Acta Neurochirurgica (2019) 161:2527–2537
https://doi.org/10.1007/s00701-019-04062-5

ORIGINAL ARTICLE - BRAIN TUMORS

Quality of life and emotional burden after transnasal and transcranial anterior skull base surgery

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Received: 16 April 2019 / Accepted: 9 September 2019 / Published online: 10 October 2019

Abstract

Objective To analyze psychopathological outcome and health-related quality of life (QOL) for cohorts of patients undergoing transcranial or transnasal anterior skull base surgery.

Methods A prospective study of patients undergoing elective surgery for various entities of the anterior skull base was performed. Evaluation for depression (ADS-K score) and anxiety (PTSS, STAI-S, STAI-T, and ASI-3 scores) was done before surgery, at 3 and 12 months after surgery. The correlation between preoperative psychological burden and postoperative quality of life as measured by the SF-36 and EuroQol questionnaires was analyzed. Incidence and influence of these psychiatric comorbidities on clinical outcome were examined and compared between transnasal and transcranial subgroups.

Results We included 54 patients scheduled for surgery of a pituitary adenoma or meningioma of the anterior skull base between January 2013 and July 2017. Of these, a cohort of 40 (74.1%) completed follow-up interviews after 3 and 12 months. There were 60.0% female patients, median age was 57 years. 57.5% of patients had a meningioma and were operated transcranially, while 42.5% of patients received transnasal surgery for pituitary adenoma. The proportion of pathological anxiety scores significantly decreased from 75.0 to 45.0% ($p = 0.002$), without difference between transnasal and transcranial subgroups. After 3 months, mean EuroQol VAS score non-significantly increased by 0.07 ($p = 0.236$) across the entire cohort without significant difference between transcranial and transnasal subgroups ($p = 0.478$). The transnasal cohort tended to score higher in anxiety scores, whereas the transcranial cohort demonstrated higher depression scores without significant difference, respectively. The individually declared emotional burden significantly decreased from 6.7 to 4.0 on the ten-point Likert scale ($p < 0.001$) equally for both subgroups (transnasal, −2.3; transcranial, −3.0; $p = 0.174$). On last examination, about half of the patients in each subgroup (41.2% vs. 52.2%; $p = 0.491$) expressed a considerable recovery of preoperative bodily complaints such as headaches, dizziness, and unrest defined as a score of at least 8 on the Likert scaled item.

Conclusion Both transnasal and transcranial approaches yield favorable postoperative QOL and psychopathological outcomes. The postoperative increase in QOL is partly influenced by preoperative expression of mental distress, which tends to resolve postoperatively.

Keywords Anterior Skull Base · Quality of life · Emotional burden · Transnasal · Transcranial

This article is part of the Topical Collection on *Brain Tumors*

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Abbreviations

ADS-K	Center of epidemiology depression scale (Allgemeine Depressionsskala)
ASI-3	Anxiety Sensitivity Index 3
EuroQol VAS	EQ VAS
Fig.	Figure
MCS	Mental component score
PCS	Physical component score
rANOVA	Repeated measures analysis of variance
SF-36	Short form 36
STAI-S	State and trait anxiety inventory – state
STAI-T	State and trait anxiety inventory – trait
QOL	Quality of life

Introduction

During the recent decades, increasing sophistication of transnasal techniques and instruments has facilitated their routine application in approaching select entities of the anterior skull base and sellar region. Employed by neurosurgeons and otolaryngologists alike, results have been excellent on the grounds of an acceptable perioperative risk profile and clinical outcome gauges even when juxtaposed against the traditional transcranial route [1–4]. Increasing attention is diverted to investigating dimensions of postoperative quality of life (QOL) of patients across several disciplines. Our own authors' experience suggests not only favorable results, but also a certain predictability, when assessing the psychopathological complex of an individual who is faced with an upcoming head surgery. Seeing as it is a topic of utmost relevance to patients, several forays have been made to quantify QOL for patients undergoing transnasal endoscopic surgery with a promising outlook [5–9]. In this regard, however, there still have been only few methodological investigations of QOL, omitting psychopathological instruments, for endoscopic and transcranial approaches to the anterior skull base and the available literature is largely focused on sino-nasal outcome qualities, primarily a scientific domain of otolaryngologists [10, 11]. We therefore report our assessment of the postoperative QOL in relation to expression of anxiety and depression in patients scheduled for transnasal or transcranial surgery of the anterior skull base.

Methods

We prospectively included patients scheduled for resection of a newly diagnosed or recurrent lesion of the anterior skull base aged over 18 years and willing to participate. We deliberately contrasted patients undergoing transnasal surgery for pituitary adenoma with those that were treated via open craniotomy for meningioma of the skull base. Both entities represent surgically curable diseases with a benign course and as such are analogical in terms of postoperative patient care and counseling on follow-up.

