Endoscopic Unilateral Transethmoid-Paraseptal Approach to the Central Skull Base

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Objectives: The endoscopic technique in transnasal skull base surgery offers optimal visualization and free manipulation in the surgical field. However, it may cause approach-related sinonasal injury, influencing patients’ quality of life (QOL). To minimize rhinological morbidity without restrictions in surgical manipulation and tumor resection, we introduced the unilateral transethmoidal-paraseptal approach. In this article, we analyzed the long-term results and sinonasal outcome of this technique.

Study Design: Retrospective analysis of medical records.

Methods: Forty-two consecutive patients underwent surgery between June 2010 and March 2014 using the transethmoid-paraseptal approach. Perioperative work-up included neurological, radiological, endocrinological, ophthalmological, and rhinological analysis. Patients’ preoperative, 1-month and 1-year postoperative QOL was measured using the Sino-Nasal Outcome Test (SNOT-22).

Results: At all individuals, a unilateral transethmoid-paraseptal approach was performed. Removal of the turbinates, posterior septal resection or a conversion to biportal surgery could be avoided in all cases. There were no intraoperative neurovascular complications. All patients had a notable improvement in any disease-related symptoms, as well as by objective criteria. Complete tumor resection was aimed in 39 cases and achieved in 31 of them. The SNOT-22 scores transiently worsened 1 month after surgery and non-significantly improved after 1 year, compared with the preoperative status. A subgroup of 7 patients with preoperative sinonasal disease evidence showed continuous significant improvement (p < .05) of SNOT-22 scores across time. The smell screening tests showed no significant difference across time.

Conclusion: The described approach allows safe removal of various skull base lesions without deterioration in sinonasal QOL and smell function.

Key Words: Transnasal endoscopy, transethmoidal approach, skull base surgery, sinonasal outcome, quality of life.

Level of Evidence: 4.

INTRODUCTION

“Every step of the procedure must be conducted under the eye of the operator,” emphasized Harvey Cushing in 1912. This more than 100-year-old wisdom is generally accepted in contemporary transnasal endoscopic surgery; namely access and visual control are essential for the precise and unhindered manipulation of instruments.

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To achieve optimal exposure, surgeons often use a wide approach with extensive intranasal dissection including the resection of nasal turbinates and part of the nasal septum. However, creating a wide exposure can cause approach-related morbidity affecting the nasal cavity and the paranasal sinuses. Rhinological symptoms secondary to surgery may only be recognized in the late postoperative period and this may be one of the reasons why sinonasal complications in transnasal procedures are rarely mentioned in the literature. Intranasal adhesions, delayed secondary healing, and extensive crusting may result from mucosal trauma of the transnasal technique and lead to symptoms such as a blocked nose, nasal discharge, hyposmia or anosmia and pain. These symptoms may contribute to sleep problems and impaired productivity.

In our technique, we have introduced rhinosurgical principles based on sinonasal physiology in transnasal neuroendoscopy in order to avoid the complications listed above. While exposing the central skull base through a unilateral (mononostril) approach we performed a partial ethmoidectomy, thus creating significant surgical space within the nasal cavity. With gentle lateralization of the intact middle and superior turbinates into the additional space made by the ethmoidectomy, an enlarged endonasal paraseptal corridor could be gained toward the sphenoid sinus. Despite its unilateral design, this approach creates sufficient exposure of...
The central skull base and allows unhindered surgical manipulation.

MATERIALS AND METHODS

Patient Population

In this study, we retrospectively analyzed the course of 42 consecutive patients treated between June 2010 and March 2014 in our skull base center, using the unilateral transethmoid-paraseptal approach. Medical records were retrospectively reviewed for demographic data, histopathological diagnosis, characteristics of surgery, length of hospital stay as well as radiological, neurological, endocrinological, ophthalmological and rhinological outcome.

Patients ranged in age from 18 to 77 years at the operation (mean age: 50.3 years) and consisted of 21 female and 21 male individuals. Pituitary adenoma was the most common pathology (30 patients, 71.4%), with a variety of tumors comprising the remainder (Table I). Preoperative ophthalmologic investigations showed visual symptoms in 25 of all cases (59.5%) and 23 of the patients (54.8%) presented with endocrine disorders.

| Pathology                  | N (%) |
|----------------------------|-------|
| Pituitary adenoma          | 30 (71.4) |
| inactive                   | 17 (40.5) |
| PRL-producing              | 6 (14.3)  |
| GH-producing               | 5 (11.9)  |
| ACTH-producing             | 2 (4.8)   |
| Rathke’s cyst              | 3 (7.1)   |
| Meningioma                 | 3 (7.1)   |
| Craniopharyngioma          | 2 (4.8)   |
| Clival chordoma            | 1 (2.4)   |
| Juvenile angiofibroma       | 1 (2.4)   |
| Lymphoma                   | 1 (2.4)   |
| Pituitary hyperplasia       | 1 (2.4)   |

