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Original Article

Comparative analysis of the effects of microscopic vs. neuroendoscopic transsphenoidal surgery on visual and pituitary function and postoperative recurrence factors in patients with pituitary tumors

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Abstract: Objective: To compare the effects of microscopic and neuroendoscopic transsphenoidal surgeries on visual function, pituitary function, and factors influencing postoperative recurrence in patients with pituitary tumors. Methods: A retrospective analysis was conducted on 164 patients with pituitary tumors who underwent surgery at The First People's Hospital of Xianyang from March 2020 to March 2022. Based on the surgical approach, patients were divided into an observation group (n=93) and a control group (n=71). The observation group underwent neuroendoscopic transsphenoidal pituitary tumor resection, while the control group underwent microscopic transsphenoidal pituitary tumor resection. General clinical data, perioperative indicators, hormone levels, quality of life, and olfactory function were compared between the two groups. Postoperative recurrence was recorded, and logistic regression analysis was performed to identify factors influencing postoperative recurrence in the patients. Results: The control group exhibited a greater amount of intraoperative bleeding and a longer postoperative hospital stay compared to the observation group (P<0.0001). The total tumor resection rate was significantly lower in the control group than that in the observation group (P=0.002). Additionally, the numbers of patients in the control group who experienced improvements in vision (P=0.013), headache (P=0.004), and sexual dysfunction (P=0.047) were lower than those in the observation group. One month after surgery, levels of prolactin, human growth hormone, adrenocorticotropic hormone, and thyroid-stimulating hormone were higher in the observation group than those in the control group. The quality of life score one month after surgery was higher in the observation group than that in the control group (P<0.0001). In addition, the olfactory function score one month after surgery was lower in the observation group compared to the control group (P<0.0001). The overall incidence of postoperative complications was higher in the control group (P=0.034). There was no statistically significant difference in recurrence rates between the two groups (P=0.102). Multivariate logistic regression analysis identified tumor size (P=0.001, OR=7.227), Knosp classification (P=0.005, OR=0.238), and Ki-67 index (P=0.001, OR=4.969) as independent risk factors for recurrence within two years in patients with pituitary tumors. Conclusion: For patients with pituitary tumors, neuroendoscopic transsphenoidal surgery is more effective than microscopic transsphenoidal surgery in reducing operative time and improving postoperative visual and pituitary function, and therefore, should be promoted in clinical practice.

Keywords: Microscopy, neuroendoscopy, transsphenoidal surgery, pituitary tumor, recurrence, risk factors

Introduction

Pituitary tumors are benign intracranial neoplasms originating from the adenohypophysis, accounting for approximately 10% to 15% of all intracranial solid tumors [1]. Autopsy and imaging studies suggest that their incidence may reach up to 20%, primarily affecting adults between the ages of 20 and 30 years [2]. The pathogenesis of pituitary tumors is complex, involving various genetic, endocrine, and molecular alterations [3]. In 2022, the World Health Organization (WHO) officially renamed pituitary tumors as Pituitary Neuroendocrine Tumors (PitNETs) and reclassified them based on cell lineage differentiation [4, 5]. However, this classification method is relatively complex and is less frequently used in clinical practice.

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Clinically, pituitary tumors are usually classified into non-functioning adenomas and functioning adenomas based on their hormonal activity and the type of hormones secreted. Functioning adenomas produce various clinical manifestations due to abnormal hormone secretion, while the mass effect of the tumor can cause corresponding neurological symptoms [6, 7].

Traditional treatment options for pituitary tumors include medication, surgery, and radiation therapy, aiming to correct hormonal abnormalities, alleviate the mass effect of the tumor, and maximize the protection of surrounding normal tissues [8]. Surgery is the preferred treatment for most pituitary tumors, as it rapidly relieves mass effects and corrects hormonal imbalances [9, 10]. With the advancement of microsurgical and neuroendoscopic techniques, transsphenoidal pituitary tumor resection has become a well-established surgical method and is currently the most commonly used approach for pituitary tumors, with over 95% of these tumors effectively resected through this route [11, 12].

However, surgical treatment still has its limitations. Because pituitary tumors are located in the sellar region adjacent to numerous critical structures, especially the bilateral cavernous sinuses, surgery carries significant risks and difficulties. Complete resection may not be achievable if the tumor invades these areas, potentially leading to postoperative residuals or recurrence [13-15]. Postoperative recurrence may cause the tumor to compress surrounding vital structures again, such as the optic nerve and pituitary gland, leading to symptoms like vision loss, headache, and endocrine dysfunction. This may necessitate reoperation or adjuvant therapy, further complicating treatment and increasing risks [16]. Especially when the tumor invades key anatomical areas such as the cavernous sinuses, the difficulty of surgical resection increases, and the risk of recurrence is higher [17]. Recurrent pituitary tumors often exhibit more aggressive behavior and resistance to treatment, resulting in poorer patient survival and quality of life.

This study is unique in systematically comparing the efficacy of microscopic surgery versus neuroendoscopic surgery in patients with pituitary tumors, particularly in terms of postoperative visual function, pituitary function recovery, and recurrence rates, aiming to provide more scientific evidence for the selection of surgical methods. Furthermore, this study explored the risk factors influencing postoperative recurrence, offering reference for improving patients' postoperative quality of life and long-term prognosis.

Methods and materials

Clinical data

A retrospective analysis was conducted on 164 patients with pituitary tumors who underwent surgical treatment at The First People's Hospital of Xianyang between March 2020 and March 2022. Among them, 71 patients treated between March 2020 and January 2021 underwent microscopic transsphenoidal pituitary tumor resection and were assigned to the control group. The remaining 93 patients, treated between February 2021 and March 2022, underwent neuroendoscopic transsphenoidal pituitary tumor resection and were assigned to the observation group. There were no statistically significant differences in baseline data between the two groups (**Figure 1**). This study was approved by the Medical Ethics Committee of The First People's Hospital of Xianyang.

Inclusion and exclusion criteria

Inclusion criteria: Patients who met the diagnostic criteria for pituitary tumors as outlined in the *Clinical Guidelines for the Treatment of Pituitary Adenomas* [18], with normal coagulation function, complete clinical data, and vision impairment limited to one eye. Additionally, only patients who did not experience cerebrospinal fluid leakage during surgery were included in the study.

Exclusion criteria: Patients with malignant tumors, psychiatric disorders, infectious diseases, a history of intracranial surgery, or those who had participated in other clinical studies were excluded.

Surgical procedures

Control group (microscopic transsphenoidal surgery): (1) Under general anesthesia, patients were placed in a supine position with the head tilted at an angle of 20° to 30°. (2) Under microscopic guidance, an incision was made in the