Patients were asked to complete an assay of several questionnaires gauging health-related QOL, physical function, symptoms of posttraumatic stress disorder, anxiety, and depression. The questionnaires used are described in Table 1 with references to their respective manual validative resources. Cut-off scores were established by our neuropsychologists after review of pertinent literature and data on our own reference cohorts of patients scheduled for elective spine surgery [12–14]. A psychiatric history was recorded when a patient received prescribed psychiatric medication or psychiatric counseling during the 12 months before surgery.

Moreover, an enquiry was made into the perceived emotional burden of patients before surgery and on last follow-up, which prompted a response on a ten-point Likert scale from least (1) to most burdened (10). Preoperative assessments included base levels of hormones. Preoperative tumor volume was determined by volumetry via *Brainlab Elements*™ software. Standard of care and surgical strategy were not altered for study patients. Psychological assessment on follow-up was assumed by neuropsychologists. The treating neurosurgeons were blinded to study participation so as to not bias neurological examination on follow-up in the outpatient setting. After discharge and on confirmation of the histopathological results, a certified Neurooncological Board meeting decided on the postoperative course for every case, in the very majority seeing patients return for clinical and radiological follow-up 3 and again 12 months after surgery according to the standard of procedure of our department. These appointments were hence coordinated for follow-up examination. For patients not able or not opting to return for follow-up in person, a 35-min structured telephone interview was administered by a psychologist for assessment of functional and psychological capacity.

Statistical analysis was performed with IBM SPSS Statistics (version 21; IBM Corp.; 2012) to test for epidemiologic characteristics, correlation between preoperative psychological scores and postoperative course using linear models as well as mean differences in QOL between those patients with pathological psychological scores beforehand and those with normal scores using Student's t test. Values of α below 0.05 were indicative of a statistically significant difference between mean values. Changes in mean scores within individuals were compared via repeated measures analysis of variance (rANOVA). The Mann-Whitney U and McNemar tests were employed for non-parametric testing of Likert scaled and binomially distributed items, respectively.

The study group acquired approval by the local ethics committee (Reference No. 409/13).

Table 1 Overview of the standardized questionnaires used in the study

Questionnaire	Description	Scores
General Depression Scale (Allgemeine Depressionsskala; ADS-K) [15]	This index is based on the *Center for Epidemiological Studies Depression Scale* (Radloff, 1977) and was devised to determine depression levels for outpatients. The 15 items are sensitive to dysthymic disorders, not only to major depression.	Cut-off ≥ 18
State Trait Anxiety Inventory (STAI-T and STAI-S) [16]	This two-part questionnaire was conceived to measure the two different dimensions of anxiety with 20 items each: a stable character trait and personal disposition; a transient state as a function of current influences.	Cut-off > 40
Posttraumatic Stress Scale (PTSS-10) [17]	The scale consists of 10 items that check for pathognomonic symptoms of posttraumatic stress disorder.	Cut-off ≥ 18
Anxiety Sensitivity Index (ASI-3) [13]	This index is a measure of susceptibility to states of anxiety and perception of potentially hazardous symptoms, 18 items.	Cut-off > 30
European Quality of Life Questionnaire (EuroQol) [18]	The concept of quality of life leans on 5 dimensions of everyday life including *Mobility, Self-care, Usual Activities, Pain/Discomfort* and *Anxiety/Depression.* The respective scores are calculated into a single index on the *Visual Analogue Scale* (VAS). Higher scores on the VAS indicate better quality of life.	Range 0–1
Short Form Health Survey (SF-36) [19]	With its 36 items, the SF-36 gauges 8 aspects of health-related quality of life of a patient. The aspects may be summarized in the *Physical Health Component Summary Score* (PCS) and *Mental Health Component Summary Score* (MCS), higher values signal favorable physical and mental capacity.	Range 0–100

Results

Patient characteristics

We included 54 patients scheduled for surgery of a pituitary adenoma or meningioma of the anterior skull base between January 2013 and July 2017. Of these, a cohort of 40 (74.1%) completed follow-up interviews after 3 and 12 months, which will be subjected to all further analysis. Table 2 summarizes baseline demographics, preoperative visual deficits, and hormonal deficiencies as well as tumor volume; subgroups of approaches did not show significant differences with the exception of diagnoses. In total, there were 23 patients with a meningioma (57.5%) and 17 patients with a pituitary adenoma (42.5).

While no pituitary adenoma was found to be malignant, one patient (2.5%) had a recurrent atypical meningioma [20]. Every pituitary adenoma was resected via a transnasal transsphenoidal route, whereas every meningioma was resected via craniotomy (Table 2).

