pituitary adenoma in which menstruation became regular and prolactin level normalized.
- 2 patients developed diabetes insipidus; one was temporary and improved and one was permanent and received replacement therapy.
- ➢ Three patients presented by **fits**; all of them were controlled by antiepileptic drugs preoperative and remained free of fits during the period of follow up.

- **Cranial nerve assessment** showed that preoperative anosmia did not improve in 2 patients whom were presented with olfactory groove meningioma during the period of follow up.

  -During the follow up period 2 patients showed recurrence after resection; one of them was the patient with convexity meningioma after 6months of follow up and one glioma patient who underwent subtotal resection showed regrowth with follow up. It should be considered that the maximum follow up period which was 12 months may not be sufficient to detect recurrence in some lesions e.g. meningiomas.

  Postoperative complications are shown in table 6

  The patients who had excellent outcome were 14 meningioma patients, 2 metastesis patients and 1 glioma patient. They had both clinical and radiological improvement.

  The patients who had good outcome were 5 meningioma patients, 3 metastesis patients, 3 glioma patients and 1 pituitary adenoma. They had improvement but with some complications.

  The patient who had Poor outcome was a patient with pituitary adenoma. The patient had permanent hormonal replacement dependence.

  There was a significant relation between the size of the lesion and the extent of excision (P value = 0.032) , between the extent of excision and the pathological type (P value =0.024)& between extent of excision and outcome (P value =0.001).

  There is no significant relation between extent of excision and nature of the lesion at surgery (P value =0.37), between pathology and outcome in this study & between the duration of symptoms and outcome (P value =0.218).

Discussion

Several approaches have been developed to decrease the size of the craniotomy, minimize brain retraction, and promote adequate exposure of the cranial base. Frazier reported the first case in 1913. He was resected the supraorbital ridge to operate on a pituitary tumor through the anterior cranial fossa (5).

Jane described a supraorbital exploration, which they considered to be the approach of choice for orbital tumors and for anterior communicating artery aneurysms, pituitary tumors, craniopharyngiomas, and parasellar or olfactory nerve meningiomas (6).

With improvements in microsurgical techniques, refined instrumentation, surgical navigation and endoscopy, anterior cranial fossa and parasellar tumors traditionally approached by a conventional large fronto-temporal or bifrontal craniotomy are now often accessed through smaller operative corridors (7).

Keyhole approaches offer minimal approach-related trauma; the supraorbital keyhole craniotomy through an eyebrow incision is one of the best examples of minimally invasive neurosurgery .8

Many felt that a keyhole approach would limit exposure and not allow adequate visualization to perform safe and successful surgery 9.

In our experience, despite the small size of the craniotomy, the exploration followed by slow CSF drainage proved to be large enough for safe intracranial microsurgical interventions while the integrity of as much normal tissue as possible was preserved. Unnecessary manipulation or brain retraction was not needed.

Early reports discussed difficulties with cosmoses both from the bony repair and the incision. Postoperative functional loss of the supraorbital nerve or frontalis branch of the facial nerve was common in early case series as well. In the setting of a breach of the frontal sinus, meningitis or CSF leak has also been reported 9.

Experience has helped to demonstrate the limitations of the approach, and many of these early limitations have been overcome. A number of case series reported in the literature demonstrate the efficacy of this approach 9.

Gross total resection was achieved in a similar extent as much larger craniotomies, being reported as 89.2% gross total resection of skull base meningiomas in the largest series 10,11,12.

Piece by piece resection with careful preservation of arachnoid planes is the most important surgical step for preservation of the microcirculation of the optic nerve and avoidance of other vessels injuries. Arteries supplying the tumor should clearly be differentiated from those supplying the optic system or hypothalamus 13

Morbidity also does not appear to be higher than in other procedures for similar pathologies including a low CSF leak rate**.** Experience and familiarity with using a particular approach are also important points to consider. However, the study by Figueiredo et al. demonstrated that less invasive openings may offer similar surgical working areas to those provided by standard craniotomies and constitute excellent alternatives to the pterional craniotomy in selected cases 13.

With the introduction of neuronavigation and intraoperative endoscopy, the angle and depth of vision enjoyed by the surgeon are well assured without additional retraction of structures. The surgical field through the supraorbital window becomes extended. Thus, the supraorbital approach is worthy use which results in less surgery related morbidity. Since exposure via this approach is relatively small, keyhole surgery should be performed by highly experienced neurosurgeons under well-equipped conditions**.**

The size of the frontal sinus must be considered in planning the supraorbital approach. A large frontal sinus displaces the craniotomy laterally, altering the operative trajectory.

To avoid unnecessary frontal sinus breaches and to choose the surgical trajectory prior to making the skin incision, they performed the surgical procedure using neuronavigation in all their cases; frameless image guidance was helpful in mapping the frontal sinus and planning the craniotomy lateral to the lateral-most edge of the sinus. We did not offer the supraorbital approach as an option to patients with large frontal sinuses, but this was only an issue in few cases.

Our study included 12 males and 18 females with mean age of 52.7 years. Different pathological lesions were treated: There were 19 meningiomas, 5 metastesis, 4 glioblastoma multiforme, and 2 pituitary adenomas.

In the study of (Eroglu et al., 2019), The supraorbital keyhole approach was used in 106 patients (55% males and 45% females). The mean age was 51.7 (range, 2-79) years.**14**

A total of 97 patients (32 men and 65 women) were operated in the study of (Gazzeri et al., 2014), their ages ranged from 10 to 75 years (mean age = 58.5 years).**15**

In 93% of our patients, the presenting symptom was headache. The rest were presented with vomiting, seizures and visual manifestations.

The smallest lesion operated upon in our study was 2cm while the largest was 8cm (average = 5cm). It should be noted that the size was given to the longest sagittal diameter of the lesion.

Perneczky reported his experience using the supraorbital eyebrow approach for the treatment of 93 anterior and middle fossa meningiomas. They could remove completely 89.2% of the tumors with minor complications and claimed that temporobasal extensions are the limitations for the approach**10**.

We did gross total resection in 80% of patients with anterior and middle fossa lesions. The lesions were subtotally removed in 5 cases: 2 meningiomas (diaphragm sellae and planum), two gliomas and one metastesis. Only 1 case of pituitary adenoma had partial resection.

The results of gross total resection of anterior cranial fossa meningiomas reported in the literature, as well as ours (80%), obtained after minimally invasive approaches to these tumors have similar results to traditional craniotomy series.

The extent of resection was significantly affected by the extension, size and attachment of the lesion, less affected by the pathological type, and not affected by the composition or nature of the lesion at surgery.

In (Eroglu et al., 2019), half of the patients (52%) had extra-axial masses. For patients with intra-axial masses, microscopic gross total resection was achieved in 74.4% of cases. An endoscope was used in 37.7% of cases. Orbitofrontal meningiomas accounted for the most common pathology in 27.4% of patients (23 frontal and 6 orbital meningiomas). Simpson grade (SGr) II and III resections were achieved in 31.0% and 69.0% of patients, respectively. Olfactory groove meningiomas were resected in 13.2% patients; all these patients underwent SGr III resections.14

The complications reported with this technique are no more than associated with standard craniotomies. The main complication is that of CSF rhinorrhea that was reported to range between 0 to 7% of cases and was observed in only two cases in our study that were successfully treated by head elevation, tight bandage and clean dry dressings, one patient improved gradually at the end of the first week and the other needed reoperation to close the dura and fixing the bone flap well with mini plates.