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| Pituitary hyperplasia       | 1 (2.4)   |

The objective of the unilateral transethmoid-paraseptal approach is to reach the central skull base without removing the nasal turbinates and to avoid excessive resection of the nasal septum. Furthermore, the mucosal surface (principally in the olfactory cleft) should be preserved and the patency of the natural paranasal sinus ostia should be kept intact in order to protect physiological sinonasal function.

Patients are placed supine. After general anesthesia and navigation system setup (Fusion ENT Navigation System, Medtronic AG, Münchenbuchsee, Switzerland), cottonoid pledges impregnated with adrenaline solution (1:1000) are inserted bilaterally toward the olfactory clefts and the sphenoid recesses to decongest the nasal mucosa. Submucosal injection of vasoconstrictor solution is avoided.

The better side for the unilateral approach is determined by both the individual anatomy and position of the lesion, access being the primary determining factor. The entire approach is performed 4-handed. After removal of the cottonoids, the intranasal anatomical landmarks are identified, and then the middle turbinate is gently medialized to expose the middle meatus (Fig. 1). As the first step of the unilateral ethmoidectomy, the uncinate process is removed with preservation of its superior part and the mucosa around the natural maxillary sinus ostium. Then the ethmoid bulla is opened and removed. The basal lamella of the middle turbinate is recognized and dissected to get access into the posterior ethmoid cells. After identifying the coronal plane of posterior wall of the maxillary sinus, which corresponds to the anterior wall of the pterygopalatine fossa, the anterior wall of the sphenoid sinus is opened through the ethmoid cells. If necessary, the sphenopalatine foramen is identified and the posterior septal branches of the sphenopalatine artery are cauterized. After ethmoidectomy, the middle and superior turbinates are gently lateralized and placed into the cavity created by the ethmoidectomy to reveal the ipsilateral ostium of the sphenoid sinus. This safely enlarges the nasal cavity and facilitates paraseptal endonasal surgical manipulation, as the sphenoidotomy can be broadened up to the skull base, toward the medial aspect of the orbit and to the contralateral side. An incision is made over the posterior septal mucosa which is then elevated, the posterior part (3–4 mm) of the vomer is dissected and removed along with the sphenoid rostrum and the anterior wall of the sphenoid sinus. Excessive removal of the posterior part of the nasal septum is unnecessary and can be avoided in all cases. Parts of the anterior wall of the sphenoid sinus of the contralateral side can be resected to gain more space, however, the overlying mucosa with the sphenopalatine branches is preserved in these cases to maintain the option of a nasoseptal flap.

After entering the sphenoid sinus, its anatomical landmarks can be identified. The sphenoid mucosa is removed only in the surgical field. The panoramic endoscopic view allows control of the vital structures of the central skull base. Beyond the sphenoid sinus, a corridor of access is created and this can be extended laterally to the sphenopalatine foramen, the pterygopalatine fossa, the pterygoid (Vidian) canal as well as the cavernous sinus, sagittally from the sphenoid planum to the lower clivus.

After pure endoscopic tumor removal, the sphenoid sinus is cleaned from congealed blood. The nasal cavity is inspected and the middle turbinate is replaced in a moderately lateralized position. In case of uneventful surgery, pedicled nasoseptal flap, nasal packing or lumbar drain are not used.

Perioperative Course

Each patient underwent detailed preoperative neurological, endocrinological, ophthalmological, and radiological examination. Rhinological investigations included nasal endoscopy and smell screening test (SmellDiskettes Olfaction Test, Novimed AG, Dietikon, Switzerland), consisting of 8 smell diskettes and a questionnaire. Seven or 8 correct answers indicate normosmic function, 6 or less show anosmia/hyposmia or low compliance. The left and the right side are investigated separately. In case of at least 7 correct answers on one side, the patient is considered to be normosmic.

Assessment of quality of life was offered to the patients asking to score preoperative symptoms using the Sino-Nasal Outcome Test (SNOT-22; Table II). The SNOT-22 contains 22 questions that can be answered on a Likert scale from 0 to 5, producing a total score from 0 to 110, with lower scores indicating fewer symptoms. Items pertain to specific sinonasal, ear/ facial, sleep dysfunction and psychological domains.

