Original Article

Fronto-Lateral Key Hole Approach versus Unilateral Sub-Frontal Approach for Tuberculum Sellae Meningioma

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ABSTRACT

Background: Tuberculum Sellae meningioma is one of the most challenging surgeries among neurosurgeons. Many approaches have been established, attempting to remove the tumor and some of them are supported by an advanced neurosurgical technology.

Objective: The aim of present study was to compare the efficacy of the fronto-lateral key hole approach via an eye brow incision and the unilateral-subfrontal approach in resection of the tuberculum sellae meningiomas.

Patients and Methods: This was a retrospective study done on 32 patients with tuberculum sellae meningioma. All patients were operated upon in Ain shams University Hospitals (Cairo, Egypt) between January 2008 and January 2014. There were two different approaches used in this study. The fronto-lateral key hole approach (16 cases) and the unilateral sub-frontal approach (16 cases).

Results: Thirty-two patients (eight males and twenty four females) with tuberculum sellae meningioma were included in this study. Age ranged from 31 to 47 years (mean: 41 years). The mean age was 42 years in fronto-lateral group and 40 years in unilateral sub-frontal group. All patients had visual acuity impairment and visual field defects. Duration of presenting symptoms ranged from 3 to 39 months (mean: 18.1 months). The mean duration of symptoms was 17.3 months in the fronto-lateral group and was 18.9 months in the unilateral sub-frontal group. The follow up duration ranged from 24 to 36 months (mean: 30 months). Surgical outcome data: as regard these parameters "surgery duration, post-operative cerebral edema and seizures, length of ICU stay and post-operative complications denote that the fronto-lateral group had a better surgical outcome". Conclusion: According to this study, it seems that, the fronto-lateral approach has better surgical outcome than the sub-frontal approach.

INTRODUCTION

Tuberculum sellae meningioma is one of the most challenging surgeries in neurosurgical field. The tumor may fill the sellar and suprasellar area with dural attachment generally at tuberculum sellae. This attachment may extend anteriorly to limbus sphenoidale, superiorly to chiasmatic sulcus, and posteriorly to diaphragma sellae. As the tumor grows it will displace, stretch, or even encase vital structures; Optic nerves may displace superiorly, internal carotid arteries may shift to the lateral, and if the tumor extends backward it may push pituitary stalk posteriorly.

Tuberculum sellae meningiomas represent 5%–10% of intracranial meningiomas. Complete removal is the optimal goal to prevent recurrence. However, treating this tumor is still challenging because of the high risk of visual pathway involvement and internal carotid artery (ICA) encasement and cavernous sinus infiltration.

Several surgical approaches such as bifrontal, unilateral frontal, supraorbital keyhole, and pterional were proposed to resect this tumor. Selection among the possible routes is greatly influenced by the personal experience of the operating surgeon. No doubt that, the preference of surgical approaches, tactics, and strategies is -finally- a surgeon's authority. And so, when considering any approach to a pathological entity, it is important to understand the advantages and disadvantages of a given procedure.

PATIENTS AND METHODS

This is a retrospective study done on thirty two patients (eight males and twenty four females) with tuberculum sellae meningioma. All patients were operated upon at the Neuro-surgery Department of Ain Shams University Hospitals from January 2008 and January 2014.

This study aimed to observe the efficacy of the fronto-lateral key hole approach and the unilateral sub-frontal approach in the resection of tuberculum sellae meningioma.
Parameters to be evaluated are: tumor size, extent, attachment, consistency, degree of tumor removal, surgery duration, post-operative cerebral edema, patient's outcome and length of ICU (Intensive Care Unit) stay.

**Pre-operative evaluation:**
Clinical and neuro-opthalmological examination (history, general and neurological examination assessment of visual acuity, visual field and fundus examination), radiological studies and endocrinological evaluation (hormonal assay: T3, T4, TSH, Cortisol level…).

Follow up data were reviewed retrospectively. Radiological investigations included both a pre-operative contrasted computed Tomography (CT) and Magnetic Resonance Imaging (MRI) of the brain.

The design of this study is experimental. Statistical analysis was performed using SPSS software with P-value of ≤ 0.05 considered statistically significant and highly significant if < or = 0.01.

The follow up duration ranged from 24 months to 36 months (mean: 30 months) post operative images were obtained, including a CT brain on post operative day 1. A follow up MRI brain was then done within 3 months. Radiographic follow up was then done according to the presence or absence of tumor residual.