One patient (2.5%) underwent adjunct radiotherapy for residual meningioma of the cavernous sinus; in all further instances, resections were judged complete according to the operating surgeon's assessment in unison with follow-up imaging.

Analysis of emotional attributes and quality of life

The proportion of patients with previous psychiatric treatment amounted to 26.5%, there was neither a statistically significant difference between transnasal and transcranial subgroups (23.8% vs. 28.6%; $p = 0.709$) nor between strata of

Table 2 Baseline characteristics and diagnoses stratified by approach

	Approach		
	Transnasal	Transcranial	*p*
	17	23	
Median age in years (range)	59 (25–77)	55 (26–97)	0.568
Female gender	52.9%	65.2%	0.206
Marital status	S, 29.4% R, – M, 70.6%	S, 21.7% R, 8.7% M, 60.9%	0.344
Psychiatric history	29.4%	31.8%	0.872
Meningioma	–	23	*< 0.001*
Pituitary adenoma	17	–	
Tumor volume (cm^3)	2.4	3.9	0.368
Visual deficit	17.6%	13.0%	0.647
Hormonal deficiency	23.5%	4.4%	0.070

p, level of significance; statistically significant *p* values in italics; *S*, single; *R*, in a relationship; *M*, married meningioma and adenoma subgroups at baseline (53.8% vs. 38.5%; $p = 0.409$). Thirty-one patients (75.0%) exhibited pathological anxiety scores and 9 (22.5%) pathological depression scores on preoperative screening. The latter proportion remained stable (20.0%; $p = 1.0$), whereas the former significantly diminished to 45.0% by 12 months ($p = 0.002$; Table 3). There was no statistically significant difference between subgroups in terms of the magnitude of changes for either dimension (anxiety, $p = 0.406$; depression, $p = 0.913$).

By 3 months of follow-up, the mean EuroQol VAS (EQ VAS) score increased by 0.07 ($p = 0.236$) across the entire cohort while the mean SF-36 MCS score increased by 0.4 ($p = 0.937$) and PCS score increased by 0.9 ($p = 0.810$; Table 4). EuroQol and MCS scores had diminished again to baseline level on last follow-up, while the mean SF-36 PCS score remained stable (Table 4).

There was no significant correlation between operative route and course of QOL scores at any point in follow-up, albeit a trend towards superior EQ VAS scores may be seen in the transnasal subgroup ($p = 0.192$; Fig. 1 and Table 4).

On comparison of different psychopathological scores between approaches, no significant differences were found with regard to the development over time for any of the instruments. The transnasal cohort generally scored higher in the anxiety scores (ASI-3, STAI-T, and PTSS-10; $p = 0.698$; $p = 0.727$; $p = 0.774$), whereas the transcranial cohort had higher scores for depression (ADS-K; $p = 0.452$). The minutest difference was found in the anxiety state (STAI-S) range ($p = 0.987$; Fig. 2). With the exception of the ASI-3, every anxiety scaling score had reduced significantly by 12 months for the entire cohort. Depression scores, however, only insignificantly tapered ($p = 0.152$; Fig. 2).

The individually declared emotional burden significantly decreased from 6.7 to 4.0 on the ten-point Likert scale ($p < 0.001$), equally for both subgroups (transnasal, − 2.3; transcranial, − 3.0; $p = 0.174$). On last examination, about half of the patients in each subgroup (41.2% vs. 52.2%; $p = 0.491$) expressed a considerable recovery of preoperative bodily complaints such as headaches, dizziness, and unrest defined as a score of at least 8 on the Likert scaled item. For the entire cohort, a score of at least 8 on this scale correlated with higher improvements in all QOL and psychopathological screening scores except the ASI-3 and PTSS-10. Most notably, the STAI-S score was reduced by 12.4 in contrast to 0.5 in the less satisfied patients scoring below 8, which was a significant difference for the transnasal cohort ($p = 0.045$; Fig. 3).

In a comparison of specific EQ subscales between last follow-up and preoperative status, *Anxiety/Depression* scores significantly worsened by 0.21 ($p = 0.035$) for the entire cohort, as opposed to a significant improvement of *Pain/Discomfort* scores ($p = 0.035$; Table 5). Between the two subgroups, the only dimension to significantly worsen was found to be *Anxiety/Depression* in the transnasal group ($p = 0.04$; Table 5). No significant differences were seen in the intergroup comparisons of mean differences.

The SF-36 dimensions were also examined, resulting in a significant increase of self-perceived *Physical Function* scores for the transnasal group (+ 5.2; $p = 0.017$; Table 5). There were no significant differences otherwise.