Reisch and Perneczky recorded the follow-up data from 450 patients who treated with the supraorbital approach for different reasons (intracranial aneurysms, cranial base meningiomas, craniopharyngiomas, pituitary adenomas, deep-seated brainstem tumors, and other miscellaneous frontotemporal or suprasellar lesions). They summarized the postoperative complications as follows:

1) Permanent partial supraorbital hypoesthesia related to a lesion of the supraorbital nerve was observed in 34 patients.

2) Permanent palsy of the frontalis muscle related to a lesion of the frontal branch of the facial nerve appeared in 25 cases. Problems with closing of the eyebrow were not noted.

3) Problems with chewing were observed in 3 patients, but atrophy of the temporalis muscle was not observed in any of them.

4) Permanent unilateral hyposmia appeared in 27 patients, and bilateral hyposmia with disturbances of tasting was reported by 9 patients.

5) Wound healing disturbances occurred in 6 cases.

6) A subcutaneous cerebrospinal fluid pouch in 20 patients; in 1 case, surgical revision was necessary.

7) Cerebrospinal fluid leak in 12 patients.

8) Rebreeding with a space-occupying effect was detected in 4 cases; one patient died; the other two patients had a poor neurological outcome despite urgent reoperation. **12**

Eroglu reviewed 106 consecutive patients who underwent this approach. Their complications included two (1.9%) patients developed transient ptosis. One (0.9%) patient developed an allergic reaction to titanium. No cerebrospinal fluid fistula or rhinorrhea occurred. Three patients developed temporary diabetes insipidus after resection of parasellar lesions (2 craniopharyngiomas and 1 pituitary adenoma). In 14 patients with olfactory groove meningiomas, 6 (42.8%) suffered from absence or diminished olfaction postoperatively, and 2 (14.2%) developed postoperative anosmia. Five (38.5%) patients underwent a subsequent resection of recurrent glial tumors. Four weeks postoperatively, 95% of patients demonstrated acceptable cosmetic results. Cosmetic results for 6 (5%) patients were unavailable .14

In our study, Transient periorbital edema occurs in all patients and totally resolved by the end of the first week. Supraorbital hypoesthesia was evident in 25 (83.3%) patients (temporary in 20 patients and permanent in 5 patients). Two patients showed superficial wound infection which subsides under antibiotic therapy. There was no temporalis muscle wasting in any patient. Eye brow elevation was lost in 28 patients (subsided in 24 patients and remained in 4 patients).No visual deterioration occurred in any of our patients. Two patients developed diabetes insipidus; one has improved and the other had the disease permanently.

The maximum follow up period for our patients was 12 months that may not be sufficient for detecting recurrence in all lesions (as in meningiomas). During this period 2 patients had recurrence; one had recurrence of sellar meningioma after total resection 6 months later and the other showed regrowth of glioma after subtotal resection.

In our study, 96.6% of our patients had excellent and good outcomes. It should be mentioned that this outcome was not related to the pathology of the underlined pathology. It was affected by the duration of
symptoms, extent of surgical excision, and cosmetic results.

The use of this approach was assessed in 45 children by **Dlouhy et al.** The endoscope assisted and expanded visualization and provided access to areas not reached by standard microscopic visualization in all cases. Cosmetic outcomes were excellent. In all cases, the scar was barely visible at 6 weeks. In 3 cases, a minor bone defect was observed on the forehead. Because of the small size of the frontal sinus in children, no frontal sinus breaches occurred. Additionally, no CSF leak or wound infection was identified.16

Mitchell et al. found that in the setting of vascular pathologies, there may be some difficulty with using two suction tubes in managing prematurely ruptured aneurysms or to obtain proximal contro.17

Some have even recommended against this approach for vascular lesions for this reason18. A prominent orbital rim may impede the surgical degree of freedom, and some authors have advocated the addition of an orbital osteotomy to improve surgical freedom and access for vascular pathologies 19,20 A similar concept led to similar adaptations to traditional approaches to frontal base and parasellar lesions in the past **21,22**

A number of authors have described different vascular pathologies safely treated through this approach, but we feel it should be limited to those with significant experience with the approach, and it may not be the best approach for some lesions (such as in subarachnoid hemorrhage, giant aneurysms, or vascular lesions in the posterior circulation) in comparison to more traditional approaches **17,23**

Cosmoses have prevented many surgeons from attempting this approach or have led to their abandonment of this approach with its introduction early on. A number of modifications have led to what many now consider to be a super cosmetic result with the supraorbital craniotomy and keyhole approach 9**.**

A limited skin incision within the eyebrow, minimal temporalis muscle dissection, a small bone flap, and closure with the orbicularis oculi muscle/pericranium layers have contributed to the success of the eyebrow incision. Temporalis muscle atrophy, so common with standard frontotemporal and pterional craniotomies, can be avoided with the eyebrow incision 20

Of course, orbicularis oculi muscle asymmetry can lead to less ideal cosmetic outcomes through this approach. This can occur through both muscle fiber and nerve injury. This can be avoided by first opening the incision only through the skin and dermis layers, and then opening the muscle more dorsally and cutting along the muscle fibers rather than across them **24,25**

Another important cosmetic consideration is performing the initial incision through the skin and dermis layers only. Cephalad dissection superficial to the orbicularis oculi, pericranium, and temporalis muscle is important for development of a separate tissue flap for covering the keyhole craniotomy during closure **.**12,17,23,26

Additional considerations for a good cosmetic result include proper repositioning of the bone flap. Care must be taken to ensure that the outer cortex of the supraorbital ridge remains intact during the approach. Use of a burr hole cover and square titanium plates prevents the appearance or palpation of the gap between the bone flap and intact native bone following bone flap replacement in the patient. Final closure of the skin layer with a running subcuticular stitch (e.g., 5-0

Prolene) without any suture knots brings the edges of the eyebrow together for proper cosmoses as well.

Summary and Conclusion

The supraorbital eyebrow approach is a minimally invasive keyhole technique that offers wide access to the anterior skull base and parasellar region by exploiting the subfrontal corridor. The approach through the eyebrow permits access to a number of lesions in the subfrontal corridor with minimal brain retraction and a much smaller area of potential injury of superficial structures. All minimally invasive techniques have a learning curve, and smaller, simpler lesions should be performed first through this approach before moving on to larger, more complicated lesions. Preoperative planning and image guidance may be used to precisely define the surgical trajectory.

The major limitation of the supraorbital approach is that it can never be the standard one for all lesions. Because of the small size of the craniotomy, the procedure must be evaluated in each case to be certain that the goal can be achieved. There is less opportunity to change the surgical plan after the craniotomy is performed.

Endoscopy can play an important role in improving visualization through the keyhole corridor. With the use of neuroendoscopy, the reach of this approach may be extended even further to include the pituitary fossa, the top third of the clivus, the interpeduncular cistern, the anterior third ventricle, and the medial and anterior temporal lobe and middle fossa. Neuromonitoring may further increase surgical safety.

Attention to details can allow this approach to be performed with superb cosmetic results while still achieving surgical efficacy and limiting complications.

- The head is retroflexed about 15° so that gravity causes the frontal lobe to fall away from the anterior cranial fossa and allow for retractor-free intracranial dissection.
- The skin incision should follow the orbital rim, and not extend medial to the supraorbital notch, to improve cosmesis and reduce the risk of frontal numbness.
- Placement of the burr hole lateral to the temporal line at the level of the frontal cranial base, avoids penetration of the orbit.