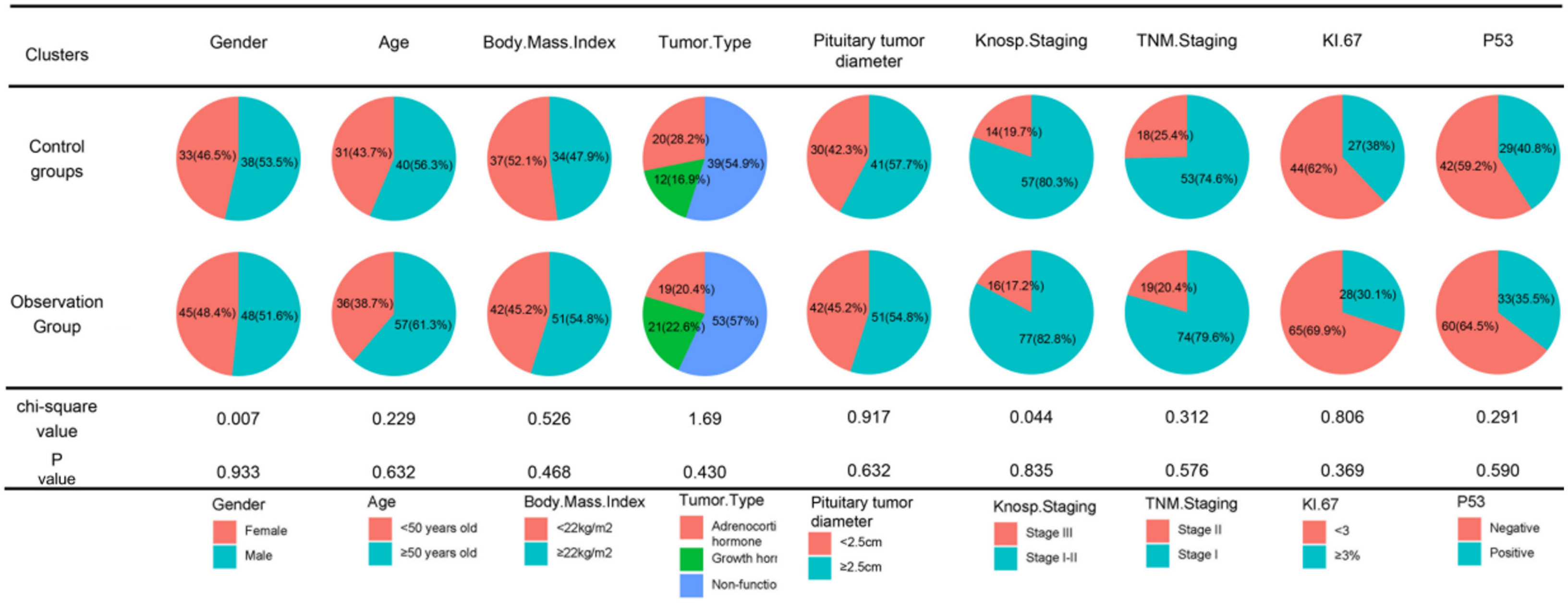

Figure 1. Comparison of baseline characteristics of patients.

nasal cavity along the middle turbinate via one nostril, creating a semicircular cut approximately 1.5 cm from the anterior wall of the sphenoid sinus, and the mucosa was incised. (3) The nasal septal mucosa was separated, and the bony nasal septum near the anterior wall of the sphenoid sinus was fractured, pushing it parallel to the contralateral nasal septal mucosa. (4) A retractor was inserted through the mucosal incision to fully expose the anterior wall of the sphenoid sinus. (5) A high-speed drill, bone rongeur, or bone chisel was used to create an opening approximately 1.5 cm in diameter in the anterior wall of the sphenoid sinus, after which the blades of the nasal retractor were inserted. (6) The position of the sellar floor was confirmed using intraoperative fluoroscopy (C-arm X-ray), and the bone of the sellar floor was expanded to a diameter of 1 cm. (7) After confirming the absence of vascular interference, a cruciate incision was made in the dura mater of the sellar floor. (8) A curette was used to remove the tumor on both sides, as well as the central tumor within the surgical area. (9) After hemostasis, the sellar floor was repaired using fascia lata and adipose tissue, the nasal mucosa was sutured, and the nasal cavity was packed with compression. Routine postoperative anti-infection treatment was performed.

Observation group (neuroendoscopic transsphenoidal surgery): (1) The anesthesia method and patient positioning were the same as those for the control group. Under neuroendoscopic guidance, 0.1% epinephrine-soaked gauze was used to repeatedly fill the sphenoethmoidal recess. (2) Using a 0° endoscope, the opening of the sphenoid sinus was located between the root of the middle turbinate and the nasal septum. The mucosa on the lower wall of the sphenoid sinus ostium was incised and hemostasis was performed. Then, the mucosal flap was reflected over the inferior turbinate to expose the bone of the sphenoid sinus. (3) A high-speed drill was used to open the anterior inferior wall of the sphenoid sinus, forming an opening of 1.5 cm × 1.5 cm. The intersinus septum and mucosa were removed to fully expose the sellar floor and clivus. (4) The bone of the sellar floor was rapidly drilled to create a bone window measuring 1 cm × 1 cm. Bipolar coagulation was used to cauterize the dura mater of the sellar floor, and a cruciate incision was made. Tumor forceps were used to remove the tumor, and a curette was used to sequentially clear the tumor tissue in the inferior, lateral, and superior regions of the sella. (5) A 30° neuroendoscope was introduced to the sellar floor to observe the tumor cavity and directly remove any residual tumor tissue. (6) After hemostasis, the sellar floor bone was reconstructed, the nasal septal mucosa was repositioned, and the nasal cavity was packed with oil gauze. Postoperative anti-infection treatment was administered.

Both groups were monitored until discharge and followed up for 2 years.

Perioperative indicators

Perioperative indicators, including surgical time, blood loss, postoperative hospital stay, and total tumor resection rate, were observed and recorded for both groups.

Changes in vision loss, headache, and sexual dysfunction

Changes in vision loss, headache, and sexual dysfunction within one month post-surgery were observed and recorded in both groups. Improvement in vision loss was defined as an increase in visual acuity at one month post-surgery compared to one week post-surgery, measured using computerized refractometry.

Hormone levels

Fasting venous blood samples (5 mL) were collected from all patients before surgery and one month after surgery. The samples were centrifuged at 3,000 rpm for 15 minutes to collect supernatant, and hormone levels were measured using an automated biochemical analyzer. The hormones tested included prolactin (PRL), human growth hormone (HGH), adrenocorticotropic hormone (ACTH), and thyroid-stimulating hormone (TSH).

Quality of life assessment

Quality of life was assessed in both groups before surgery and one month after surgery using a comprehensive quality of life questionnaire. The scale includes four dimensions: physical function (5 items), psychological function (5 items), social function (5 items), and material life status (4 items), with each item scored from 1 to 5, where higher scores indicate better quality of life [19].

Olfactory function

Olfactory function was assessed in both groups before surgery and one month after surgery using the T&T olfactometry method. The maximum score is 5 points, with higher scores indicating poorer olfactory function [20].

Complications and recurrence

The occurrence of complications during the study period was recorded for both groups, including hypopituitarism, nasal septal perforation, postoperative cerebrospinal fluid leakage, and diabetes insipidus. The total complication rate was calculated as: total number of complications/total number of cases × 100%. Additionally, recurrence was statistically analyzed for both groups after 2 years of follow-up. The recurrence rate was calculated as: number of recurrences/total number of cases × 100%.

Outcome measures

Primary outcome: The recurrence rate within 2 years after surgery was statistically analyzed, and logistic regression analysis was used to identify independent risk factors influencing recurrence.

Secondary outcomes: The perioperative indicators, total tumor resection rate, and improvements in vision loss, headache, and sexual dysfunction were compared between the two groups. Changes in hormone levels, quality of life scores, and olfactory function scores before and one month after surgery were also compared. The incidence of postoperative complications was compared between the groups.

Statistical analysis

Data were analyzed using SPSS 26.0 statistical software. Normally distributed measurement data were expressed as mean ± standard deviation (SD). Between-group comparisons were performed using independent sample t-tests, while within-group comparisons were performed using paired t-tests. One-way analysis of variance (ANOVA) was used for multiple group comparisons, followed by least significant difference (LSD) t-tests for post hoc comparisons. Categorical data were compared using the chi-squared (χ^2) test. Logistic regression analysis was employed to identify independent risk factors influencing recurrence. A *P*-value of <0.05 was considered statistically significant.