Pre-operative radiological investigation included CT and MRI brain for all patients. Angiography or embolization was not done in any patient.

**Surgical approaches:**
The surgical techniques (Fronto-lateral Supraorbital key-Hole approach & unilateral Sub-frontal approach) have been described in many publications

**RESULTS**

Thirty-two patients were included in this study. Sixteen patients included in each group (fronto-lateral key-hole group and unilateral sub-frontal group).

The female: male ratio in each group was 3: 1. Ages ranged from 31 to 47 years (mean: 41 years) with a mean age of 42 years in the fronto-lateral group and 40 years in the unilateral sub-frontal group.

All patients suffered from variable degree of visual acuity diminution and visual field defects. Duration of symptoms before presentation ranged from 3 to 39 months (mean: 18.6 months). The second most common symptom was headache which was present in twenty eight patients. Endocrinological disorders were not found in any patient.

All demographic, clinical, surgical and patient's outcome data were shown in tables (1 and 2). Two illustrated cases are shown in fig. (1&2).

The pre-operative radiological studies (CT & MRI brain) showed different tumor sizes. Ten patients had a tumor size < 3 cm (eight cases were approached by fronto-lateral approach and 2 cases by unilateral sub-frontal approach). The rest of cases had a tumor size ≥ 3 cm, (fourteen cases were approached by unilateral sub-frontal approach and eight cases by fronto-lateral approach).

The tumor consistency was firm in twenty two cases (twelve cases in fronto-lateral group & ten cases in unilateral sub-frontal group). Whereas, the tumor was soft in ten cases (six cases in unilateral sub-frontal group & four cases in fronto-lateral group).

As regard the tumor extension, there was an anterior extension to the optic canal in fourteen cases (eight cases in unilateral sub-frontal group & six cases in fronto-lateral group). Lateral extension to the carotid cisterns was found in six cases (all of them in unilateral sub-frontal group). Posterior extension was only in two cases (both in the unilateral sub-frontal group). There was no tumor displacement or encasement of vital neuro-vascular structures in ten cases (all in frontolateral group).

As regard tumor resection, Simpson™ classification was used in this study. Tumor resection "Grade I" was done in six cases (four cases in fronto-lateral group & two cases in unilateral sub-frontal group). Tumor resection "Grade II" was done in twenty two cases (twelve cases in unilateral sub-frontal group & ten in fronto-lateral group). Tumor resection "Grade IV" was done in four cases (two cases in each group). Histo-pathologically, all tumors were benign "WHO grade I".

Post-operative mortality occurred only in one case (in the unilateral sub-frontal group). This case was with post-operative clinical evidence of hypothalamic insult. This patient had post-operative diabetes insipidus, high fever and died on the 5th post-operative day.

Post-operative Cerebro-Spinal Fluid (CSF) rhinorrhea occurred in seven cases (all in the unilateral sub-frontal group). Five patients had responded well to insertion of a lumbar drain for (3-5) days and parenteral antibiotics. But, there were only two patients who needed a delayed surgical repair.

Post-operative anosmia was found in twelve cases (all were in the unilateral sub-frontal group).

Post-operative cerebral edema was found in five cases (all were in the unilateral sub-frontal group).

Post-operative seizures were found in five cases (all were in the unilateral sub-frontal group).

Eighteen cases had post-operative visual improvement (ten cases in the fronto-lateral group & eight cases in the unilateral sub-frontal group).

As regard the duration of surgery, it was found that, in the unilateral sub-frontal group: the mean duration from skin to dura was 5.5 hours, the mean duration from dura to closure was 7 hours. However in the frontototeral group, the mean duration from skin to dura was 19 minutes and the mean duration from dura to closure was 5.5 hours.
The mean ICU stay was 3.3 days in the unilateral sub-frontal group and was 1.3 days in the fronto-lateral group.

Post-operative impaired eye brow elevation (at the same side of surgery) was found in fourteen cases (all in the fronto-lateral group). All patients with "post-operative impaired action of the occipito-frontalis muscle regained the normal function of the muscle around 5 months post-operatively.

Finally, as regard the cosmetic results, scar complications (wound scar or frontal burr holes disfigurement) were found in thirteen cases (eleven cases in the unilateral sub-frontal group & two cases in fronto-lateral group). Surgical outcome data in both fronto-lateral and subfrontal groups and their statistical significance are shown in table (3).