- Careful drilling of the inner edge of the bone above the orbital rim can considerably increase the volume of the surgical corridor.
- After opening the dura mater, the first step should be the sufficient drainage of CSF by opening the chiasmatic and carotid cisterns.
- The bone flap should be placed medially and frontally with the mini plates used for closure of the burr hole and remaining defects closed with bone cement for a pleasant cosmetic outcome.

It is often an excellent alternative to the endonasal approach for many midline frontal fossa and parasellar lesions depending on tumor location and surgeon experience. The major advantage of the supraorbital over the endonasal route is a simplified skull base closure and reduced risk of postoperative CSF leak. It is a valuable approach for selected patients.

List of abbrevations

ACA	**Anterior Cerebral Artery**
AVMs	Arterio-venous Malformations
CSF	Cerebrospinal Fluid
CT	Computerized tomography
CTA	Computed Tomography Angiography
FMRI	Functional MRI
GBM	Glioblastoma multiforme
ICA	Internal Carotid Artery
ICP	Intracranial Pressure
MCA	Middle Cerebral Artery
MRI	Magnetic Resonance Imaging
MRS	Magnetic Resonance Spectroscopy
ON	Optic Nerve
SAH	Subarachnoid Hemorrhage
SD	Standard Deviation

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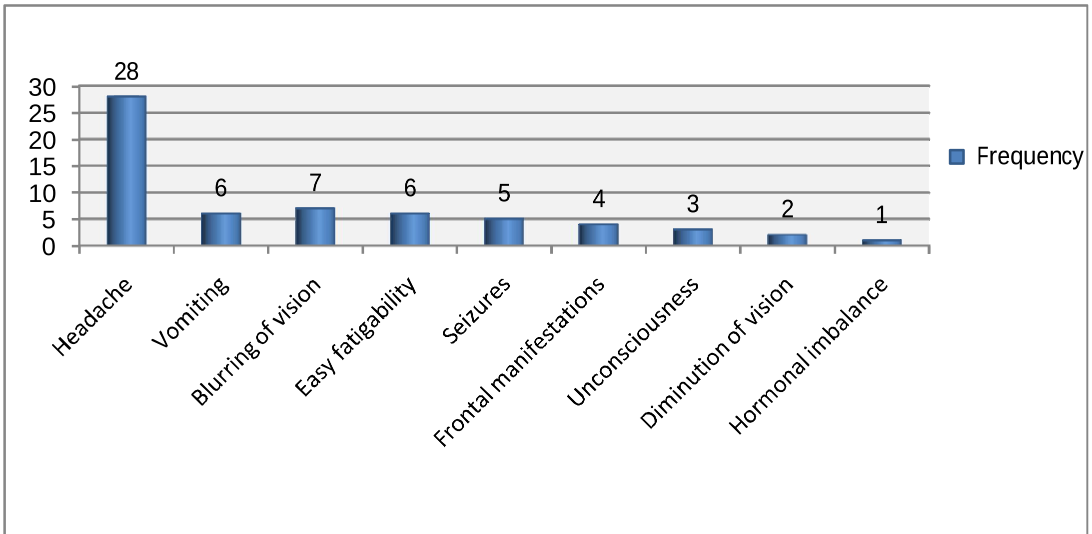
Tables

Table1 Age wise variation

		Minimum	Maximum	Mean (SD)
Age in years		38	67	52.7 (8.32)
		Sex		**Total**
Age group		**Male Frequency (%)**	**Female Frequency (%)**	

			30- <40	0(0)	2(6.67)	2(6.67)
			40- <50	5(16.67)	4(13.33)	9(30)
			50- <60	6(20)	6(20)	12(40)
			60- 70	1(8.33)	6(20)	7(23.33)
Total		12(40)	18(60)		30(100)	

Fig. Frequency of different health problems



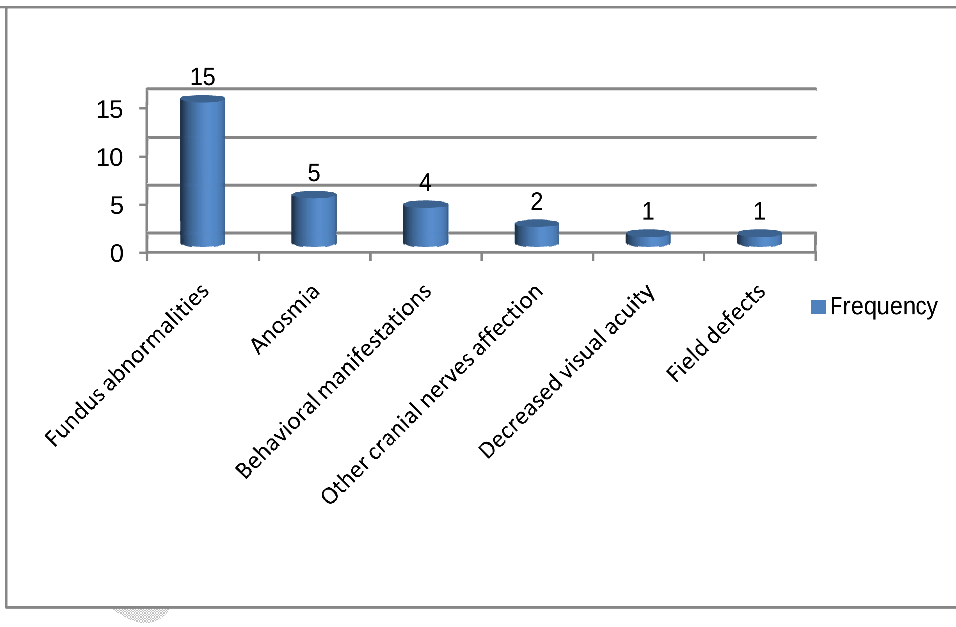


Fig. Frequency of different abnormalities

Nature of lesion	Frequency (%)
Purely solid	20 (66.7)
mixed	9 (30)
cystic	1 (3.33)
total	30 (100)