Results

Perioperative indicators

A comparison of perioperative indicators revealed no significant difference in surgical time between the two groups (84.63±7.53 vs. 85.00 [76.00, 92.00]; *P*=0.843; **Figure 2A**). However, the control group had significantly higher blood loss compared to the observation group (62.75±4.99 vs. 52.92±4.65; *P*<0.001; **Figure 2B**) and a longer postoperative hospital stay (8.00 [8.00, 9.00] vs. 5.00 [4.00, 6.00]; *P*<0.001; **Figure 2C**).

Comparison of total tumor resection rate and improvements in vision loss, headache, and sexual dysfunction

The total tumor resection rate was significantly lower in the control group than that in the observation group (*P*=0.002). Additionally, fewer patients in the control group experienced improvements in vision loss (*P*=0.013), headache (*P*=0.004), and sexual dysfunction (*P*=0.047) compared to the observation group, with statistically significant differences (**Figure 3**).

Comparison of hormone levels before and one month after surgery

One month after surgery, levels of PRL, HGH, ACTH, and TSH were significantly higher in the observation group compared to the control group. Specifically: PRL: 22.46±1.15 vs. 18.68±2.09; *P*<0.0001 (**Figure 4A**); HGH: 21.13±1.31 vs. 17.06±2.30; *P*<0.0001 (**Figure 4B**); ACTH: 23.13±0.98 vs. 19.85±2.12; *P*<0.0001 (**Figure 4C**); TSH: 17.50 [16.30, 18.20] vs. 14.99±1.25; *P*<0.0001 (**Figure 4D**).

Comparison of quality of life scores and olfactory function before and one month after surgery

One month after surgery, the observation group demonstrated significantly higher scores in social function (22.00 [22.00, 23.00] vs.

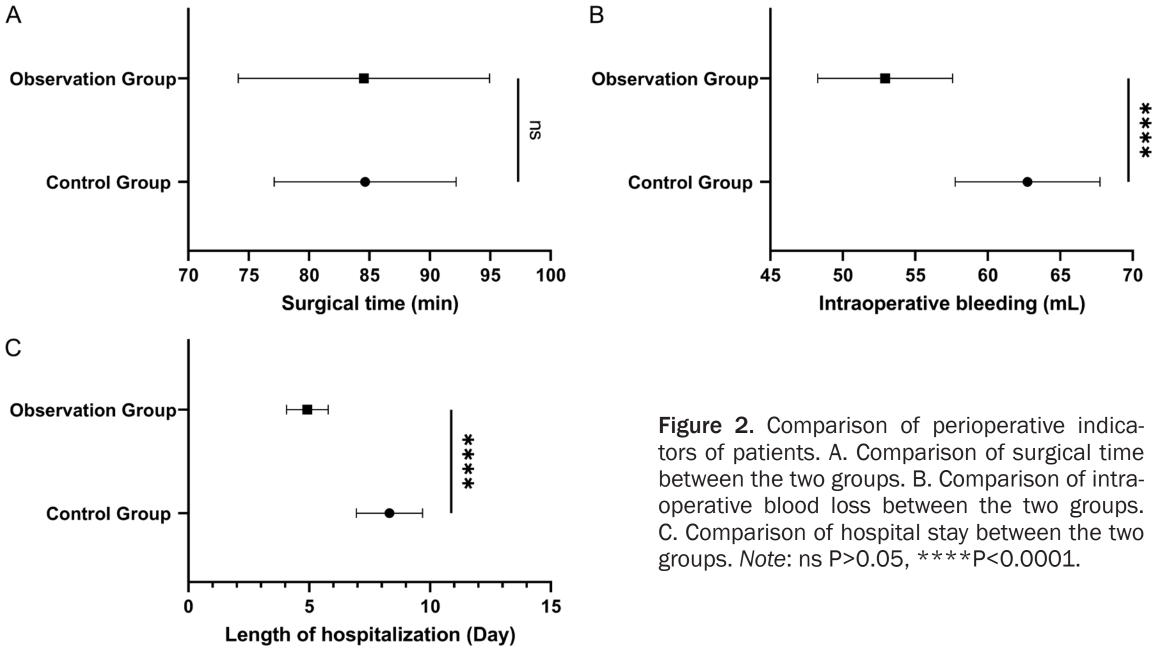

Figure 2. Comparison of perioperative indicators of patients. A. Comparison of surgical time between the two groups. B. Comparison of intraoperative blood loss between the two groups. C. Comparison of hospital stay between the two groups. *Note*: ns P>0.05, ****P<0.0001.

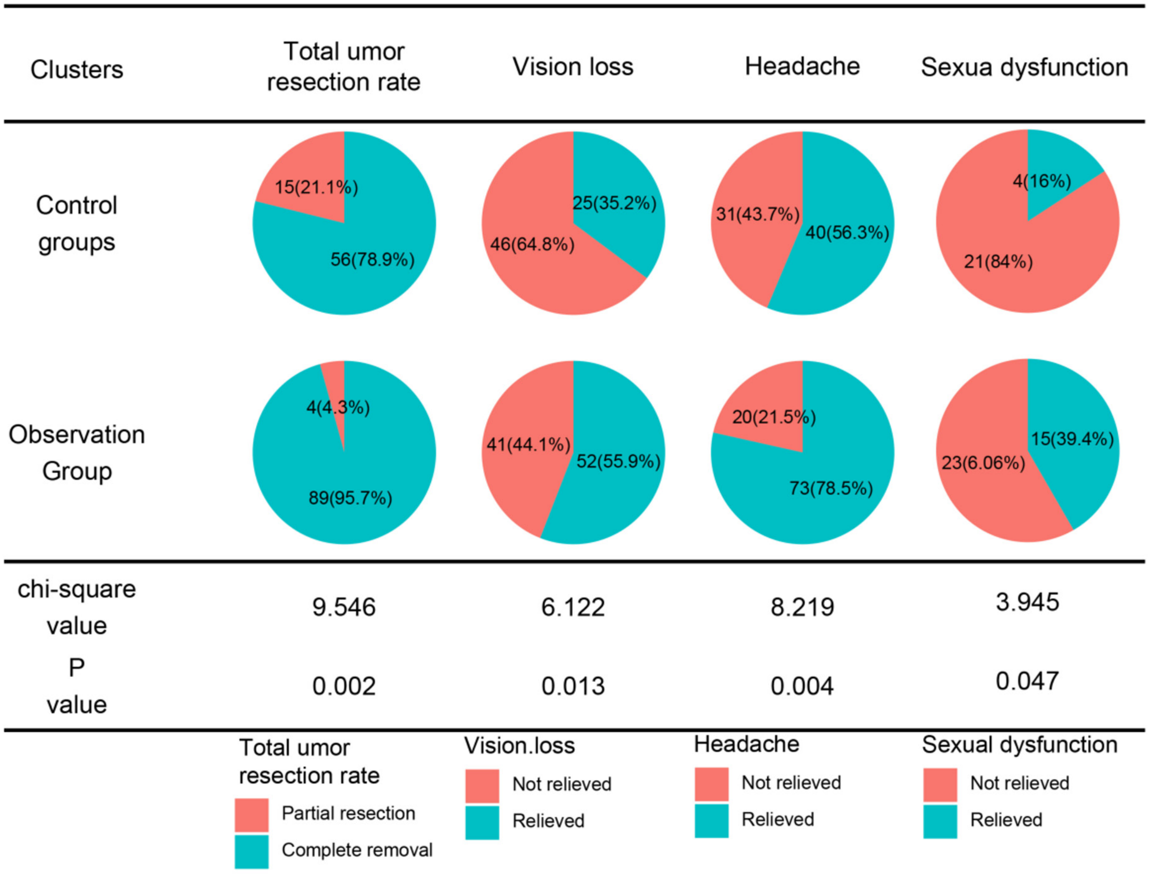

Figure 3. Comparison of total tumor resection rate, improvement in vision loss, headache, and sexual dysfunction in patients.