Table (1): Demographic and clinical data concerned with "unilateral sub frontal approach":

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Age/sex: Mean= 40 Yrs ± SD: 4.2</th>
<th>Duration Of symptoms: Mean= 18.9 months ± SD: 10.3</th>
<th>Pre-operative V.A Impairment</th>
<th>Tumor Size (cm)</th>
<th>Tumor Extent Acc. To Simpson Classification</th>
<th>Tumor Resection Grade</th>
<th>Tumor consistency</th>
<th>Duration of surgery</th>
<th>Post-operative impaired action of the occipito-frontalis muscle regained the normal function of the muscle around 5 months post-operatively</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>31/F</td>
<td>21</td>
<td>-</td>
<td>5</td>
<td>O.C III firm</td>
<td>3</td>
<td>40</td>
<td>7</td>
<td>-</td>
<td>Anosmia, CSF leak, Wound scar</td>
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<tr>
<td>2</td>
<td>42/F</td>
<td>23</td>
<td>+</td>
<td>3</td>
<td>O.C III firm</td>
<td>3</td>
<td>42</td>
<td>7.5</td>
<td>+</td>
<td>Anosmia, Seizures, Cerebral edema</td>
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<tr>
<td>3</td>
<td>40/M</td>
<td>17</td>
<td>+</td>
<td>3.5</td>
<td>ICA III soft</td>
<td>3</td>
<td>41</td>
<td>7.5</td>
<td>+</td>
<td>Wound scar, CSF leak</td>
</tr>
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<td>4</td>
<td>43/M</td>
<td>11</td>
<td>-</td>
<td>5</td>
<td>O.C IV firm</td>
<td>4</td>
<td>42</td>
<td>7</td>
<td>+</td>
<td>Anosmia, Seizures, Cerebral edema</td>
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<td>4.5</td>
<td>O.C III Firm</td>
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<td>39</td>
<td>7</td>
<td>+</td>
<td>Anosmia, CSF leak, Wound scar</td>
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<td>40/F</td>
<td>3</td>
<td>+</td>
<td>2.5</td>
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<td>40</td>
<td>7</td>
<td>+</td>
<td>Anosmia, CSF leak, Wound scar</td>
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<td>ICA III firm</td>
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<td>Anosmia, Seizures, Cerebral edema</td>
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</tbody>
</table>

Severe visual defects include (counting fingers, hand movement, perception of light and no perception of light)

V.A: Visual Acuity, ICA: Internal Carotid Artery, O.C: Optic Canal= absent      += present
Table (2): Demographic and clinical data concerned with supra orbital key-hole approach

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Age/sex</th>
<th>Duration of symptom</th>
<th>Mean=</th>
<th>Preoperative V.A impairment</th>
<th>Tumor size (cm)</th>
<th>Tumor Extent area</th>
<th>Tumor Resection Grade</th>
<th>Tumor Resection Acc. To Simpson Classification⁎①</th>
<th>Tumor consistency</th>
<th>Duration of surgery</th>
<th>Visual outcome</th>
<th>Complications</th>
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</tbody>
</table>

IEBE = impaired eye brow elevation

Table (3): Surgical outcome in both "fronto-lateral and sub frontal groups":

<table>
<thead>
<tr>
<th>Surgical approach</th>
<th>Surgical outcome data</th>
<th>Fronto-lateral approach</th>
<th>Subfrontal approach</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean duration of tumor exposure from skin to dura</td>
<td>19 minutes</td>
<td>41 minutes</td>
<td>0.000*</td>
<td></td>
</tr>
<tr>
<td>Mean ICU stay</td>
<td>1.3 days</td>
<td>3.3 days</td>
<td>0.000**</td>
<td></td>
</tr>
<tr>
<td>Post-operative cerebral edema</td>
<td>0% of patients</td>
<td>37.5% of patients</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Post-operative seizures</td>
<td>0% of patients</td>
<td>37.5% of patients</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Post-operative CSF Rhinorrhea</td>
<td>0% of patients</td>
<td>50% of patients</td>
<td>0.002*</td>
<td></td>
</tr>
<tr>
<td>Post-operative anosmia</td>
<td>0% of patients</td>
<td>75% of patients</td>
<td>0.000*</td>
<td></td>
</tr>
<tr>
<td>IEBE</td>
<td>88% of patients</td>
<td>0% of patients</td>
<td>0.000*</td>
<td></td>
</tr>
<tr>
<td>Mortality</td>
<td>0% of patients</td>
<td>6.25% of patient</td>
<td>0.333</td>
<td></td>
</tr>
<tr>
<td>Scar complication</td>
<td>6.3% of patients</td>
<td>69% of patients</td>
<td>0.000*</td>
<td></td>
</tr>
<tr>
<td>Total or near total surgical resection of the tumor</td>
<td>75% of patients</td>
<td>87.5% of patients</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Post-operative visual outcome improvement</td>
<td>62.5% of patients</td>
<td>50% of patients</td>
<td>0.164</td>
<td></td>
</tr>
</tbody>
</table>