A multivariate linear regression analysis identified the preoperative STAI-S score as a positive independent predictor for lower EQ and SF-36 PCS scores after 12 months for the transcranial cohort. A higher preoperative SF-36 MCS score by contrast predicted higher EQ and SF-36 PCS scores for the transcranial subgroup. The transnasal cohort exhibited a significant inverse correlation between gender and postoperative EQ scores, females generally scored lower after 12 months (Tables 6 and 7).

Discussion

The operative route a surgeon chooses to address a given lesion is a function of a variety of factors. Principally, anatomical determinants of the prospective operative corridor as well as familiarity with available instruments all enter into the decision-making process, such considerations however solely pertain to the surgical outcome. No true consensus is available

Table 3 Proportion of patients with pathological anxiety and depression scores preoperatively and on follow-up, stratified by approach. Statistically significant *p* values in italics

		Approach		Intergroup comparison: *p*	Total
		Transnasal	Transcranial		
Anxiety	Preoperative	76.5%	73.9%	0.853	75.0%
	3 months	52.9%	47.8%	0.749	50.0%
	12 months	47.1%	43.5%	0.822	45.0%
Intragroup comparison: *p*		0.125	*0.016*		*0.002*
Depression	Preoperative	17.6%	26.1%	0.527	22.5%
	3 months	6.2%	21.7%	0.187	15.4%
	12 months	5.9%	30.4%	0.055	20.0%
Intragroup comparison: *p*		0.501	1.0		1.0

Table 4 Development of QOL scores stratified by approach

	Approach			
	Transnasal	Transcranial	Intergroup comparison: *p*	Total
EuroQol VAS preoperative	0.81 ± 0.20	0.73 ± 0.19	0.259	0.76 ± 0.19
EuroQol VAS 3 months	0.83 ± 0.15	0.83 ± 0.16	0.920	0.83 ± 0.15
EuroQol VAS 12 months	0.82 ± 0.16	0.72 ± 0.27	0.192	0.76 ± 0.25
Intragroup comparison: *p*	0.749	0.173		0.236
SF-36 PCS preoperative	44.5 ± 11.2	46.6 ± 10.7	0.541	45.6 ± 11.0
SF-36 PCS 3 months	45.2 ± 9.7	44.4 ± 8.8	0.757	44.7 ± 9.1
SF-36 PCS 12 months	44.3 ± 9.9	45.1 ± 11.3	0.942	44.9 ± 9.9
Intragroup comparison: *p*	0.919	0.432		0.810
SF-36 MCS preoperative	50.4 ± 9.1	43.7 ± 12.0	0.441	46.4 ± 11.1
SF-36 MCS 3 months	50.3 ± 8.6	44.5 ± 13.4	0.295	46.8 ± 11.9
SF-36 MCS 12 months	49.8 ± 9.1	44.1 ± 13.9	0.448	46.4 ± 12.0
Intragroup comparison: *p*	0.977	0.935		0.937

on psychological outcome and influence on health-related QOL after surgery via different approaches. The transnasal approach is a technique for surgery of anterior skull base lesions that has been increasingly adopted for selected cases and refined tremendously in the recent decades [4, 21]. Extents of resection, complication rates, and functional outcomes have been reported to be favorable and in no way inferior to the traditional open craniotomies, when it is applied accordingly and in expert hands [1, 2, 11, 22, 23]. Still, the rate of CSF leak remains the Achilles' heel of the endoscopic approach in particular when compared with the traditional open approach [24–26].

The continuous scientific discourse has so far largely neglected the psychological impact of such procedures, which may be the most substantial influence on a patient's perceived postoperative outcome and QOL, not necessarily tumor control [27–29]. Martinez-Devesa et al. found a third of their cohort with skull base lesions to suffer from acute mental distress, although their investigation focused on malignant entities [30]. Only a handful other publications exist on the subject matter, a direct comparison between transnasal and transcranial strategies being exceptional [31, 32]. Results by Abergel et al. as well as Yao et al. imply a clinically significant advantage for the endoscopic technique in their papers,