Preoperative cranial CT- and MRI-imaging was used to plan the approach and for navigation purposes. Additional intraoperative CT- (Siemens Somatom Sensation, Siemens AG, Erlangen, Germany) or MRI-scan (Polestar, Medtronic AG) was available to help the evaluation of the extent of resection.

Intrasinus endoscopy was performed on the 1–3 postoperative days to carefully remove congealed blood and mucus in
order to provide a nasal airway yet not disturb any grafts. Nasal douching, sprays and ointments were applied to help wound healing and prevent drying and excessive crusting. Routine endoscopic examination was repeated at 1 month and 1 year, and the smell screening test at 1 year after surgery.

In all cases, the postoperative neurological, endocrinological, and ophthalmological status was evaluated. MRI-scans were routinely performed on the first day after surgery, after 3 months and 1 year, and repeated in the late postoperative course according to the particular case.

1-month and 1-year postoperative SNOT-22 scores of patients were also measured. Thus, results at three different time points became comparable. A smell screen test was repeated 1 year after surgery.

Statistical analysis of results was performed with Excel software (Microsoft Corp., Redmond, Washington, USA).

Fig. 1. Surgical steps of the endoscopic unilateral transeptal-paraseptal approach, right side
A: View of the lateral wall (LW) of the right nasal cavity, the middle turbinate (MT) and the nasal septum (S). B: The middle turbinate is pushed to medial with a dissector (*). The inferior turbinate (IT) can be also seen. C: An incision is performed with a sickle knife (*) on the lateral nasal wall at the lateral part of the uncinate process (UP). D: After the removal of the uncinate process (uncinectomy), the ethmoid bulla (EB) is identified. E: The ethmoid bulla and further anterior ethmoid cells are dissected to find the basal lamella (BL) of the middle turbinate. The posterior wall of the maxillary sinus (MS) and the medial wall of the orbit (O) can be identified. F: After the removal of the basal lamella of the middle turbinate, the posterior ethmoid cells (PEC) are opened. G: The posterior septal branches of the sphenopalatine artery (arrow) are dissected with a ball probe (*). Superiorly to them, the posterior ethmoid cells are removed to enter the sphenoid sinus (SS). H: View of the sphenoid sinus with the prominence of the ipsilateral optic nerve (ON) and the internal carotid artery (ICA). I: The endoscope is pulled back and positioned medially from the middle turbinate and the superior turbinate (ST). An incision is performed with a scalpel (*) on the posterior nasal septum. J: The mucosa and the periosseum of the nasal septum is gently pulled away to get access to the underlying posterior bony nasal septum. K: The mucoperiostal sheath is carefully detached on both sides. View of the tumor (T), the sphenoid rostrum (SR) and the vomer (V). L: View of the tumor in the sphenoid sinus after rostrectomy.
**Ethics**

This study was conducted in accordance with the ethical standards and the 1964 Helsinki Declaration and its later amendments as well as local ethical standards. Prior filling out the above described questionnaires, patients consented to the evaluation of the obtained data.

**RESULTS**

In each case an endoscopic unilateral transethmoidal-paraseptal approach was performed. The majority were done (24 patients, 57.1% of all cases) on the right side. Eight individuals (19.0%) had undergone previous transnasal neurosurgical procedure at another institute. There was clinical evidence of concurrent paranasal sinusitis in 7 cases (16.7%). Nine individuals (21.4%) presented with a marked septal deviation leading to an additional septoplasty. Inferior turbinoplasty was performed of 1 patient (2.38%) to achieve adequate access. There were no intraoperative nasal, paranasal, introrbital or intracranial neurovascular complications. The skull base defect was routinely covered with Tacho-sil (Takeda Pharmaceuticals International GmbH, Zurich, Switzerland). In 2 cases with intraoperative cerebrospinal fluid (CSF)-leak from the sellar region (related to tumor removal), abdominal fat graft was used. A pedicled nasoseptal flap for reconstruction was created in 5 patients (11.9%) with large skull base defects. A lumbar drainage was never used. The average duration of surgery was 189.0 ± 90.5 minutes (range: 80–555 minutes).

After surgery, all patients had a notable improvement in any disease-related symptoms, as well as by objective neurological and endocrinological criteria. There were no postoperative neurovascular complications. Postoperative hospitalization ranged from 3 to 10 days (mode: 5 days). There were 2 cases (4.8%) of CSF-leak postoperatively, making surgical revision necessary. Transient diabetes insipidus was seen in 5 patients (11.9%) who were treated satisfactorily with desmopressin and electrolyte replacement. Reoperation was needed in 1 case (2.4%) to manage intractable nasal bleeding. Complete resection was aimed in 39 cases. Among them, an early postoperative MRI showed residual tumor in 2 cases, necessitating further therapy. Minimal and/or stable contrast agent enhancement was seen in 6 cases, considered as possible residual tumor. These patients showed no further subjective or objective symptoms of residual disease across time. Based on that, a complete removal was achieved in 31 cases (79.5% of 39 patients) according to the latest postoperative investigation performed at least 1 year after surgery.