Table . Nature of lesion and their frequency

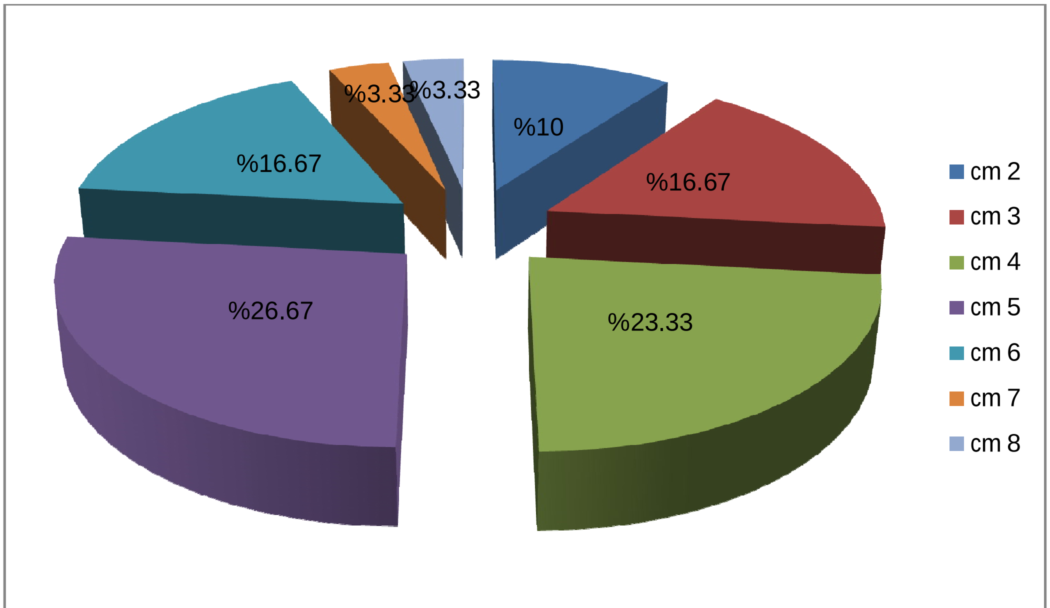


Figure 1 Pie chart

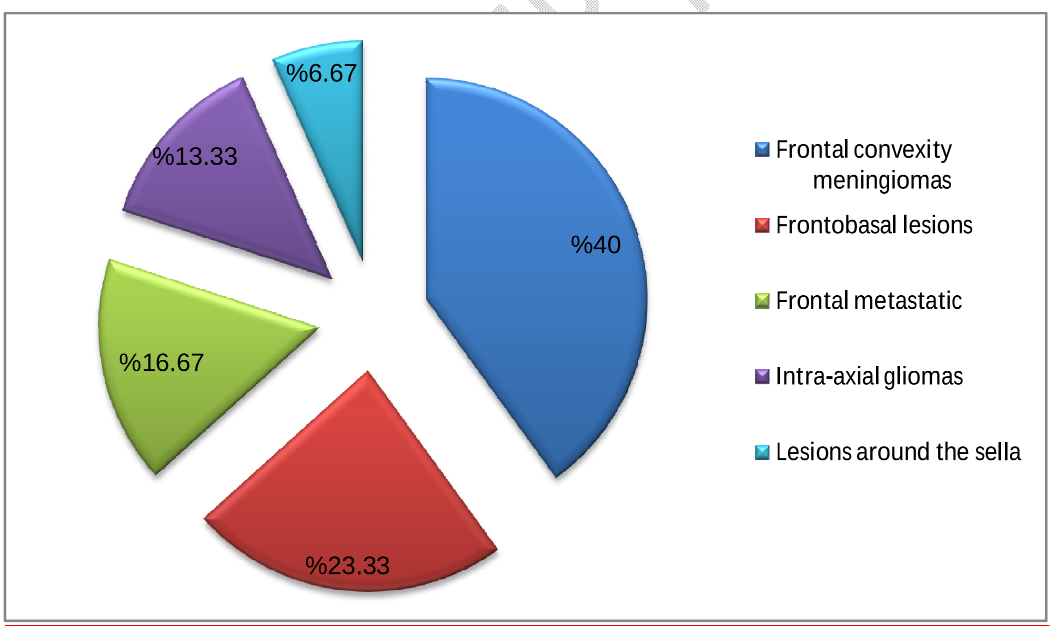


Figure2 Pie chart showing different lesions

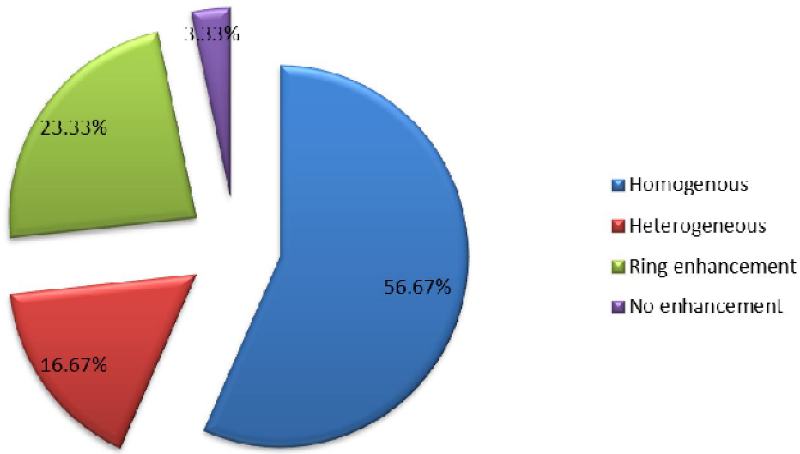


Figure3 Pie chart showing different lesions

Attachment	Frequency (%)
Meninges	19 (63.33)
Optic pathway	2 (6.67)
Main vessels	2 (6.67)
Hypothalamus	1 (3.33)
Bone	4 (13.33)
Optic pathway + main vessels	1 (3.33)
Pituitary stalk + main vessels	1 (3.33)

Table5 Attachment and frequency ratio

Complication	Transient	Permanent
	Frequency (%)	Frequency (%)
Visual deterioration	0 (0)	0
Endocrinal complication	1(3.3)	1(3.3)
Cranial nerve affection	0 (0)	2 (6.7)
Subgaleal collection	7 (23.33)	0 (0)
Superficial wound infection	2 (6.7)	0 (0)
Cosmetic problems	27 (90)	3 (10)
Lost eye brow elevation	24 (80)	4 (13.3)
Periorbital edema	30 (100)	0 (0)
Supraorbital hypoesthesia	20 (66.7)	5 (16.7)
CSF leak	1(3.3)	1 (3.3)

Table6 Different complications

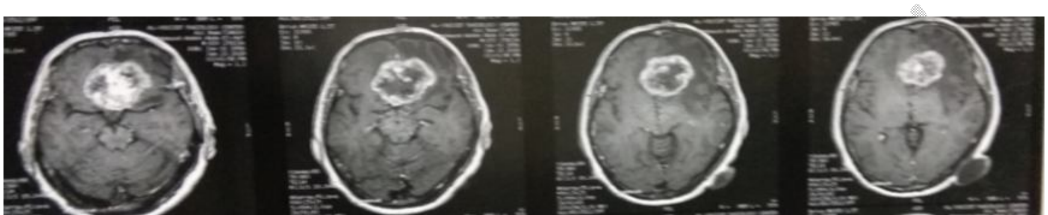
Cases:

Case1: A right handed 60 year old male patient presented by headache and convulsions with no known chronic illness, On examination: the patient was fully conscious and oriented (GCS

15/15), anosmia was detected and all other cranial nerves were intact, CT brain: mass in the olfactory groove was detected with calcification, These imaging characteristics were consistent mostly with an olfactory groove meningioma. The patient underwent elective resection of his tumor by a right supraorbital endoscopic assisted craniotomy through the right eyebrow, Operative time: around 270 minutes, Blood loss: 670 ml.**<u>Postoperative data:</u>**

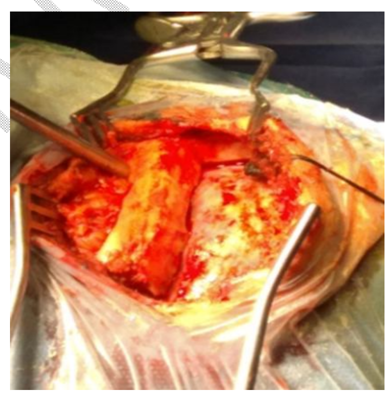
The patient was vitally stable, fully conscious and cranial nerves were intact except anosmia. There was right eye lid edema that had been resolved at day 4. CSF leak happened for 5 days then stopped gradually.