IEBE = impaired eye brow elevation Total =100% near-total< 100% &> 90%
* * highly significant" " significant
DISCUSSION

There are many publications of surgical approaches to tuberculum sellae meningioma since its first report. All of these approaches have their advantages and disadvantages, but in the present time only several approaches are popular among neurosurgeons, those are unilateral subfrontal, bilateral subfrontal, pterional and supra-orbital Key hole approaches. In Ain Shams University Hospitals, Neurosurgical Department, resecting tuberculum sellae meningioma is usually performed via one of these approaches.

The subfrontal exposure was first published by Fedor Krause in the first volume of his pioneering work “Surgery of the Brain and Spine”, published in 1908.

During the last decades, a variety of subfrontal approaches have been described in the neurosurgical literature. Recent publications on the subfrontal exposures describe limited skin incision and soft tissue dissection with limited craniotomy and brain retraction in accord with the enormous development of diagnostic facilities and neurosurgical techniques. In 1998 Van Lindert reported surgical experience using a supraorbital subfrontal craniotomy with eye-brow-skin incision for the treatment of 197 intracranial aneurysms.


The eye brow incision in frontolateral supraorbital Keyhole approach is essentially a modification of the standard well-known subfrontal approach miniaturization of both the skin incision and the craniotomy. Thus, with some practice the approach is relatively time-sparing compared to standard skull base approaches.

In this study, the mean duration of tumor exposure from skin to dura in the sub-frontal group was 41 minutes and was "only" 19 minutes in the fronto-lateral group. P-value was 0.000 (highly significant statistical difference between both approaches). This was found to be similar with the most published studies. This reflected on the post-operative recovery of patients and their needs for ICU admission. Regarding the need of ICU stay, all patients underwent fronto-lateral approach need less ICU stay (mean: 1.3 days) than the sub-frontal group (mean: 3.3 days). P-value was 0.000 (highly significant statistical difference between both groups). This matched with other published studies.

These results emphasize on the concept of minimal invasive technique of the fronto-lateral approach.

Regarding the occurrence of the post-operative cerebral edema, 37.5% of patients had post-operative cerebral edema in the sub-frontal group while none in the fronto-lateral group. P-value was 0.02 (significant statistical difference between both approaches). 37.5% of patients had post-operative seizures in the sub-frontal group and none in the fronto-lateral group. P-value was 0.02 (significant statistical difference). This emphasizes the role of fronto-lateral approach in minimizing the surgical trauma to the brain by decreasing both retraction and exposure of the cortex.

Telera et al. mentioned in their series of removal of supra-sellar meningiomas via supra orbital approach that there were no frontal lobe contusions in post operative MRI nor any epileptic seizures observed.

Regarding the incidence of CSF leak, the results of this study highlighted the high risk of frontal sinus violation during exposure in the subfrontal craniotomy in comparison with supraorbital and pterional approaches.

No cases with post-operative CSF leak in the fronto-lateral group, whereas 50% of the patients
suffered from post-operative CSF leak in the sub-frontal group. P-value was 0.002 (highly significant statistical difference between both groups).

In Czirjak's series of 173 supraorbital craniotomies, the frontal sinus was entered only in three patients (1.7%). Reisch and Perneckzy reported a rate of 2.6% of CSF leak in a cohort of 450 patients operated by the same approach.

Considering the post-operative anosmia, 75% of patients in the sub-frontal group had post-operative anosmia while none of the patients in the fronto-lateral group. P-value was 0.000 (highly significant statistical difference between both groups). But in a series of 34 patients who underwent bilateral subfrontal approach for removal of tuberculum sellae meningiomas by Choky et al., there was only one case of post operative anosmia.