Twenty-nine patients (69.0%) have completed the SNOT-22 tool at all the 3 time points. In the later course, 2 unrelated deaths were reported. Clinician-assessed early postoperative rhinological symptoms were minor in all cases. Compared to SNOT-22.
22 scores prior surgery, in the early postoperative period there was a marked deterioration (Table III). Mean domain scores of the SNOT-22 improved but did not differ significantly from the preoperative period to 1 year after surgery (Table IV). There was a significant improvement ($p = .041$) of the total scores from 1 month to 1 year after surgery.

The mean score of any items was $0.8 \pm 0.4$ showing majority of answers “no problem” and “very mild problem”. Most rhinological items enquired about in the questionnaire show a non-significant improvement 1 year after surgery from the preoperative situation.

Pre- and postoperative side-specific smell function test results were available in 17 patients for comparison. Most of them (15 individuals, 88.2%) presented with preoperative normosmic function. The average preoperative result for the smell screening test was $6.9 \pm 0.9$ on the right side (range: 5–8) and $6.9 \pm 1.0$ on the left side (range: 5–8). One year after surgery, normosmic smell function was found in 94.1% of the investigated patients (16 individuals). The average score was $7.2 \pm 0.1$ on the right side (range: 4–8) and $7.2 \pm 0.1$ on the left (range: 4–8). There was no significant difference between pre- and postoperative results ($p = .119$). There was no marked change of smell function on the side of the performed approach.

A subgroup of patients with evidence of paranasal sinusitis prior surgery (7 individuals) was separately examined. Their preoperative SNOT-22 scores were significantly improved 1 month ($p = .027$) and also 1 year after surgery ($p = .011$). There was no significant change of smell function across time ($p = .448$).

**TABLE III.**

| Time since surgery | Preoperative score* | Postoperative score* | $p^\dagger$ |
|--------------------|---------------------|----------------------|-----------|
| 1 month            | $17.7 \pm 18.9$     | $19.8 \pm 15.6$      | 0.524     |
| 1 year             | $17.7 \pm 18.9$     | $15.9 \pm 16.9$      | 0.665     |

*Scores range from 0 to 110, values are mean ± standard deviation.
†Paired 2-tailed t test, alpha < 0.05.

**DISCUSSION**

The goal in the endoscopic transnasal approach is to gain safe and wide exposure to the central skull base. Early interest has focused on the completeness of surgical removal and only recently has there been more attention in other aspects of the patient’s postoperative symptoms and subjective well-being. Various tools have been developed to evaluate QOL, and a multidimensional questionnaire that examines an individual’s overall perception of well-being provides a broader overview. The SNOT-22 is a well-recognized QOL tool consisting of rhinological, ear/facial, sleep dysfunctional and psychological items and assesses symptoms along with the social and emotional consequences of paranasal sinus disease. It is also able to detect sinonasal morbidity caused by transnasal neurosurgical intervention.

In this study, we demonstrated our initial experience with the transethmoid-paraseptal approach. Beyond radiological, neurological and endocrinological data, we thoroughly analyzed patient’s nasal functions and satisfaction after surgery.

Gil et al. were to first to study QOL related to anterior skull base surgery using a specific tool, the Anterior Skull Base Questionnaire (ASBQ). Abergel et al. administered it to 39 patients undergoing skull base surgery and prospectively recognized a transient worsening of QOL that improved in the late postoperative course. McCoul et al. prospectively analyzed the SNOT-22 and ASBQ scores of 85 patients undergoing endoscopic binos- tril skull base surgery. Compared to SNOT-22 data prior surgery, they observed an early postoperative impairment and a significant late improvement. We found a notable, but statistically not significant improvement in the SNOT-22 outcome after a transient postoperative deterioration, nor was a significant change noted when SNOT-22 domains were analyzed separately. However, we analyzed a small subgroup of 7 individuals with preoperative sinonasal disease evidence who showed continuous and significant improvement in their SNOT-22 data across time. Pant et al. reported on a prospective series of 51 patients undergoing endoscopic skull base surgery using numerous approaches. Similarly to our results, they found that the early postoperative SNOT-22 scores are significantly higher than the late ones. However, the lack of preoperative data supplied detracts from the evaluation of their patients’ entire course. In their retrospective study, Suberman et al. administered