Image 1 : Preoperative:



Intraoperative: position, incision, dissection& extension of bone flap

Image 2 :



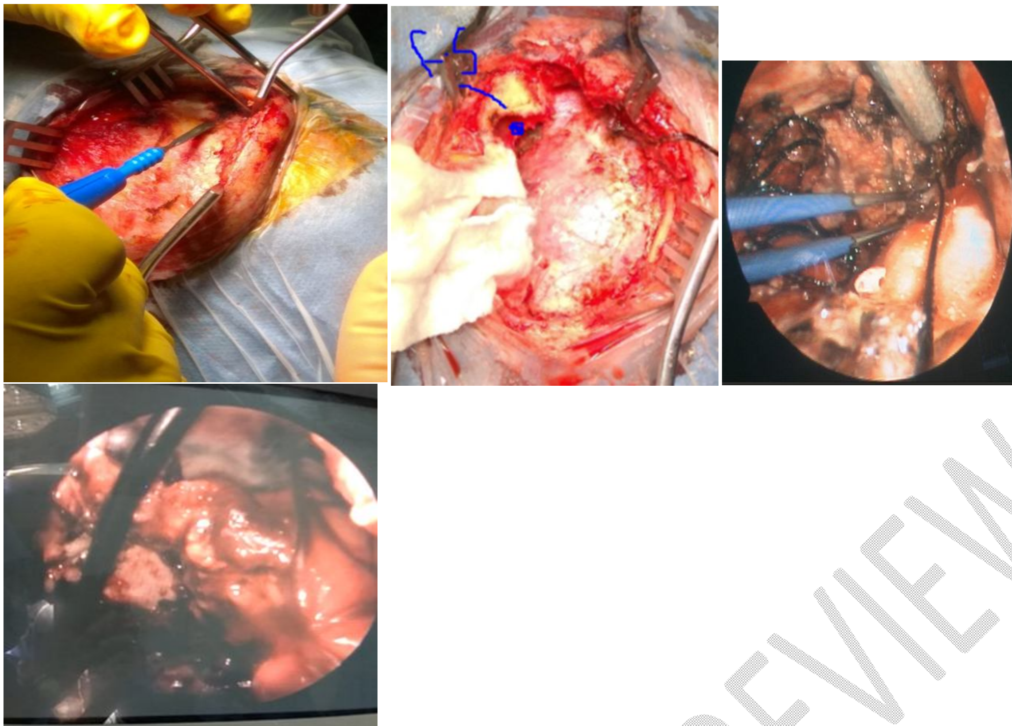


Image 3 : Operative phase

Image 4 : Post operative phase

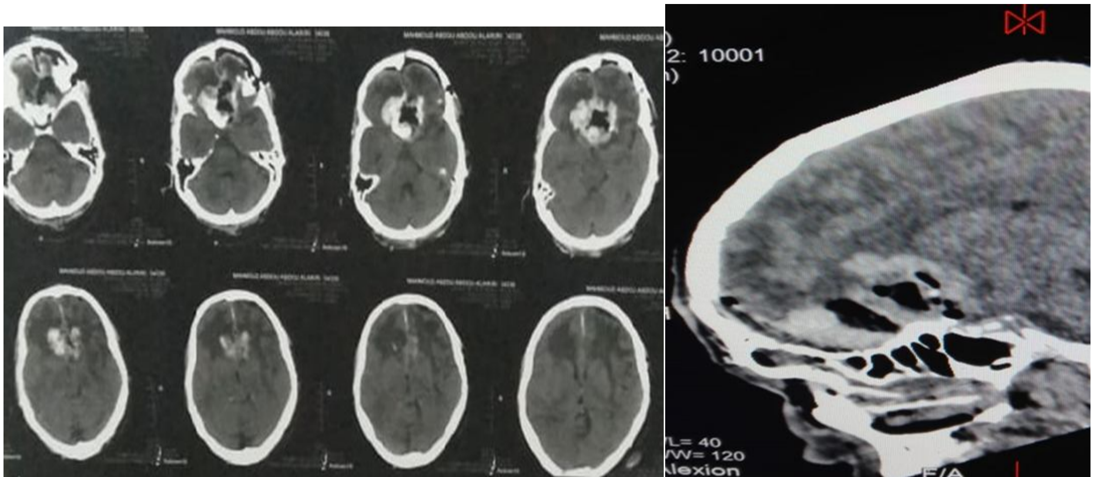


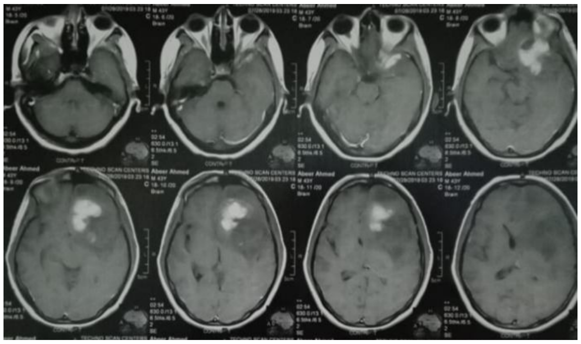
Image 5 : CT SCAN images

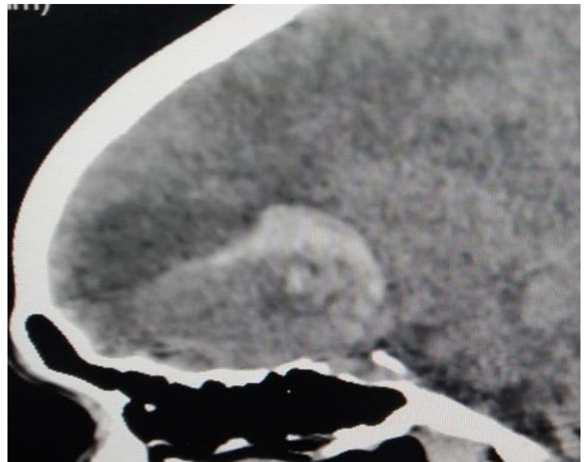
Case2 : A right handed 43 year old female presented by headache of gradual course. The patient had breast cancer, underwent mastectomy then received chemo and radiotherapy, On examination: No cranial nerves abnormality.

CT brain: showed left frontal hyper dense sol, with midline shift, Operative time: around 180 minutes& Blood loss: 300 ml.Her imaging characteristics were most consistent with metastasis. The patient underwent elective resection of her tumor by a left supraorbital endoscopic assisted craniotomy through the left eyebrow. She had a gross total resection of the mass.**<u>Postoperative data:</u>**

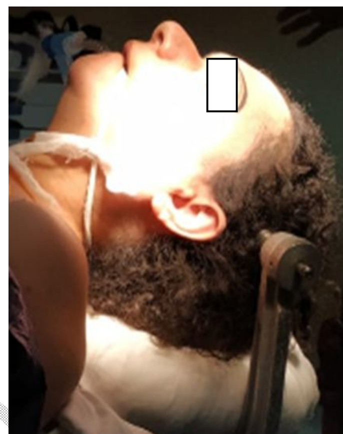
The patient was admitted to the Intensive Care Unit (ICU) for 4 days then discharged to a regular inpatient ward. She gained her conscious level gradually. There was no cranial nerves affection. The wound healed cleanly. The patient was discharged at day 10 postoperative. The histopathological analysis revealed adenocarcinoma.
Preoperative images