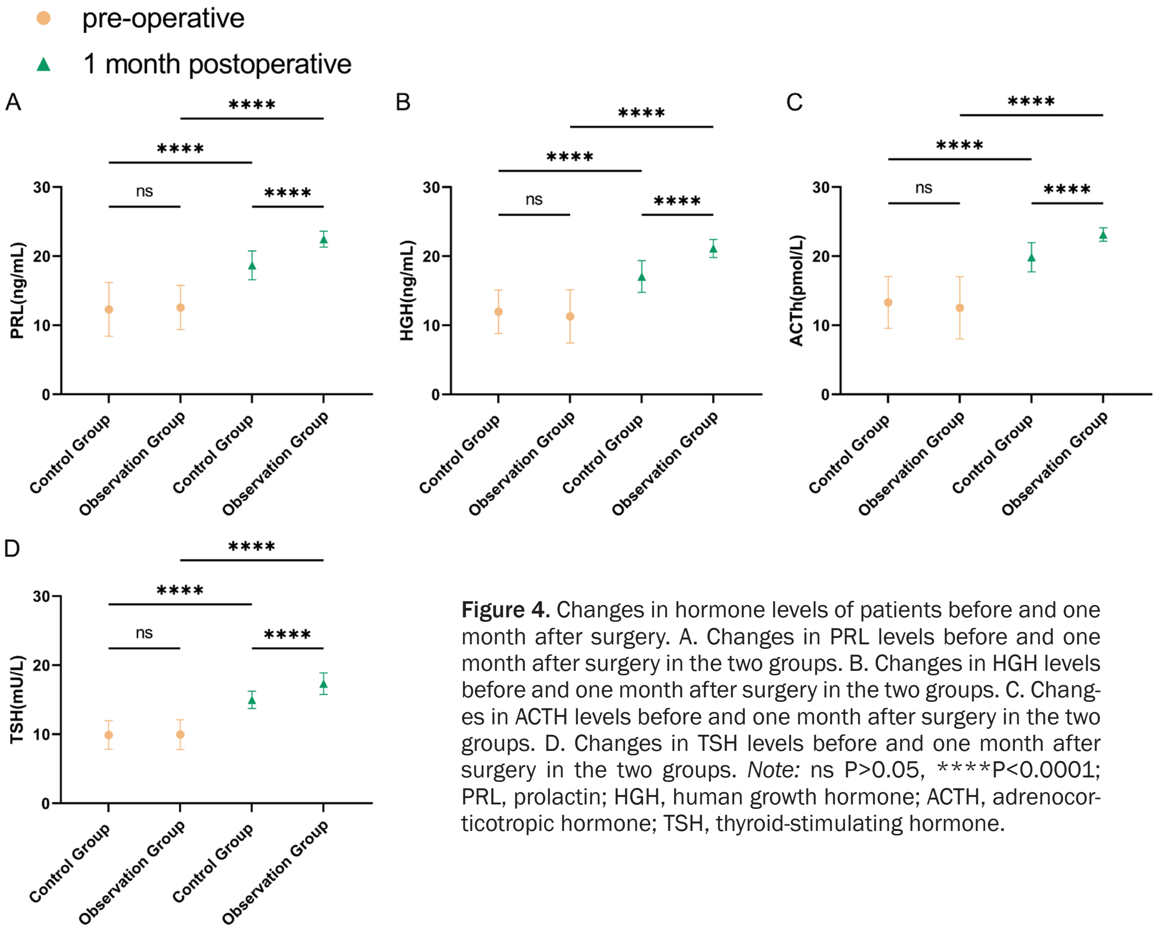

Figure 4. Changes in hormone levels of patients before and one month after surgery. A. Changes in PRL levels before and one month after surgery in the two groups. B. Changes in HGH levels before and one month after surgery in the two groups. C. Changes in ACTH levels before and one month after surgery in the two groups. D. Changes in TSH levels before and one month after surgery in the two groups. *Note:* ns P>0.05, ****P<0.0001; PRL, prolactin; HGH, human growth hormone; ACTH, adrenocorticotropic hormone; TSH, thyroid-stimulating hormone.

18.82±2.41; *P*<0.0001; **Figure 5A**), physical function (21.00 [21.00, 22.00] vs. 18.00 [17.00, 19.00]; *P*<0.0001; **Figure 5B**), psychological function (23.00 [23.00, 24.00] vs. 20.00 [18.00, 21.00]; *P*<0.0001; **Figure 5C**), and material life status (17.00 [16.00, 18.00] vs. 14.00 [13.00, 15.00]; *P*<0.0001; **Figure 5D**) compared to the control group. In addition, the olfactory function score was significantly lower in the observation group than that in the control group (1.00 [1.00, 1.00] vs. 2.00 [2.00, 2.00]; *P*<0.0001; **Figure 5E**), indicating better olfactory function in the observation group.

Postoperative complications

Statistical analysis of postoperative complications revealed no significant differences in the incidence of individual complications between the control and observation groups (*P*>0.05). However, the total incidence of postoperative complications was significantly higher in the control group compared to the observation group (*P*=0.034; **Figure 6**).

Recurrence rate within 2 years and analysis of risk factors

After 2 years of follow-up, 17 patients in the control group experienced recurrence, resulting in a recurrence rate of 23.94%, while 13 patients in the observation group experienced recurrence, with a recurrence rate of 13.98%. There was no statistically significant difference in recurrence rates between the two groups (*P*=0.102).

To identify risk factors affecting recurrence rates, we compared the baseline data and laboratory indicators between patients with and without recurrence. Significant differences were found in tumor size, Knosp classification, Ki-67 index, and total tumor resection rate between the recurrence and non-recurrence groups (**Tables 1** and **2**). Multivariate logistic regression analysis revealed that tumor size (*P*=0.001, OR=7.227), Knosp classification (*P*=0.005, OR=0.238), and Ki-67 index (*P*=0.001, OR=4.969) were independent risk