88% patients suffered from immediate impairment of ipsilateral eye brow elevation in the frontolateral group while there were no cases of similar complication in the sub-frontal group P-value was 0.000 (highly significant statistical difference between both groups). Sanchez-Vazquez et al. mentioned in his retrospective study of the role of supraorbital approach in dealing with anterior skull base lesion that the inability to raise the ipsilateral eye brow immediately after surgery was a complaint in all patients (41 patients) 100%. Nasrin Fatemi stated in his series that only two out of thirteen patients underwent supraorbital craniotomies- recorded post operative transient frontalis paresis.

However, Choky et al. reported that careful preservation of the blood supply to optic apparatus and early un-roofing of the optic canal using a bilateral subfrontal approach led to further improvement in long-term postoperative visual outcome. Also, it has been reported that the undersurface of the ipsilateral optic nerve and chiasm are not as well visualized as in the subfrontal approach.

Total (100%) or near total (less than 100% and greater than 90%) removal in recent microsurgical series in tuberculum sellae meningiomas ranged from 66% to 100% via pterional or subfrontal routes with tumor size between 8 and 60 mm, and from 70% to 100% via the supraorbital route with tumor size between 8 & 80 mm.

The post-operative visual outcome did not show any statistical difference between both groups P-value was 0.164.

In this study, total or near total removal of the tuberculum sellae meningiomas was 87.5% in unilateral subfrontal approach, and 75% in supraorbital approach (tumor size ranged from 30 to 60 mm). These results showed no statistical difference between both groups P-value was 0.06.

The mortality rates were dramatically reduced in recent microsurgical series concerned with tuberculum sellae meningiomas surgery, the range is from 0 to 8.6%. But in Nakumura's series of tuberculum sellae meningiomas differ significantly depending on the selected surgical approach: non for supraorbital and 9.5% for the subfrontal approach. In this study, there was one case of mortality in a patient approached via subfrontal approach.

One of the drawbacks of the fronto-lateral supraorbital approach is the immediate impairment of the ipsilateral eye brow elevation, in this study 88% of patients had suffered from this problem (all of these patients regained the normal functionality of their eye brow within 5 months). While no cases in the subfrontal group complained of this complication.

Sanchez-Vazquez et al. mentioned in his retrospective study of the role of supra-orbital approach in dealing with anterior skull-base lesions that the inability to raise the eyebrow immediately after surgery was a complaint in all forty one patients; however, in five, the defect disappeared during the 1st month after surgery, in eight others it disappeared after the 2nd month, and in the remaining patients it disappeared completely after the 3rd month following surgery. He attributed this paralysis to detachment of the frontal epicranial aponeurosis because it was not a permanent condition in any of the patients. Also, in a series of thirteen patients (nine meningiomas and four craniopharyngiomas) exposed to debulking via supraorbital craniotomy; Nasrin Fatemi mentioned that only two patients recorded post-operative transient frontalis paresis.

Regarding the post-operative distressing complaint of the forehead disfiguring burr holes, there was an obvious statistical difference between both approaches (P-value = 0.000 highly significant statistical difference between both groups) in Nakumura's series.

When considering any approach to a pathological entity, it is important to understand the advantages and disadvantages of a given procedure. And so, the optimal approach for surgical resection of tuberculum sellae meningioma should be determined according to many factors such as the tumor anatomical details (size, consistency and attachment) relation to the neurovascular structures e.g. optic apparatus, ICA, cavernous sinus and pituitary stalk. Therefore, that approach follows should be the recommended approach. In this study there were some limitations; the study size was small, follow up was relatively short and no available comparative studies between all approaches for tuberculum sellae meningiomas collected in one research in the current literature. Additionally, the long learning curve of the frontolateral supraorbital approach is reflected on the personal performance regarding the

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choice of the approach. This study was the work of different surgeons, which is another limitation.

CONCLUSION

Tuberculum sellae meningiomas can be approached by different surgical routes. Both of frontolateral and sub-frontal approaches have advantages and disadvantages. Every neuro-surgeon has his authority in preference, tactics and strategies in treating tuberculum sellae meningioma. According to this study, the frontolateral approach has more advantages than the subfrontal approach in resection of tuberculum sellae meningiomas.

REFERENCES