**TABLE IV.**

| Domain                | Preoperative score* | 1 year postoperative score* | $p^\dagger$ |
|-----------------------|---------------------|-----------------------------|-----------|
| Rhinological§         | $4.1 \pm 7.2$       | $3.8 \pm 5.1$              | 0.789     |
| Psychological§         | $6.9 \pm 7.2$       | $5.9 \pm 6.6$              | 0.506     |
| Ear/facial†           | $2.7 \pm 3.8$       | $2.4 \pm 3.2$              | 0.768     |
| Sleep dysfunction§     | $4.0 \pm 4.9$       | $3.8 \pm 4.7$              | 0.871     |

*Values are mean ± standard deviation.
†Paired 2-tailed t test, alpha < 0.05.
§Scores range from 0 to 40. Items: need to blow nose, sneezing, cough, runny nose, postnasal discharge, thick nasal discharge, nasal obstruction, loss of smell and/or taste.
†Scores range from 0 to 20. Items: ear fullness, dizziness, ear pain, facial pain and/or pressure.
§Scores range from 0 to 20. Items: difficulty falling asleep, waking up at night, waking up tired, lack of good night’s sleep.
between the late postoperative SNOT-20 scores.20 Simi-
gery, Pledger et al. found no significant difference
follow-up would be necessary. In another comparative
of ethmoid cells to treat chronic ethmoiditis.30 However,
mark paper from 1950, Takahashi described the removal
Friedman et al. its partial removal has no effect on olfac-
tion–a common act to gain additional space during sur-
dition.21 However, Swanson et al. demonstrated that mid-
ly turbinate resection can increase the risk of frontal
risus disease.22 Rice et al. point out that excessive turbi-
nate removal can lead to crusting, bleeding, paradoxical
breathing difficulty, recurrent infections, nasal odor,
pain and often clinical depression and empty nose-
syndrome.23

In case of a large tumor extension, a biportal tech-
nique may be necessary. However, the transethmoid-
paraseptal approach, described in this article, has
become our standard treatment choice for most skull
base lesions. The advantage of this technique based on
functional endoscopic sinus surgery is the wide exposure
of the sphenoid sinus and central skull base, yet still
being able to preserve important sinonasal structures
that affect QOL.24 Protection of the nasal mucosa and
the olfactory cleft could be achieved without turbinate
and septal resection. Patients reported on minor postop-
erative discomfort with normal ventilation after surgery.
With minimal endonasal dissection and coagulation,
scarring of the olfactory mucosa could be avoided, result-
ing in a diminished risk of developing iatrogenic hypo-
smia. According to our results, the described technique
does not influence the sense of smell. The middle turbi-
nate’s controlled slight lateralization facilitates patency
of the ethmoid infundibulum and the olfactory cleft.

Ethmoidectomy is the key act to gain additional
space in order to temporarily lateralize the turbinates
without resecting them. The transethmoidal approach of
various paranasal sinus pathologies has often been
described in the rhinological literature.25–29 In his land-
mark paper from 1950, Takahashi described the removal
of ethmoid cells to treat chronic ethmoiditis.30 However,
this did not gain wide acceptance among neurosurgeons
as it assumes detailed anatomical knowledge and
thought to be time-consuming. A recent meta-analysis
on endoscopic pituitary surgery found the range of mean
surgical duration to be 102–255 minutes.31 Our data
(189 minutes) is acceptable compared with these results,
particularly in view of the spectrum of diseases in this
group. After ethmoidectomy, the neurosurgical time may
be subjectively shorter as maneuverability is increased.

Rhino-neurosurgical cooperation is advocated dur-
ing the patient’s entire treatment as there is common
decision making, a shorter intraoperative time, better
surgical results and it may also shorten the surgical
learning curve.32,33 Each phase of the care (treatment
planning, surgical preparation, surgery, postoperative
care, management of complications) is done together.
The endoscopically assisted four hand technique initially
described by May et al. enables bimanual surgery.34

CONCLUSION

The majority of surgeons use a binostril approach
and remove a large part of the nasal septum.3,26–27 With
the transethmoid-paraseptal technique a free, two-handed
manipulation and wide skull base visualization was still
possible using mononostril dissection, without the need
of turbinate resection.

The unilateral transethmoid-paraseptal approach
allowed safe and fast removal of various skull base
lesions without any deterioration in long term sinonasal
QOL and smell function scores. Surgery does not lead to
deterioration in QOL according to the SNOT-22 survey.
In the subgroup who had sinonasal disease, SNOT-22
scores showed a significant improvement across time.
A prospective analysis of further patients is necessary to
totally evaluate this technique. The technique described
advocates rhino-neurosurgical cooperation.

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