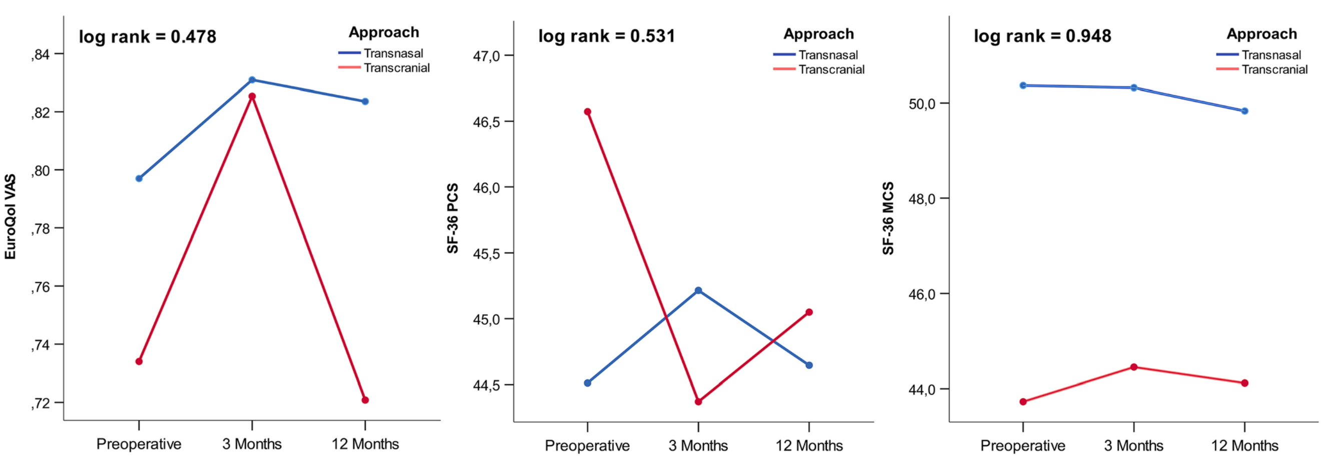

Fig. 1 Development of QOL scores stratified by approach

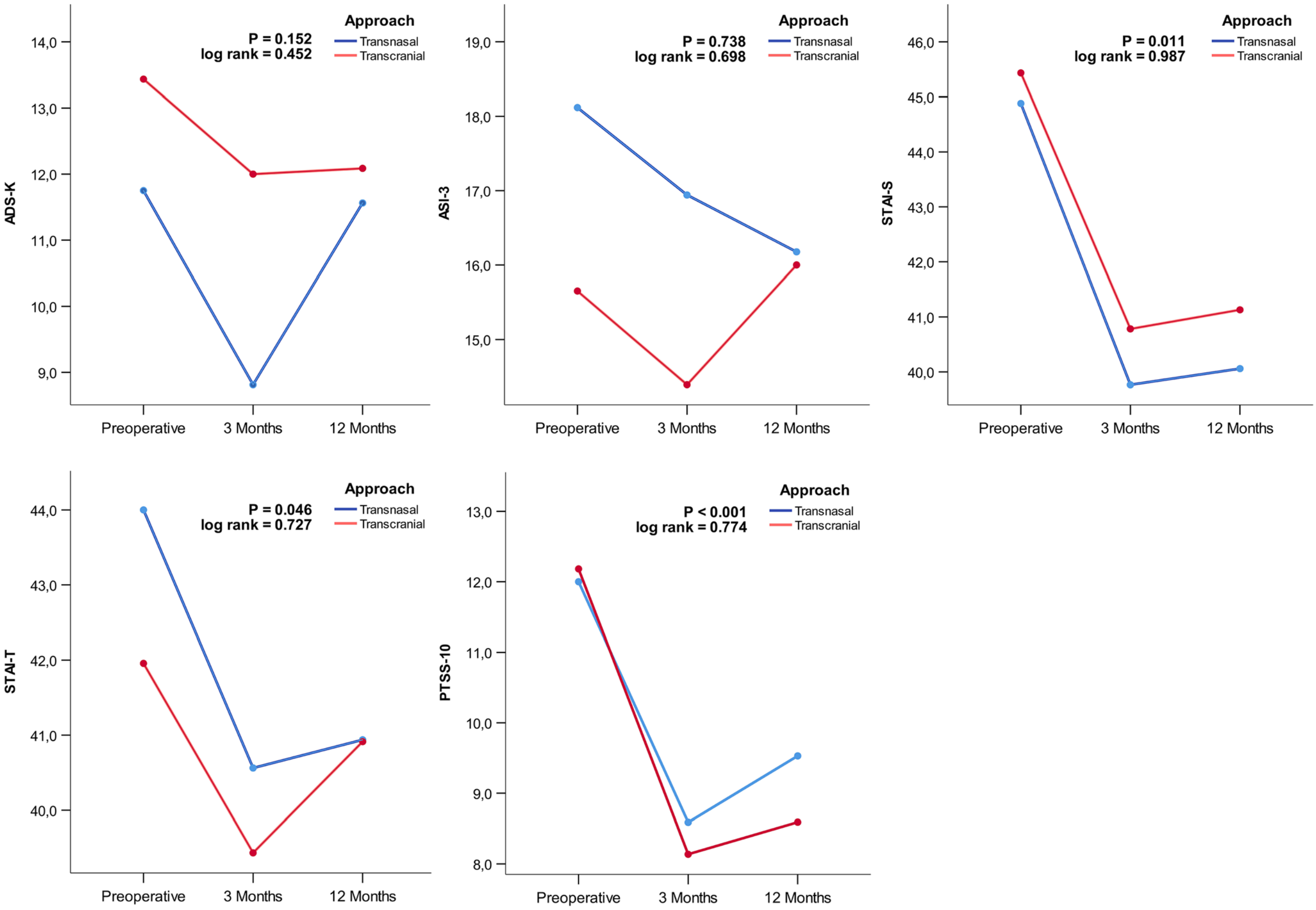

Fig. 2 Development of psychopathological scores stratified by approach

although only the former employed a specialized QOL instrument designed for anterior skull base entities [10, 33]. The majority of other available literature by contrast utilizes outcome measures specified for sino-nasal dimensions of QOL. Psychopathological dimensions and their correlation to QOL are infrequently analyzed in similar investigations.

In our study, we sought to complement the scarcely available data detailing the QOL and psychopathological development, with a view to contribute to the scientific juxtaposition of both strategies.

Typically, in our department, pituitary adenomas are addressed via the transnasal transsphenoidal corridor, whereas skull base meningiomas usually are addressed transcranially. There remains ambiguity even on an individual case basis, although visualization and control of lesions extending to the suprasellar region are thought to be hampered through

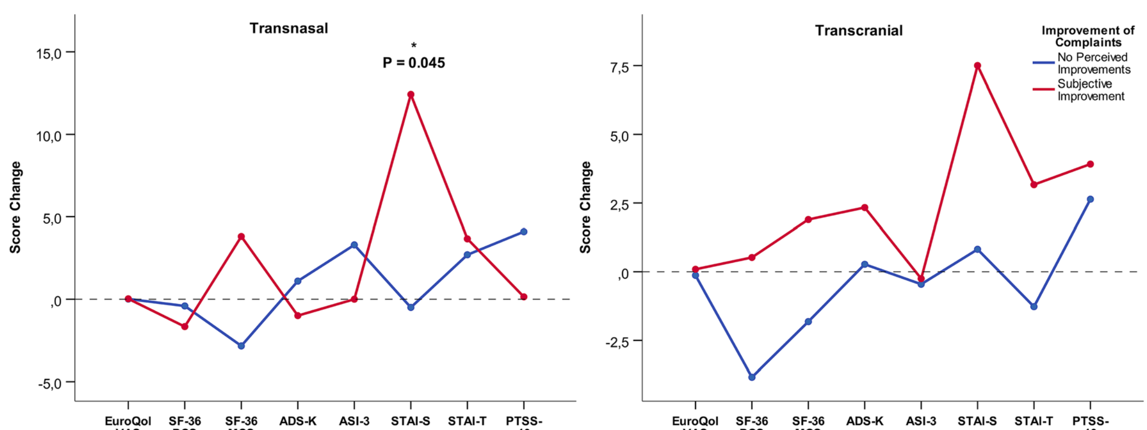

Fig. 3 Changes in psychopathological parameters for patients with self-perceived improvement of bodily complaints and those without. Positive changes signify an improvement for the respective scale

