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## Return to work and factors influencing recovery after endoscopic transsphenoidal surgery for hypothalamic and pituitary tumors

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This study investigated the return-to-work (RTW) rates and associated factors following endoscopic transsphenoidal surgery (eTSS) among patients with pituitary and hypothalamic tumors in Japan. The primary research question aimed to determine the variables affecting early RTW post-surgery. A retrospective analysis was conducted on 44 preoperatively employed patients who underwent eTSS at a single center between April 2018 and January 2025. Clinical data, including demographics, tumor characteristics, comorbidities, and perioperative variables, were extracted from the medical records. The primary outcome was RTW within 3 months of surgery. Statistical analyses were performed using t-tests and Fisher's exact tests. The median time to RTW was 5 weeks, and the RTW rates were 38.6%, 69.5%, and 75.0% at 1, 3, and 6 months, respectively, with an overall RTW rate of 84.1%. Factors such as a prolonged length of hospital stay (LOS), mental disorders, and the absence of prior TSS were significantly linked to delayed RTW at 3 months. Mental disorders also tended to decrease RTW at 6 months. No significant associations were found between adequate hormone replacement and age, sex, tumor type, or endocrinological dysfunction. Patients receiving multidisciplinary support for RTW tended to experience longer recovery periods, possibly reflecting a greater need. In patients undergoing eTSS for pituitary region tumors, a history of mental disorders, prolonged LOS, and no history of prior TSS were key factors associated with delayed RTW. Early identification of these factors may facilitate tailored multidisciplinary RTW support strategies.

**Keywords** Pituitary adenoma, Pituitary neuroendocrine tumor, Craniopharyngioma, Endoscopic transsphenoidal surgery, Return to work, Multidisciplinary support

Hypothalamic and pituitary tumors, including pituitary neuroendocrine tumors (PitNETs) and craniopharyngiomas (CPs), commonly manifest with visual disturbances and endocrinological dysfunction, significantly impacting patients' work or school attendance<sup>1,2</sup>. Endoscopic transsphenoidal surgery (eTSS) performed via a neuroendoscopy through the endonasal approach has become the established surgical technique for these tumors. It provides enhanced visualization and access while being less invasive, thus avoiding brain manipulation<sup>3,4</sup>. Despite potential complications such as cerebrospinal fluid (CSF) leakage, endocrinological dysfunction, and electrolyte imbalance, advancements in endoscopic procedures have resulted in more reliable and minimally invasive procedures. Recent reports indicate favorable outcomes<sup>5,6</sup>.

These tumors commonly impact individuals in the working-age population, which corresponds to the demographic most active in employment. In modern Japan, changes in society and legislation have prolonged the working age, emphasizing the significance of postoperative return to work (RTW) for patients with hypothalamic and pituitary tumors. While prior studies have explored RTW outcomes and influencing factors in patients with cancer and various brain tumors, research specifically focusing on hypothalamic and pituitary tumors is limited<sup>7,8</sup>. In the Netherlands, approximately 40% of patients face work disabilities after being diagnosed and treated for PitNETs and related lesions. This is largely due to prolonged hormone replacement

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therapy, diminished physical and cognitive health-related quality of life, and insufficient support<sup>1</sup>. Additionally, social reintegration programs have been established for brain tumor patients based on these findings; however, similar initiatives are lacking for individuals affected by sellar and suprasellar tumors<sup>9–11</sup>.

Although some data exist regarding postoperative complications, such as hyponatremia, which affect the length of hospital stay (LOS) or readmission rates, and expert opinions from a limited number of pituitary surgeons have addressed the timing of activity resumption, comprehensive evidence regarding work reintegration is insufficient<sup>12,13</sup>. Reports have suggested that patients with pituitary tumors have lower RTW rates than the general population<sup>14</sup>. However, these findings often stem from eras in which microsurgery remains the primary surgical approach; thus, they fail to reflect the current outcomes associated with minimally invasive endoscopic surgery.

There is a lack of data on current employment and RTW rates among patients with hypothalamic and pituitary tumors in the era of endoscopic procedures. Additionally, the impact of early multidisciplinary support on balancing treatment and occupational reintegration and its effect on postoperative RTW outcomes is not well understood.