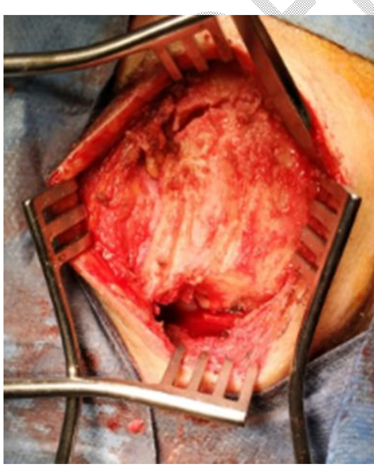
Image 6:

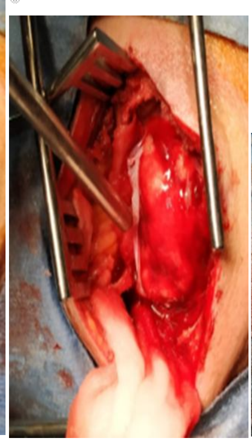




Position, incision, dissection







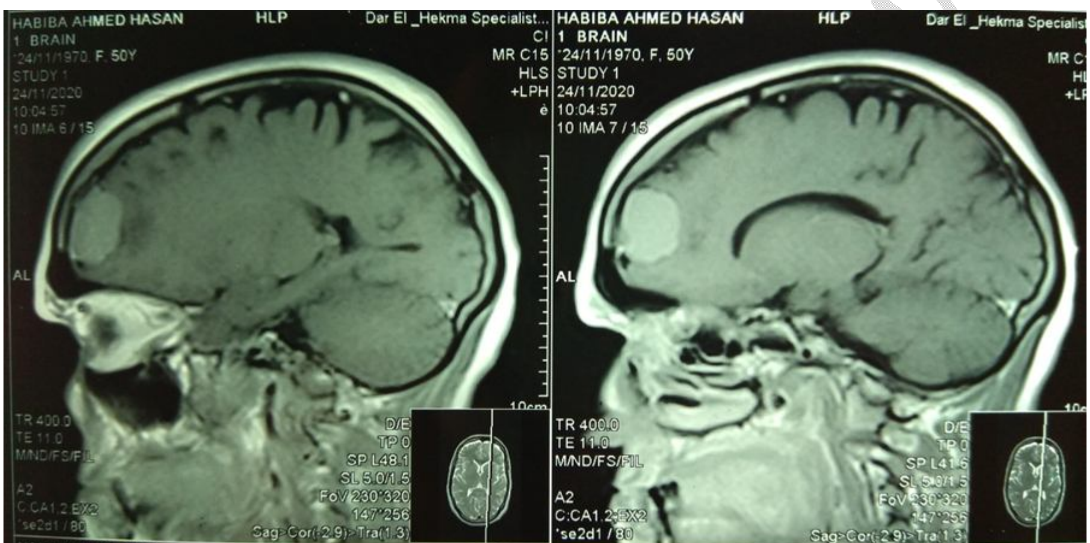
- **Case 3: 50 year old female presented by headache of gradual course**

A right handed 50 year old female presented by headache of gradual course.

On examination: No cranial nerves abnormality.

CT brain: showed left frontal hyper dense space occupying lesion. Her imaging characteristics were most consistent with convexity meningioma. The patient underwent elective resection of her tumor by a left supraorbital endoscopic assisted craniotomy through the left eyebrow. She had a gross total resection of the mass, **Postoperative data:**The patient was admitted to the ICU for 10 hours then discharged to a regular inpatient ward. She gained her conscious level immediately. There was no cranial nerves affection. The wound healed cleanly after inflammation for few days. The patient was discharged at day 4 postoperative. The histopathological analysis revealed meningioma WHO1.

Image 7 : Scan images



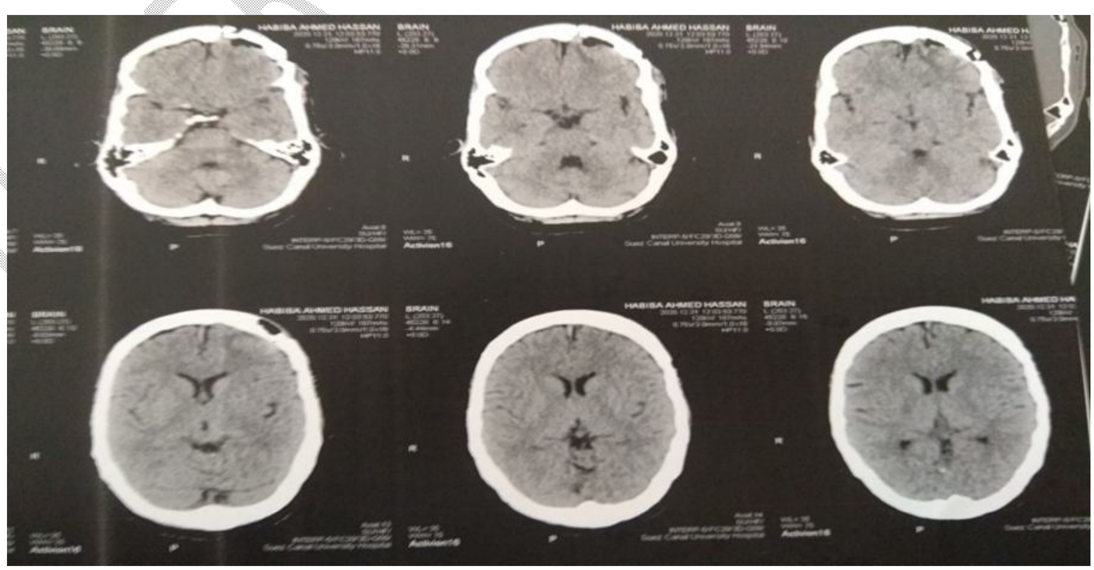


Image 8 : CT scan

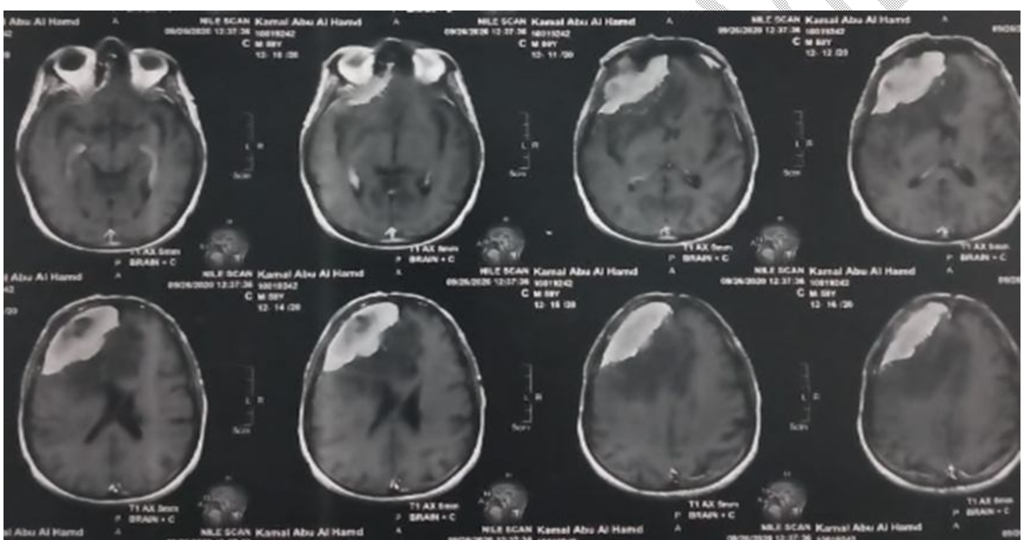
Case 4:

A 59 years old male presented with headache, blurring of vision, and convulsions. He was known to be hypertensive and had chronic liver disease, On examination: He was fully conscious and there was no cranial nerves abnormality, CT brain: Right frontal hyper dense lesion with dural base, MRI of the brain with gadolinium contrast revealed right frontal hyper intense lesion with homogenous intensity with dural base.