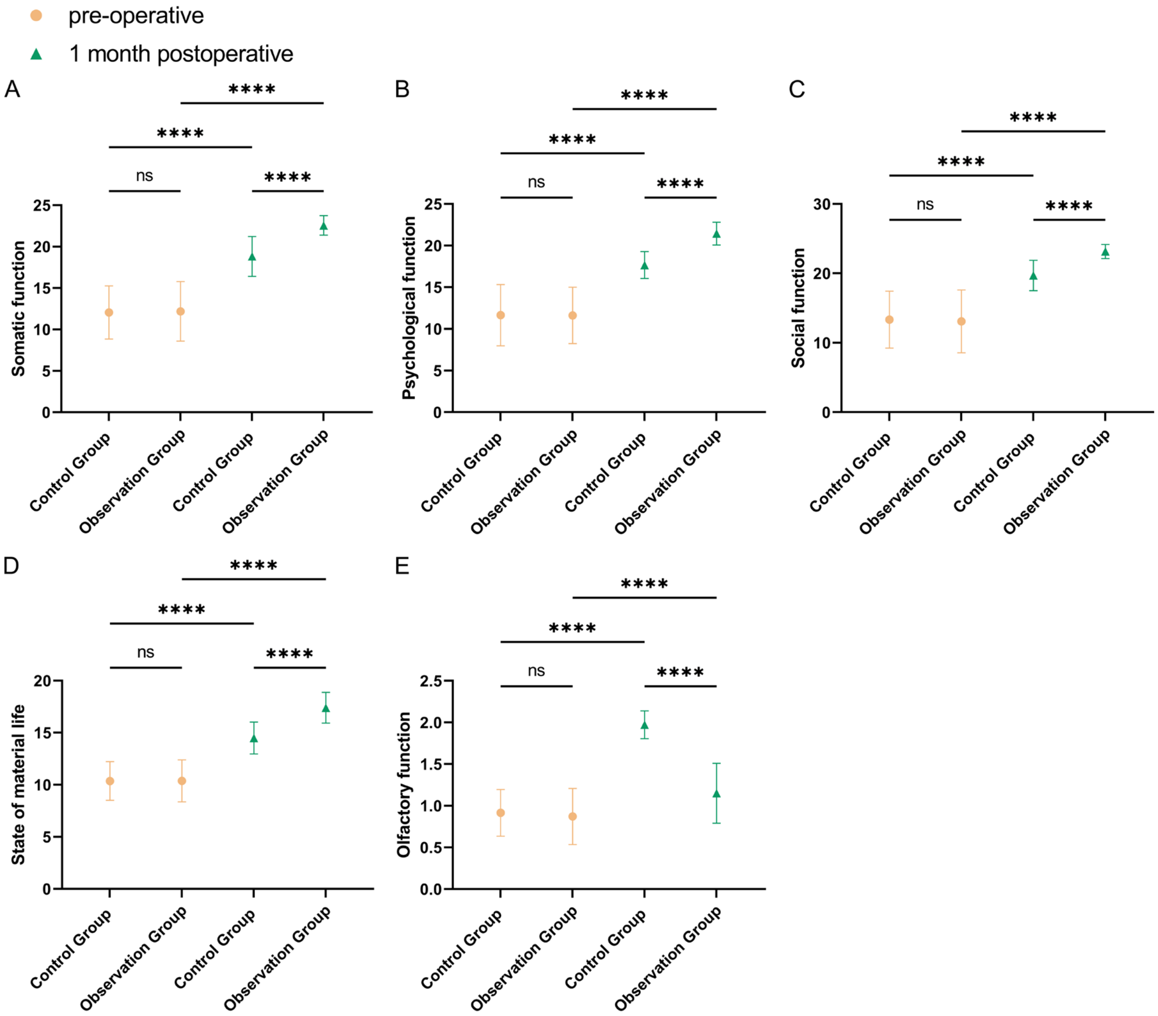

Figure 5. Changes in quality of life scores and olfactory function of patients before and one month after surgery. A. Changes in social function scores before and one month after surgery in the two groups. B. Changes in physical function scores before and one month after surgery in the two groups. C. Changes in psychological function scores before and one month after surgery in the two groups. D. Changes in material life status scores before and one month after surgery in the two groups. E. Changes in olfactory function scores before and one month after surgery in the two groups. *Note*: ns P>0.05, ****P<0.0001.

factors for recurrence within 2 years in patients with pituitary tumors (**Tables 3-5**).

Discussion

Pituitary adenomas are common intracranial tumors characterized by large size and invasiveness [21]. Although transsphenoidal surgery has become the primary treatment method, and endoscopic techniques have become increasingly mature, there is still controversy regarding the choice of surgical method, particularly concerning the impact of microscopic versus endoscopic surgery on postoperative visual function, pituitary function, and recurrence rates [22, 23]. This study found that endoscopic surgery demonstrated better outcomes in improving postoperative visual and pituitary function, and had a lower recurrence rate. These findings provide new evidence for selecting the optimal surgical method.

Our study demonstrated that endoscopic surgery results in less intraoperative blood loss and shorter postoperative hospital stays compared to microscopic surgery, with no significant difference in surgical time between the two methods. Endoscopic surgery offers a broader surgical view, allowing surgeons to operate more precisely, thereby reducing dam-

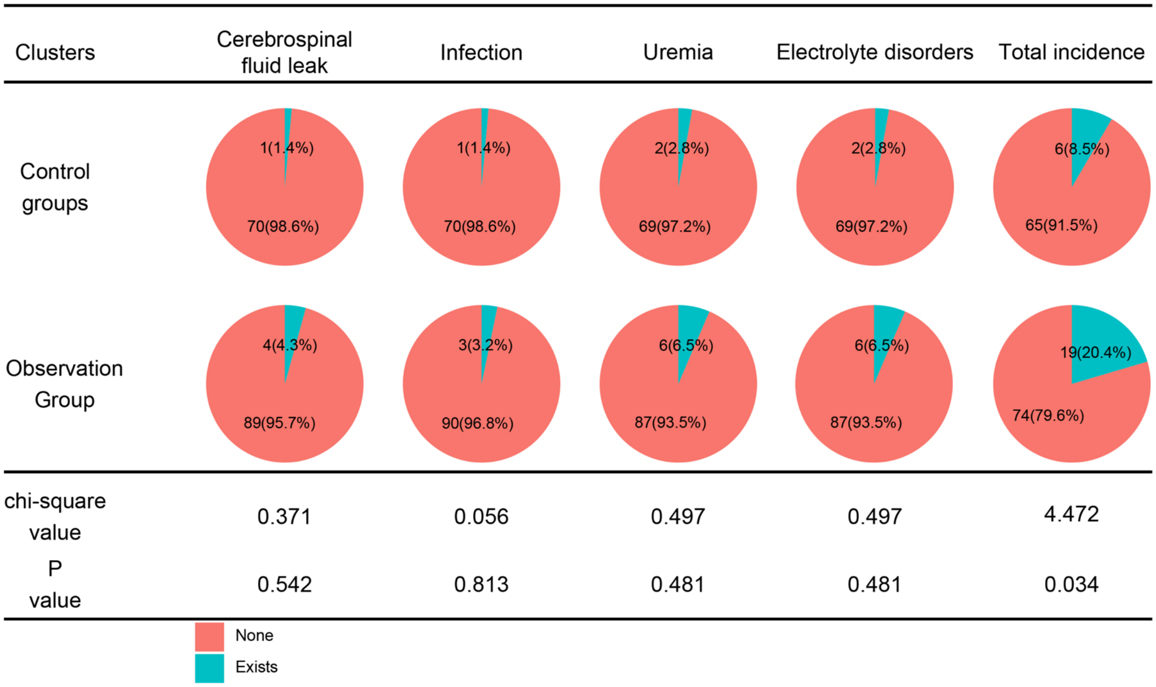

Figure 6. Postoperative complications in patients.

age to blood vessels and surrounding tissues and lowering intraoperative blood loss [24]. The minimally invasive nature of endoscopic surgery leads to less tissue damage, facilitating faster postoperative recovery and reducing complications, which in turn shortens hospital stays [25]. Although microscopic surgery is a more traditional and widely used method, with surgeons potentially being more skilled and efficient in its execution, endoscopic surgery provides superior visualization and minimally invasive advantages. However, it may require additional time for adjusting and operating the endoscopic equipment [26].

Previous studies have reported varying outcomes. Ding et al. [27] found that the endoscopic group had significantly less intraoperative blood loss and shorter postoperative hospital stays than the microscopic group, consistent with our findings. However, they also reported a shorter surgical time for the endoscopic group, which differs from our results. Little et al. [28] analyzed data from seven pituitary tumor centers and found no difference in hospital stays between the endoscopic and microscopic groups. In contrast, Findlay et al. [29] collected data from nine pituitary surgery centers and analyzed 600 pituitary tumor patients, identifying microscopic surgery as an independent risk factor for prolonged postoperative hospital stays. These discrepancies may be attributed to differences in surgical team expertise, standardized surgical procedures, and patient management strategies across centers. Nonetheless, the overall evidence supports the advantage of endoscopic surgery in reducing intraoperative blood loss and shortening hospital stays, while highlighting that surgical time may be influenced by various factors.