This study retrospectively analyzed the employment status and RTW outcomes, along with related factors, in patients who underwent eTSS for hypothalamic and pituitary tumors, a recent practice in Japan.

## Methods

### Ethical approval

This retrospective study was approved by the Ethics Committee of the University of Occupational and Environmental Health, Japan (Approval Number: UOEHCRB22-012). The study was conducted in accordance with the principles of the Declaration of Helsinki.

### Study design and patient selection

We conducted a retrospective analysis of patients who underwent eTSS for hypothalamic and pituitary tumors at our institution from April 2018 to January 2025. A total of 135 patients were identified, comprising individuals who underwent extended transsphenoidal approaches and combined transcranial and transnasal procedures. Of these, 52 were verified to have been employed before the surgery. Eight cases were excluded due to insufficient data on RTW, leaving 44 patients for the final analysis. Cases without confirmed employment status or without a job were excluded from the analysis. Informed consent was obtained from all patients through an opt-out procedure.

### Data collection

Clinical data were collected from the medical records. The main outcome was RTW within 3 months post-surgery, defined as resuming the same or a comparable job as before the surgery. The secondary outcomes included RTW within 1 and 6 months post-surgery.

### Variables and outcomes

Potential factors affecting RTW were analyzed, including patient age, sex, pathological diagnosis, history of prior surgery and mental disorders, LOS, presence of preoperative and postoperative endocrinological dysfunction, presence of preoperative and postoperative visual impairment (visual acuity or visual field deficit), surgical procedures, and occurrence of postoperative CSF leakage. Mental disorders were defined as physician-diagnosed conditions documented in the medical record and consistent with Diagnostic and Statistical Manual of Mental Disorders (DSM) criteria, including depression, panic disorder, and delirium. Tumor extension into the hypothalamus was assessed preoperatively and postoperatively using the Puget score on Magnetic resonance image (MRI). Regarding employment, full-time jobs (8 h/day) or part-time jobs, physically demanding or mentally demanding jobs, and night shift requirements were considered. RTW support by a multidisciplinary team was consistently provided from hospitalization to the actual return to work, based on the patient's preferences.

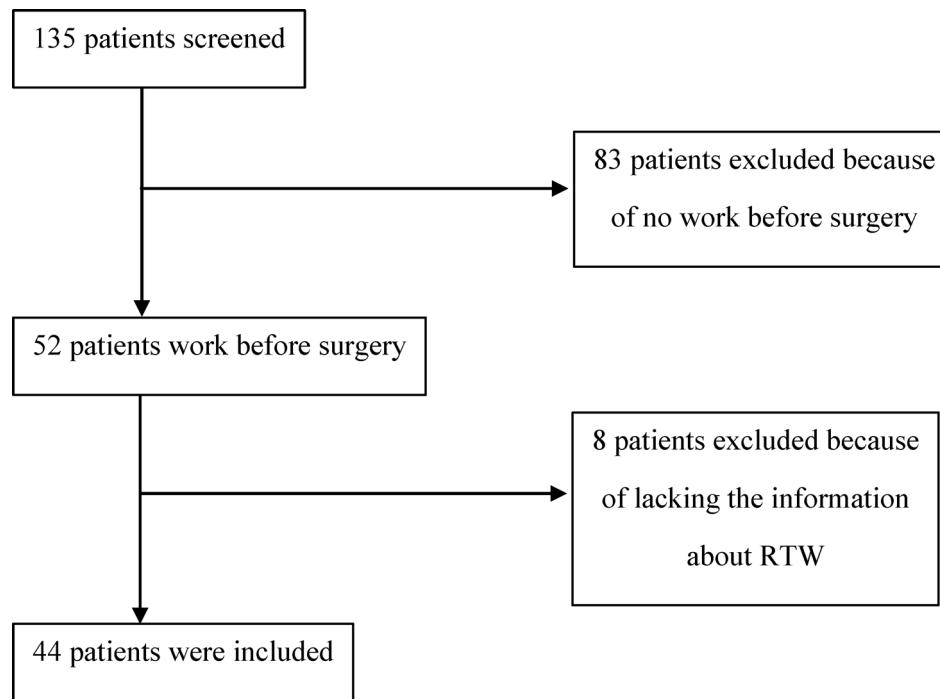
### Statistical analysis

All quantitative data are reported as mean  $\pm$  standard deviation (SD) if normally distributed and as median (interquartile range [IQR]) if not; qualitative data are presented as N (%). Student's t-tests were employed for quantitative data, while Fisher's exact tests were used for qualitative data to assess the associations between the examined factors and patient outcomes. All statistical analysis were univariate; multivariate analysis was not performed due to limited sample size and risk of model overfitting. Statistical significance was defined as  $p < 0.05$ . All statistical analyses were performed using the no-cost statistical software EZR<sup>15</sup>.