Table 5 Comparison of the different dimensions of EuroQol and SF-36 between preoperative status and last follow-up, stratified by approach. Negative values denote decrease from preoperative to follow-up value

	Total		Approach				
	Mean difference	*p*	Trans nasal	*p*	Transcranial	*p*	Intergroup comparison: *p*
EuroQol							
Mobility	+ 0.03	0.564	0	0.332	+ 0.05	0.570	0.619
Self-care	+ 0.09	0.180	+ 0.07	0.329	− 0.11	0.748	0.773
Usual Activities	0	1.0	+ 0.07	0.619	− 0.05	0.274	0.426
Pain/Discomfort	*+ 0.21*	*0.035*	+ 0.13	0.187	+ 0.26	0.163	0.493
Anxiety/Depression	*− 0.21*	*0.035*	*+ 0.20*	*0.039*	− 0.21	0.078	0.956
SF-36							
General Health	+ 0.4	0.753	− 1.4	0.694	+ 1.9	0.586	0.555
Role – Emotional	− 6.3	0.358	− 2.4	0.832	− 9.3	0.288	0.638
Physical Function	− 2.6	0.052	*+ 5.2*	*0.017*	− 0.6	0.719	0.081
Role – Physical	− 5.7	0.480	− 1.8	1.0	− 8.8	0.389	0.588
Bodily Pain	− 6.2	0.121	− 2.0	0.726	− 9.3	0.109	0.317
Mental Health	+ 0.7	0.853	− 1.7	0.667	+ 2.5	0.908	0.405
Social Functioning	+ 2.6	0.399	+ 0.8	0.829	+ 3.9	0.222	0.572
Vitality	− 0.2	0.750	+ 0.4	0.929	− 0.5	0.753	0.867

the transnasal corridor. As such, transcranial and transnasal resections of the cohort at hand are comprised of skull base meningiomas and pituitary adenomas, respectively. Surgical outcome in both subgroups was immaculate, with only one residual meningioma receiving adjunct radiotherapy, every other resection was deemed complete as per the operating surgeon's assessment and postoperative imaging.