The total tumor resection rate is a critical factor in improving postoperative prognosis, as a higher resection rate generally correlates with a lower risk of recurrence and better functional recovery [30]. The improvement in vision, headache, sexual dysfunction, and olfactory function following surgery is linked to relief from tumor compression, recovery of hormone levels, and the degree of tissue damage caused during surgery. Effective alleviation of these symptoms greatly enhances the quality of life in patients [31].

Endoscopic surgery offers a broader field of view and greater precision, allowing for more thorough tumor resection while minimizing damage to surrounding healthy tissues. This contributes to a lower incidence of postopera-

Table 1. Baseline count data in patients with or without recurrence

Factors	Total	Non-recurrence Group (n=134)	Recurrence Group (n=30)	χ^2 Value	*P*-value
Treatment Plan					
Control Group	n=71	54 (40.3%)	17 (56.67%)	2.675	0.102
Observation Group	n=93	80 (59.7%)	13 (43.33%)		
Gender					
Male	n=86	72 (53.73%)	14 (46.67%)	0.491	0.484
Female	n=78	62 (46.27%)	16 (53.33%)		
Age					
≥50 years	n=97	78 (58.21%)	19 (63.33%)	0.266	0.606
<50 years	n=67	56 (41.79%)	11 (36.67%)		
Body Mass Index					
≥22 kg/m^2	n=85	65 (48.51%)	20 (66.67%)	3.238	0.072
<22 kg/m^2	n=79	69 (51.49%)	10 (33.33%)		
Tumor Type					
ACTH-producing	n=39	32 (23.88%)	7 (23.33%)	0.005	0.997
Growth hormone-producing	n=33	27 (20.15%)	6 (20%)		
Non-functioning adenoma	n=92	75 (55.97%)	17 (56.67%)		
Tumor Size					
≥2.5 cm	n=92	66 (49.25%)	26 (86.67%)	13.931	<0.001
<2.5 cm	n=72	68 (50.75%)	4 (13.33%)		
Knosp Staging					
Stage I-II	n=134	117 (87.31%)	17 (56.67%)	15.403	<0.001
Stage III	n=30	17 (12.69%)	13 (43.33%)		
TNM Staging					
Stage I	n=127	107 (79.85%)	20 (66.67%)	2.439	0.118
Stage II	n=37	27 (20.15%)	10 (33.33%)		
Ki-67					
≥3%	n=55	37 (27.61%)	18 (60%)	11.536	<0.001
<3%	n=109	97 (72.39%)	12 (40%)		
P53					
Positive	n=62	53 (39.55%)	9 (30%)	0.951	0.329
Negative	n=102	81 (60.45%)	21 (70%)		
Total Tumor Resection Rate					
Complete Resection	n=145	122 (91.04%)	23 (76.67%)	4.947	0.026
Partial Resection	n=19	12 (8.96%)	7 (23.33%)		
Complications					
Occurred	n=25	20 (14.93%)	5 (16.67%)	0.058	0.81
Did Not Occur	n=139	114 (85.07%)	25 (83.33%)		

tive complications and improved functional recovery [32]. In contrast, the limited view provided by microscopic surgery may leave residual tumors and lead to a higher rate of complications, thereby impeding functional recovery. Additionally, endoscopic surgery's ability to better preserve normal pituitary tissue helps in the recovery of hormone levels, which in turn improves sexual and endocrine functions [33].

Several studies support these findings. Van et al. [34] observed that the total resection rate was significantly lower in the microscopic group than in the endoscopic group, with higher complication rates in the former. Similarly, Liu et al. [35] found that the endoscopic group had a higher total tumor resection rate, greater improvement in postoperative hormone levels, and fewer postoperative complications. Bryl et

Table 2. Baseline measurement data in patients with or without recurrence

Factors	Total	Non-recurrence Group (n=134)	Recurrence Group (n=30)	t/Z Value	*P*-value
Surgical Time (minutes)	84.58±9.24	84.32±9.27	85.73±9.20	0.759	0.452
Intraoperative Blood Loss (mL)	57.18±6.84	56.90±6.68	58.43±7.51	1.033	0.308
Hospital Stay (days)	6.00 [5.00, 8.00]	6.00 [5.00, 8.00]	7.50 [5.00, 8.75]	1.399	0.156
Pre-treatment PRL (ng/mL)	12.45±3.50	12.55±3.50	11.98±3.54	-0.802	0.427
Pre-treatment HGH (ng/mL)	11.58±3.57	11.82±3.58	10.50±3.36	-1.911	0.062
Pre-treatment ACTH (pmol/L)	12.88±4.20	12.89±4.05	12.84±4.92	-0.047	0.963
Pre-treatment TSH (mU/L)	9.93±2.11	9.98±2.05	9.69±2.41	-0.62	0.539

Note: PRL, prolactin; HGH, human growth hormone; ACTH, adrenocorticotropic hormone; TSH, thyroid-stimulating hormone.

Table 3. Univariate logistics regression of factors affecting recurrence

Variable	β Value	SD	*P* Value	OR	Lower	Upper
Treatment Plan	0.661	0.408	0.105	1.937	0.874	4.384
Gender	-0.283	0.405	0.484	0.753	0.337	1.668
Age	0.215	0.417	0.606	1.240	0.554	2.887
Body Mass Index	0.753	0.424	0.076	2.123	0.943	5.049
Tumor Type	0.018	0.243	0.941	1.018	0.638	1.670
Tumor Size	1.902	0.564	0.001	6.697	2.447	23.621
Knosp Staging	-1.661	0.451	0.000	0.190	0.078	0.461
TNM Staging	-0.684	0.443	0.123	0.505	0.215	1.238
Ki-67	1.369	0.420	0.001	3.932	1.745	9.157
P53	-0.423	0.436	0.332	0.655	0.267	1.500
Surgical Time	0.017	0.022	0.449	1.017	0.974	1.063
Intraoperative Blood Loss	0.033	0.030	0.266	1.033	0.975	1.096
Hospital Stay	0.128	0.098	0.191	1.137	0.936	1.379
Total Tumor Resection Rate	-1.130	0.527	0.032	0.323	0.117	0.947
Pre-treatment PRL	-0.047	0.058	0.418	0.954	0.851	1.069
Pre-treatment HGH	-0.109	0.060	0.071	0.897	0.794	1.006
Pre-treatment ACTH	-0.003	0.048	0.958	0.997	0.907	1.097
Pre-treatment TSH	-0.066	0.096	0.491	0.936	0.775	1.130
Complications	0.131	0.547	0.811	1.140	0.353	3.136

Note: PRL, prolactin; HGH, human growth hormone; ACTH, adrenocorticotropic hormone; TSH, thyroid-stimulating hormone.

Table 4. Assignment table

Variable	Assignment
Tumor Size	≥2.5 cm =1, <2.5 cm =0
Knosp Staging	Stage I-II =1, Stage III =0
KI-67	≥3% =1, <3% =0
Tumor total excision rate	Total resection =1, partial resection =0
Recurrence	Relapse =1, No recurrence =0

al. [36] also reported significantly improved quality of life for patients undergoing endoscopic resection of non-functional pituitary adenomas compared to those treated with microscopic surgery. Collectively, these studies demonstrate that endoscopic surgery offers superior clinical outcomes and promotes better overall recovery in patients with pituitary adenomas.