## Results

### Patient characteristics

A total of 44 patients were included in the analysis (Fig. 1). Table 1 presents the demographic data and clinical characteristics of the patients who underwent eTSS for hypothalamic and pituitary tumors. The median age was  $53.4 \pm 12.4$  years (range: 24–75), with 17 female and 27 male patients. The distribution of diagnoses included 29 cases (65.9%) of nonfunctioning PitNETs, 5 cases (11.4%) of functioning PitNETs (2 adrenocorticotrophic hormone, 2 growth hormone, and 1 prolactin), 6 cases (13.6%) of CPs, 2 cases (4.5%) of Rathke's cleft cysts, and 2 cases (4.5%) of xanthogranulomas. Pituitary apoplexy was observed in 8 patients (18.2%) at admission. The Puget score, as assessed on preoperative MRI, was 0–1 in 38 cases (86.3%) preoperatively, whereas it was in 37 cases (84.1%) postoperatively; it was 2 in 6 cases (13.6%) and 7 cases (15.9%), respectively. Regarding surgical



**Fig. 1.** Flow chart showing patient selection and exclusion. RTW, return-to-work.

procedures, extended eTSS and/or combined transcranial and transsphenoidal procedures were performed in 8 cases (18.2%), and conventional eTSS was performed in another 36 cases (81.8%). Twelve (27.3%) patients had a history of prior TSSs (revision TSS). Six (13.6%) patients had a history of mental disorders, including two cases each of panic disorder, depression, and severe delirium. All cases required ongoing specialized medical treatment.

Based on the clinical symptoms, visual field disturbance was observed in 21 cases (47.7%) and double vision in 4 cases (9.1%). Preoperatively, endocrinological dysfunction was noted in 21 patients (47.7%), with new-onset postoperative endocrinological dysfunction occurring in 6 patients (13.6%). Diabetes insipidus (DI) was present in 9 patients (20.5%), with 4 cases being transient and improving (9.1%). All patients requiring hormone replacement therapy received appropriate treatment. Postoperative hyponatremia affected 11 cases (25.0%), while postoperative CSF leakage occurred in 3 cases (6.8%). Four patients (9.1%) received radiotherapy post-surgery. The median LOS was 15 days, with an IQR from 11.75 to 21 days.

In terms of employment status, 29 (65.9%) individuals were employed full-time (8 h/day), and 15 (34.1%) were employed part-time. Among all cases, 26 (59.1%) were associated with physically demanding jobs, while the rest were related to mentally demanding roles. Twelve patients (27.3%) needed to work night shifts. The multidisciplinary support team offered RTW support interventions in seven cases (15.9%). In two of these instances, the team provided written opinions to employers as part of the RTW process.

#### RTW-related outcomes

The median time for RTW following surgery was 5 weeks (IQR 2–12). The RTW rate at 3 months, defined as the primary outcome, was 69.5% (29/44). Furthermore, the RTW rates at 1 and 6 months were 38.6% (17/44) and 75.0% (33/44), respectively. RTW status was monitored for up to 67 weeks throughout the observation period, with 84.1% (37/44) of patients returning to work.

When categorized by employment type, RTW rates at 1, 3, and 6 months, as well as overall, were 37.9% (11/29), 69.0% (20/29), 82.8% (24/29), and 89.7% (26/29), respectively, in the full-time group and 40.0% (6/15), 60.0% (9/15), 60.0% (9/15), and 73.3% (11/15), respectively, in the part-time group (Fig. 2). There were no significant differences in the RTW rate between employment types at any time point ( $p=1$ , 0.738, 0.144, and 0.207, respectively). In all instances, the patients returned to the same or equivalent occupational role held before surgery.