His imaging characteristics were most consistent with a convexity meningioma. The patient underwent elective resection of his tumor by a right supraorbital endoscopic assisted craniotomy through the right eyebrow. He had a gross total resection of a WHO grade II meningioma, Operative time: around 200 minutes& Blood loss: 350 ml.

The patient was admitted to the ICU for 24 hours then discharged to a regular inpatient ward. He was vitally stable, fully conscious and the cranial nerves were intact. There was weak eye lid elevation for few days then improved. The wound healed cleanly. The patient was discharged at day 4 postoperative.

Image 9 : Preoperative images



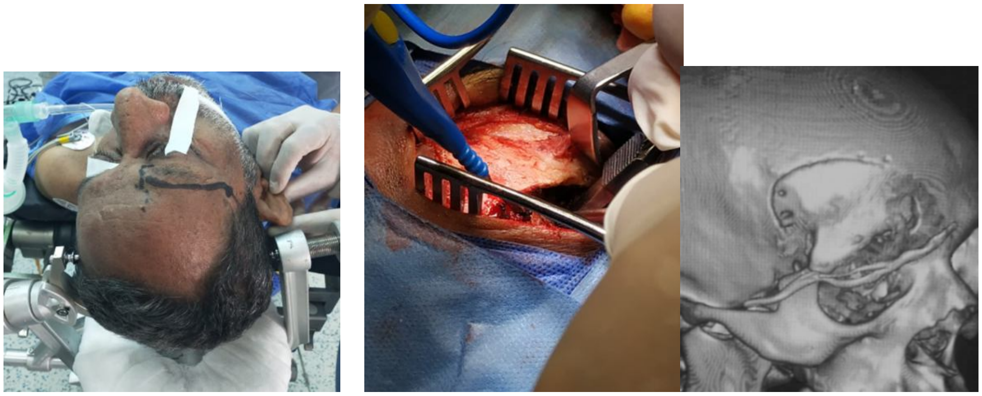


Image 10 : Position, dissection & bone flap

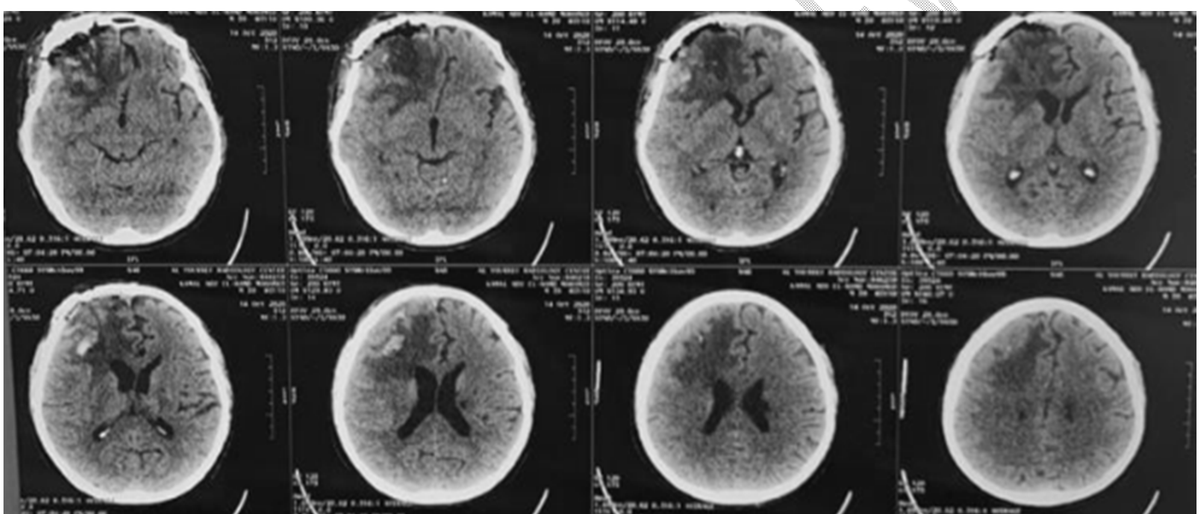


Image 11 : Follow-up MRI brain with contrast -axial view- 6 months postoperative

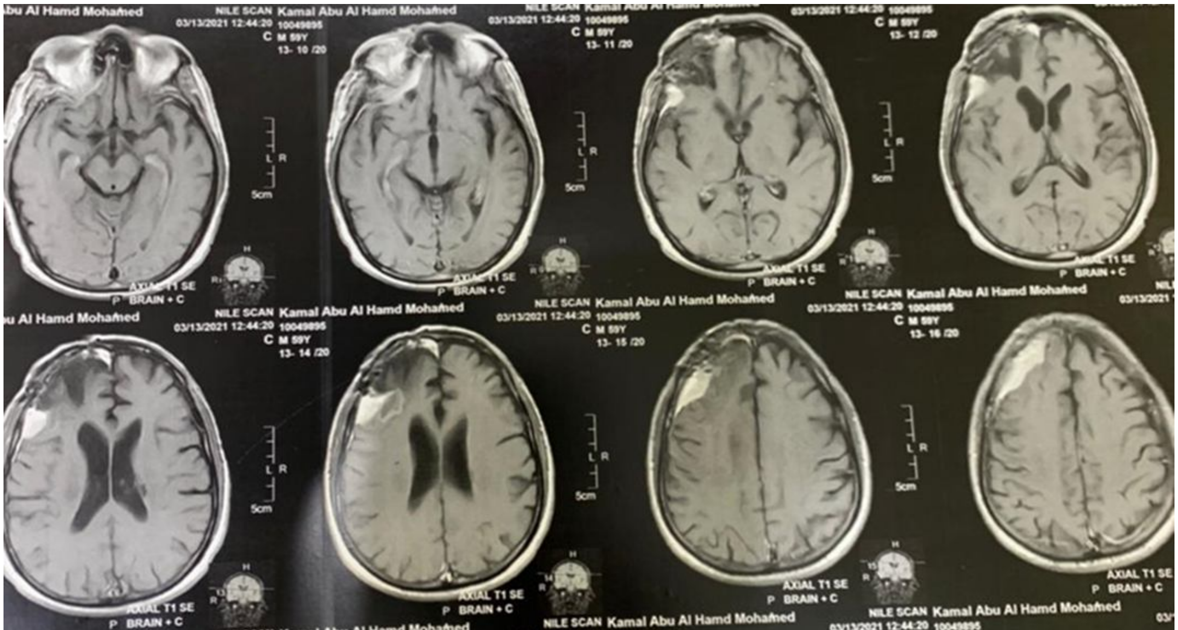


Image 12: Postoperative CT brain

Case 5 A right handed 59 year old male presented by disturbed level of consciousness, persistent vomiting, and convulsions. He had chronic renal illness.On examination: GCS was 13/15, Cranial nerves examination: the patient was not cooperative.CT brain revealed left frontal hypo dense lesion with surrounding brain edema.MRI brain with contrast revealed left frontal intra-axial hypo intense lesion in T1 and hyper intense in T2 with irregular ring enhancement. His imaging characteristics were most consistent with glioblastoma multiforme (GBM).The patient underwent emergent resection of his tumor by a left supraorbital endoscopic assisted craniotomy through the left eyebrow. He had a gross total resection of the mass, The patient was admitted to the ICU for 2 days then discharged to a regular inpatient ward. He gained conscious level gradually. The cranial nerves were intact. The wound healed cleanly. The patient was discharged at day 7 postoperative. The histopathological analysis revealed GBM WHO grade 4.