In our 2-year follow-up analysis, no significant difference was observed in postoperative recurrence rates between the two surgical groups, indicating that while endoscopic surgery offers notable short-term advantages in perioperative outcomes and functional recovery, both methods provide comparable long-term tumor control. Further analysis using

Table 5. Multivariate logistics regression analysis of factors affecting recurrence

Variable	β Value	SD	*P* Value	OR	Lower	Upper
Tumor Size	1.978	0.605	0.001	7.227	2.427	27.328
Knosp Staging	-1.434	0.515	0.005	0.238	0.085	0.655
KI-67	1.603	0.483	0.001	4.969	1.972	13.301
Tumor total excision rate	-0.926	0.637	0.146	0.396	0.114	1.440

logistic regression identified tumor size, Knosp staging, and Ki-67 expression levels as independent risk factors for postoperative recurrence. Larger or more aggressive tumors pose greater challenges for complete resection, and even if surgery appears successful, small residuals may go undetected and proliferate over time, increasing the risk of recurrence [37, 38]. Knosp staging, which measures the degree of tumor invasion into the cavernous sinus, further complicates resection. Tumor invasion into these critical areas increases the difficulty of achieving complete removal, and even with the enhanced visualization offered by endoscopic surgery, highly invasive tumors may still leave behind residuals that can lead to recurrence [22, 39]. Ki-67, a marker of tumor cell proliferation, is another important factor; higher Ki-67 expression reflects increased malignancy and rapid postoperative proliferation of residual tumor cells, further elevating the risk of recurrence [40]. These findings underscore the notion that while surgical methods play a role in short-term outcomes, long-term tumor control is primarily influenced by the biological characteristics of the tumor itself, such as size, invasiveness, and proliferative activity. Therefore, tumor characteristics should be a critical consideration in surgical planning, and long-term follow-up is essential for optimal management.

In this study, we found that neuroendoscopic surgery has significant advantages in improving postoperative function and reducing complications in patients with pituitary tumors. However, this study has certain limitations. For example, as a single-center retrospective study, the experience and skill level of the surgical team may affect the generalizability of the results, and there may be some selection bias and information collection bias in patient selection. Additionally, although we conducted a 2-year follow-up, given that some pituitary tumors may recur slowly, this follow-up period may not be sufficient to fully evaluate postoperative recurrence. Furthermore, due to the relatively small sample size of this study, we did not construct a prediction model for postoperative recurrence. Building such a model with limited data could lead to issues like overfitting or unstable predictions, which would compromise the model's reliability. According to the "one-in-ten" rule, our sample size was insufficient to include all potential variables without risking model overfitting, and some critical factors might have been overlooked during factor screening. In the future, we aim to collect more samples to build a stable and robust prediction model. Additionally, the study lacks a randomized controlled design, which may result in uncontrolled confounding factors, such as baseline characteristics and treatment regimens, potentially affecting surgical outcomes and recurrence rates. Multi-center, randomized controlled, long-term follow-up studies are needed to comprehensively validate the effects of different surgical methods on pituitary tumor treatment and provide more broadly applicable evidence.

In summary, for patients with pituitary tumors, neuroendoscopic transsphenoidal surgery offers better outcomes than microscopic transsphenoidal surgery, by shortening surgical time, improving postoperative visual and pituitary function, and is worth promoting in clinical practice.

Disclosure of conflict of interest

None.

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References

[1] Ostrom QT, Price M, Neff C, Cioffi G, Waite KA, Kruchko C and Barnholtz-Sloan JS. CBTRUS statistical report: primary brain and other central nervous system tumors diagnosed in the

United States in 2015-2019. Neuro Oncol 2022; 24 Suppl 5: v1-v95.

[2] Molitch ME. Nonfunctioning pituitary tumors. Handb Clin Neurol 2014; 124: 167-184.

[3] Melmed S, Kaiser UB, Lopes MB, Bertherat J, Syro LV, Raverot G, Reincke M, Johannsson G, Beckers A, Fleseriu M, Giustina A, Wass JAH and Ho KKY. Clinical biology of the pituitary adenoma. Endocr Rev 2022; 43: 1003-1037.

[4] Zhang F, Zhang Q, Zhu J, Yao B, Ma C, Qiao N, He S, Ye Z, Wang Y, Han R, Feng J, Wang Y, Qin Z, Ma Z, Li K, Zhang Y, Tian S, Chen Z, Tan S, Wu Y, Ran P, Wang Y, Ding C and Zhao Y. Integrated proteogenomic characterization across major histological types of pituitary neuroendocrine tumors. Cell Res 2022; 32: 1047-1067.

[5] Kim YS, Ahn S, Lee YS, Jeun SS and Park JS. Clinicopathological analysis of non-functioning pituitary adenomas (PAs) according to the 2022 WHO classification. Pituitary 2024; 27: 665-672.

[6] Erkan B, Barut O, Akbas A, Akpinar E, Akdeniz YS, Tanriverdi O and Gunaldi O. Results of endoscopic surgery in patients with pituitary adenomas: association of tumor classification grades with resection, remission, and complication rates. J Korean Neurosurg Soc 2021; 64: 608-618.

[7] Sathyakumar R and Chacko G. Newer concepts in the classification of pituitary adenomas. Neurol India 2020; 68: S7-S12.

[8] Khan DZ, Hanrahan JG, Baldeweg SE, Dorward NL, Stoyanov D and Marcus HJ. Current and future advances in surgical therapy for pituitary adenoma. Endocr Rev 2023; 44: 947-959.

[9] Assadi M, Nemati R, Shooli H, Rekabpour SJ, Nabipour I, Jafari E, Gholamrezanezhad A, Amini A and Ahmadzadehfar H. An aggressive functioning pituitary adenoma treated with peptide receptor radionuclide therapy. Eur J Nucl Med Mol Imaging 2020; 47: 1015-1016.

[10] Gupta T and Chatterjee A. Modern radiation therapy for pituitary adenoma: review of techniques and outcomes. Neurol India 2020; 68: S113-S122.

[11] Ottenhausen M, Conrad J, Kalasauskas D, Netuka D and Ringel F. Pituitary surgery in germany-findings from the european pituitary adenoma surgery survey. Exp Clin Endocrinol Diabetes 2023; 131: 362-366.

[12] Netuka D, Grotenhuis A, Foroglou N, Zenga F, Froehlich S, Ringel F, Sampron N, Thomas N, Komarc M and Majovsky M. Pituitary adenoma surgery survey: neurosurgical centers and pituitary adenomas. Int J Endocrinol 2022; 2022: 7206713.

[13] Netuka D, Grotenhuis A, Foroglou N, Zenga F, Froehlich S, Ringel F, Sampron N, Thomas N, Komarc M, Kosák M and Májovský M. Endocrinological aspects of pituitary adenoma surgery in Europe. Sci Rep 2022; 12: 6529.

[14] Honda S, Tajima Y, Yoshida Y, Horiguchi K and Iwadate Y. Aneurysm formation after gamma-knife surgery for pituitary adenoma. Acta Neurol Belg 2023; 123: 723-725.

[15] Charleux T, Vendrely V, Huchet A, Trouette R, Ferrière A, Tabarin A, Jecko V, Loiseau H and Dupin C. Management after initial surgery of nonfunctioning pituitary adenoma: surveillance, radiotherapy or surgery? Radiat Oncol 2022; 17: 165.

[16] Lv L, Yin S, Zhou P, Hu Y, Chen C, Ma W, Jiang Y, Wang Z and Jiang S. Clinical and pathologic characteristics predicted the postoperative recurrence and progression of pituitary adenoma: a retrospective study with 10 years follow-up. World Neurosurg 2018; 118: e428-e435.