Almost a third of patients reported a history of psychiatric treatment during screening, which may seem moderately higher than comparable historic cohorts with a rate of 21%; our own unpublished data however varies between 21 and 31% for different entities and is likely subjected to statistical deviation [34]. These proportions were evenly distributed among strata of approaches.

Table 6 Multivariate linear regression analysis of correlation between changes in EQ VAS and SF-36 scores and independent predictors for the transnasal cohort. Statistically significant *p*-values in italics

Transnasal	EuroQol	*p*	95% confidence interval		SF-36	*p*	95% confidence interval	
			Lower bound	Upper bound			Lower bound	Upper bound
Age	− 0.006	0.203	− 0.016	0.004	− 0.131	0.766	− 1.161	0.899
Gender	*− 0.219*	*0.048*	− 0.435	*− 0.003*	− 1.575	0.870	− 24.202	21.052
Relationship status	0.138	0.397	*− 0.233*	0.509	− 8.001	0.632	− 46.839	30.838
Psychiatric history	0.064	0.602	− 0.221	0.348	5.536	0.665	− 24.265	35.337
Preop. STAI-S score	− 0.001	0.881	− 0.010	0.009	− 0.167	0.684	− 1.125	0.790
Preop. STAI-T score	− 0.003	0.705	− 0.022	0.016	− 0.442	0.598	− 2.386	1.501
Preop. ASI-3 score	− 0.003	0.544	− 0.017	0.010	− 0.248	0.678	− 1.642	1.146
Preop. PTSS-10 score	0.007	0.634	− 0.027	0.041	− 0.072	0.962	− 3.646	3.502
Preop. ADS-K score	− 0.002	0.811	− 0.021	0.017	0.372	0.669	− 1.654	2.398
Preop. SF-36 MCS	0.010	0.066	− 0.001	0.020	− 0.110	0.815	− 1.208	0.988

Table 7 Multivariate linear regression analysis of correlation between changes in EQ VAS and SF-36 scores and independent predictors for the transcranial cohort. Statistically significant *p*-values in italics

Transcranial	EuroQol	*p*	95% confidence interval		SF-36	*p*	95% confidence interval	
			Lower bound	Upper bound			Lower bound	Upper bound
Age	− 0.001	0.873	− 0.010	0.009	− 0.022	0.930	− 0.558	0.514
Gender	0.123	0.279	− 0.113	0.358	10.983	0.096	− 2.281	24.248
Relationship status	0.067	0.486	− 0.136	0.270	3.179	0.556	− 8.252	14.610
Psychiatric history	− 0.218	0.075	− 0.461	0.025	− 10.696	0.115	− 24.400	3.009
Preop. STAI-S score	*− 0.015*	*0.043*	0.001	0.030	*− 0.864*	*0.042*	0.037	1.691
Preop. STAI-T score	− 0.002	0.814	− 0.019	0.015	− 0.116	0.801	− 1.096	0.864
Preop. ASI-3 score	0.006	0.363	− 0.008	0.021	0.188	0.622	− 0.621	0.997
Preop. PTSS-10 score	− 0.016	0.341	− 0.053	0.020	0.268	0.780	− 1.773	2.309
Preop. ADS-K score	− 0.016	0.300	− 0.049	0.016	− 0.627	0.469	− 2.454	1.200
Preop. SF-36 MCS	0.020	0.009	0.006	0.034	0.953	0.023	0.155	1.750

Proportions of abnormal anxiety scores dramatically receded postoperatively for both surgical routes (Table 3 and Fig. 2), underscoring the temporary psychological distress experienced by patients who are faced with an upcoming cranial surgery. Such has been reported previously and comes without surprise, although the impact of a malignant diagnosis remains controversial [35–37]. The slightly, almost significantly higher depression scores in the transcranial subgroup seem to hint at a purported benefit for transnasally operated patients in terms of their perceived psychological burden of disease. The absence of unspecific bodily complaints may contribute to a favorable bodily function and thereby self-perceived mental health, which is supported by the analysis of dimensions of both QOL instruments (Table 5).