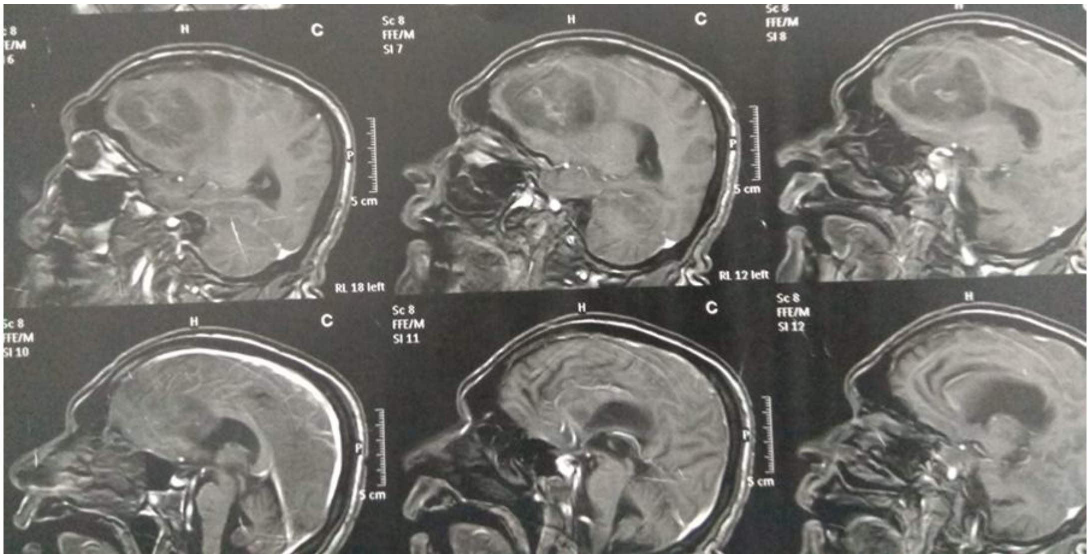


Image 13 : Pre-operative MRI brain with contrast (sagittal view).

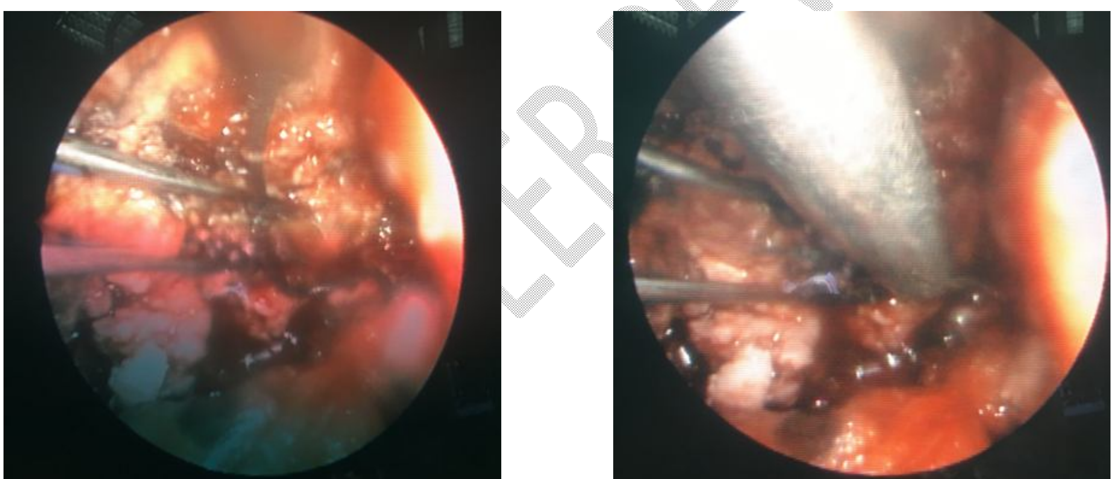


image 14 : intraoperative endoscopic views

image 15 : Skin closure

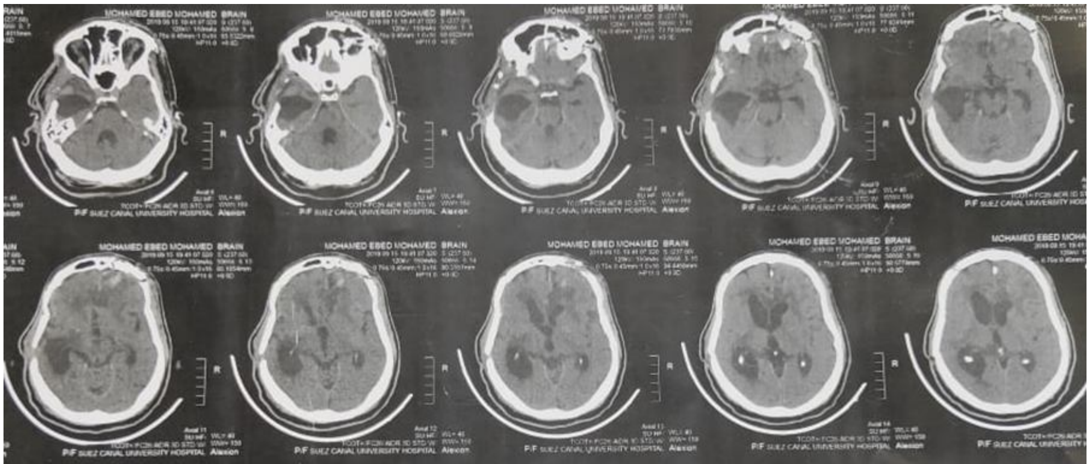


Image 16 : Post-operative CT brain.

Case 6 A right handed 63 year old female presented by headache of gradual course, disturbed level of consciousness, vomiting, and convulsions. The patient had malignant breast cancer and underwent mastectomy and received chemotherapy and radiotherapy, On examination: GCS 13/15, CT brain showed right frontal isodense space occupying lesion with midline shift.MRI brain with contrast showed right frontal intra-axial space occupying lesion with heterogeneous enhancement. Her imaging characteristics were most consistent with metastasis**, <u>Intraoperative procedures:</u>** The patient underwent elective resection of her tumor by a right supraorbital endoscopic assisted craniotomy through the right eyebrow.Operative time: around 200 minutes& Blood loss: 400 ml.**<u>Postoperative data:</u>** The patient was admitted to the ICU for 4 days then discharged to a regular inpatient ward. She gained conscious level gradually. The cranial nerves were intact. The wound healed cleanly. There was right eye lid edema that had been improved by the end of the first week.The patient was discharged at day 10 postoperative. The histopathological analysis revealed adenocarcinoma.

Image 17: post operative images