[17] Raghu ALB, Flower HD, Statham PFX, Brennan PM and Hughes MA. Sellar remodeling after surgery for nonfunctioning pituitary adenoma: intercarotid distance as a predictor of recurrence. J Neurol Surg B Skull Base 2020; 81: 579-584.

[18] Raverot G, Burman P, McCormack A, Heaney A, Petersenn S, Popovic V, Trouillas J and Dekkers OM; European Society of Endocrinology. European society of endocrinology clinical practice guidelines for the management of aggressive pituitary tumours and carcinomas. Eur J Endocrinol 2018; 178: G1-G24.

[19] Fong DYT, Chan BKY, Li S, Wan CH and Kazis LE. Average and individual differences between the 12-item MOS short-form health survey version 2 (SF-12 V.2) and the veterans RAND 12-item health survey (VR-12) in the Chinese population. Health Qual Life Outcomes 2022; 20: 102.

[20] Hosoya K, Komachi T, Maeda Y, Akazawa H, Ogino E, Yoshida A, Okubo K and Miwa T. Evaluation of odor recognition threshold measurement methods in T&T olfactometry: a survey study. Auris Nasus Larynx 2024; 51: 61-68.

[21] Lee CH. Pituitary neuroendocrine tumor: is it benign or malignant? Brain Tumor Res Treat 2023; 11: 173-176.

[22] Chen Y, Cai F, Cao J, Gao F, Lv Y, Tang Y, Zhang A, Yan W, Wang Y, Hu X, Chen S, Dong X, Zhang J and Wu Q. Analysis of related factors of tumor recurrence or progression after transnasal sphenoidal surgical treatment of large and giant pituitary adenomas and establish a nomogram to predict tumor prognosis. Front Endocrinol (Lausanne) 2021; 12: 793337.

[23] Ilie MD, Vasiljevic A, Bertolino P and Raverot G. Biological and therapeutic implications of the tumor microenvironment in pituitary adenomas. Endocr Rev 2023; 44: 297-311.

[24] Bernat AL, Troude P, Priola SM, Elsawy A, Farrash F, Mete O, Ezzat S, Asa SL, De Almeida J, Vescan A, Monteiro E, Almeida JP, Zadeh GM and Gentili F. Endoscopic endonasal pituitary surgery for nonfunctioning pituitary adenomas: long-term outcomes and management of recurrent tumors. World Neurosurg 2021; 146: e341-e350.

[25] Devarajan A, Vasan V, Dullea JT, Zhang JY, Vasa D, Schupper AJ, Nichols N, Ranti D, McCarthy L, Rao M, Sudhir S, Cho L, Rutland JW, Post KD, Bederson J and Shrivastava RK. Clinical and operative risk factors associated with prolonged length of stay after endoscopic pituitary adenoma resection. Neurosurgery 2024; 95: 392-399.

[26] Zaidi HA, Awad AW, Bohl MA, Chapple K, Knecht L, Jahnke H, White WL and Little AS. Comparison of outcomes between a less experienced surgeon using a fully endoscopic technique and a very experienced surgeon using a microscopic transsphenoidal technique for pituitary adenoma. J Neurosurg 2016; 124: 596-604.

[27] Ding ZQ, Zhang SF and Wang QH. Neuroendoscopic and microscopic transsphenoidal approach for resection of nonfunctional pituitary adenomas. World J Clin Cases 2019; 7: 1591-1598.

[28] Little AS, Kelly DF, White WL, Gardner PA, Fernandez-Miranda JC, Chicoine MR, Barkhoudarian G, Chandler JP, Prevedello DM, Liebelt BD, Sfondouris J and Mayberg MR; TRANSSPHER Study Group. Results of a prospective multicenter controlled study comparing surgical outcomes of microscopic versus fully endoscopic transsphenoidal surgery for nonfunctioning pituitary adenomas: the Transsphenoidal Extent of Resection (TRANSSPHER) Study. J Neurosurg 2020; 132: 1043-1053.

[29] Findlay MC, Drexler R, Khan M, Cole KL, Karbe A, Rotermund R, Ricklefs FL, Flitsch J, Smith TR, Kilgallon JL, Honegger J, Nasi-Kordhishti I, Gardner PA, Gersey ZC, Abdallah HM, Jane JA Jr, Marino AC, Knappe UJ, Uksul N, Rzaev JA, Galushko EV, Gormolysova EV, Bervitskiy AV, Schroeder HWS, Eördögh M, Losa M, Mortini P, Gerlach R, Antunes ACM, Couldwell WT, Budohoski KP, Rennert RC, Azab M and Karsy M. A multicenter, propensity score-matched assessment of endoscopic versus microscopic approaches in the management of pituitary adenomas. Neurosurgery 2023; 93: 794-801.

[30] Liu J, Hu P, Zhou H, Wang B, Liu X, Wu F, Li Y, Liu X, Dang L, Tang Y, Li Z, Liu Z and Wei F. Complications and prognosis of primary thoracic and lumbar giant cell tumors treated by total tumor resection. BMC Musculoskelet Disord 2023; 24: 281.

[31] Sagan KP, Andrysiak-Mamos E, Tyburski E, Sagan LM and Syrenicz A. Quality of life and sleep in patients with pituitary adenoma in relation to tumor type and compression of the optic chiasm. J Clin Med 2021; 10: 1879.

[32] Zhang J, Wang Y, Xu X, Gu Y, Huang F and Zhang M. Postoperative complications and quality of life in patients with pituitary adenoma. Gland Surg 2020; 9: 1521-1529.

[33] Zhao M, Li K, Niu H, Zhao Y and Lu C. Perioperative hormone level changes and their clinical implications in patients with pituitary adenoma: a retrospective study of 428 cases at a single center. Front Endocrinol (Lausanne) 2023; 14: 1286020.

[34] Van Gompel JJ, Atkinson JLD, Choby G, Kasperbauer JL, Stokken JK, Janus JR, O'Brien EK, Little JT, Bancos I, Davidge-Pitts CJ, Ramachandran D, Herndon JS, Erickson D and Lanier WL. Pituitary tumor surgery: comparison of endoscopic and microscopic techniques at a single center. Mayo Clin Proc 2021; 96: 2043-2057.

[35] Liu H, Zhou Y, Chen Y, Wang Q, Zhang H and Xu Y. Treatment outcomes of neuroendoscopic and microscopic trans-sphenoidal pituitary adenomectomies and the effects on hormone levels. Minerva Surg 2023; 78: 518-524.

[36] Bryl M, Woźniak J, Dudek K, Czapiga B and Tabakow P. The quality of life after transnasal microsurgical and endoscopic resection of nonfunctioning pituitary adenoma. Adv Clin Exp Med 2020; 29: 921-928.

[37] Lu L, Wan X, Xu Y, Chen J, Shu K and Lei T. Prognostic factors for recurrence in pituitary adenomas: recent progress and future directions. Diagnostics (Basel) 2022; 12: 977.

[38] Zhang X, Yang F and Han N. Recurrence rate and exploration of clinical factors after pituitary adenoma surgery: a systematic review and meta-analysis based on computer artificial intelligence system. Comput Intell Neurosci 2022; 2022: 6002672.

[39] Yuhan L, Zhiqun W, Jihui T and Renlong P. Ki-67 labeling index and Knosp classification of pituitary adenomas. Br J Neurosurg 2024; 38: 393-397.

[40] Li H, Liu Z, Li F, Shi F, Xia Y, Zhou Q and Zeng Q. Preoperatively predicting Ki67 expression in pituitary adenomas using deep segmentation network and radiomics analysis based on multiparameter MRI. Acad Radiol 2024; 31: 617-627.