The temporary slight increases of QOL scores are in accordance with published literature, but the clinical significance for the individual is questionable due to the minute changes [38–45].

Our QOL results seem somewhat ambiguous. A temporary relief of distress is mirrored in the rise of EQ scores after 3 months, but is followed with a declining trend for the transcranial group. A closer look at the SF-36 scores may help differentiate the postoperative courses of recovery: the self-perceived physical role and function seem to suffer for transcranially operated patients and remain stagnant during follow-up, all while the transnasal group experiences a significant increase of the Physical Function items in the SF-36 (Tables 4 and 5). The self-perceived QOL of patients seems to largely be influenced by symptoms and complaints not clearly attributable to a distinct neurological impairment. On follow-up, patients often report periodic headaches, unspecific dizziness, numbness at the area of the skin incision, or palpitations especially in the elderly, even though improvement of preoperative symptoms occurs in up to 86% according to published data [46, 47]. In our study, half of both subgroups experienced a clinically significant improvement of bodily complaints after 12 months of follow-up. It follows that both approaches seem equivalent in terms of generating unspecific symptoms, although patients undergoing transnasal surgery recover their bodily function significantly in contrast to the transcranial subgroup and thus exhibit generally lower levels of psychological distress.

Upon analysis of the 5 distinct dimensions of the EuroQol scale, the *Pain/Discomfort* and *Anxiety/Depression* items undergo the most notable changes. While the former increases by a significant amount for the cohort, the latter significantly diminishes for the transnasal subgroup, but not for the other (Table 5). Yao et al. reported similar results for emotional outcome, whereas they found a significant positive impact on physical function and everyday utility scores after transnasal surgery, which is also discernible in our data (Table 6) [33]. Equally, the SF-36 dimension *Physical Function* significantly increases for the transnasal subgroup. This development is crucial to understanding the physical and emotional coping mechanisms of patients undergoing cranial surgery. A plausible explanation would be that the prospect of a transcranial surgery evokes a greater perceived invasion into a patient's physical autonomy and thus emotional resilience, which is partly relieved immediately after. Particularly for the transcranial subgroup, the QOL outcomes are a function of the degree of preoperative state anxiety, as mirrored in the significant multivariate analysis for the STAI-S scale.

It would be, without a doubt, premature to abstract any true equipoise in terms of psychological outcome and QOL for both approaches from our results; still, even on separate bases of judgment, we may assume that particularly patients in the transnasal group undergo favorable physical recovery, while patients in the transcranial subgroup show impaired QOL outcome with elevated state anxiety before surgery. Some predictability stems from the correlation analysis, which fairly consistently saw patients with high SF-36 MCS values and low STAI-S values score higher in QOL measures on follow-up. We therefore see utility in the preoperative psychopathological screening of patients undergoing surgery, in that those exhibiting psychological distress may be selected for perioperative psychooncological counseling and support on follow-up.

Consensus of published works reads that there is a need for a scientifically validated specialized instrument to measure QOL as a function of psychopathological parameters for neurosurgical patients, which is not as widely available as sinonasal outcome instruments. For our study, we specifically chose to use widely accepted and validated psychopathological and QOL instruments, so as to help applicability and comparability of the results with similar studies. The instruments we employed have been widely accepted in everyday clinical use and extensively validated scientifically. Conversely, the disease-specific scales developed, such as the Sino-Nasal Outcome Test (SNOT-22), have been shown to be subpar in their psychometric properties for neurosurgical appliances [48]. In response, another disease-specific QOL inventory has only recently been developed and validated with the *Skull Base Inventory* [49, 50]. Its routine clinical application remains to be tried and tested.

Study limitations

This study was based on two different patient cohorts with differing entities. Naturally, there are no grounds for a direct comparison of transnasal and transcranial approaches. Still, both meningioma and adenoma patients retain a similar follow-up schedule as well as perioperative care and therefore perception of disease, all of which greatly informs the scores and measures we employed. We strictly abstain from generalizing results to conclude that both approaches would produce comparable results, but merely offer a confrontation under standardized conditions.

The validity of our results additionally suffers from a relatively low cohort size which is further hampered by considerable loss to follow-up of 25.9%.

Conclusion

Both transnasal and transcranial approaches independently yield favorable postoperative outcomes in terms of psychological relief and QOL. Analysis of QOL subscales reveals that the domain of self-perceived bodily function is improved after transnasal surgery.

Funding information The study was fully financed by the Department of Neurosurgery

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study group acquired approval by the local ethics committee (Ethikkommission der Technischen Universität München, registration no. 409/13.

Informed consent Informed consent was obtained from all individuals participating in this study.

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