At 3 months after surgery, the patients were categorized into two groups: those who had resumed work within 3 months (RTW group) and those who had not (non-RTW group) (Table 2). The RTW group exhibited a significantly shorter LOS compared to the non-RTW group ( $\text{mean} \pm \text{SD}: 15.6 \pm 6.9 \text{ vs. } 30.2 \pm 26.2 \text{ days}, p < 0.01^{**}$ ). Furthermore, the RTW group showed a significantly higher rate of revision TSS (37.9 vs. 6.7%,  $p = 0.035^*$ ). In contrast, the prevalence of mental disorders was significantly lower in the RTW group than in the non-RTW group (0 vs. 40.0%,  $p < 0.01^{**}$ ). The two groups were similar in terms of age, sex, diagnosis, type of surgical procedure, clinical symptoms, and employment status.

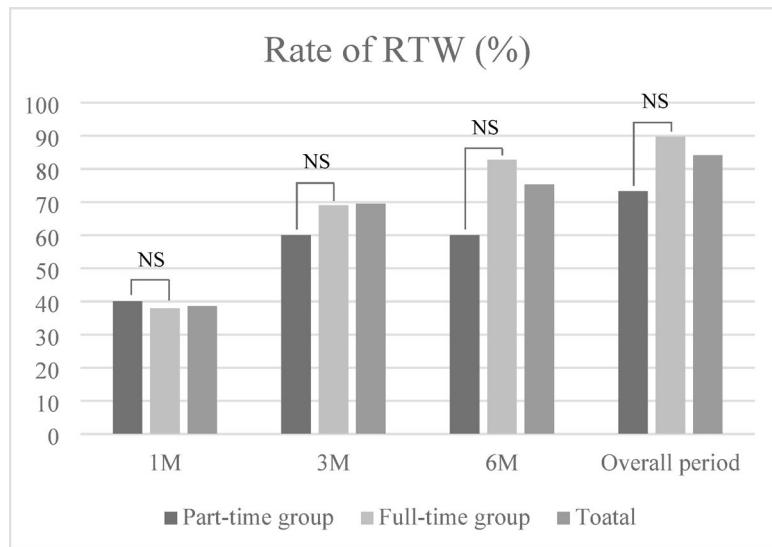
Similarly, when assessing RTW within 1 and 6 months postoperatively, the average LOS for patients who returned to work within 1 month was significantly shorter compared to those who did not ( $12.6 \pm 3.2 \text{ vs. }$

Variable	All patients (N = 44)
Demographics	
Age, years, median [IQR]	55 [19.25]
Female, n (%)	17 (38.6)
Clinical characteristics	
Diagnosis, n (%)	
Non-functional PitNET	29 (65.9)
Functional PitNET	5 (11.4)
CP	6 (13.6)
Rathke's cleft cyst	2 (4.5)
Xanthogranuloma	2 (4.5)
With Pituitary apoplexy	8 (18.2)
Surgical procedure, n (%)	
Conventional eTSS	36 (81.8)
Extend eTSS/combined surgery	8 (18.2)
History, n (%)	
Prior surgery	12 (27.3)
Mental disorder	6 (13.6)
LOS, median [IQR]	15 [9.25]
Clinical symptoms, n (%)	
Visual field disturbance	21 (47.7)
Double vision	4 (9.1)
Endocrinological dysfunction	
Preoperatively	21 (47.7)
Postoperatively (new onset)	6 (13.6)
DI	
Transient	9 (20.5)
Eternal	4 (9.1)
Hyponatremia	11 (25.0)
CSF leakage	3 (6.8)
Puget score 2	
Preoperative	6 (13.6)
Postoperative	7 (15.9)
Employment status	
Full-time job	29 (65.9)
Part-time job	15 (34.1)
Physically demanding job	25 (56.8)
Mentally demanding job	19 (43.2)
Night shift	10 (22.7)
RTW support	7 (15.9)

**Table 1.** Demographic data and clinical characteristics of patients. IQR, interquartile range; PitNET, Pituitary neuroendocrine tumor; CP, craniopharyngioma; eTSS, endoscopic transsphenoidal surgery; LOS, length of hospital stays; DI, diabetes insipidus; CSF, cerebrospinal fluid; RTW, return-to-work.

$24.6 \pm 17.8$  days,  $p = 0.0145^*$ ). In contrast, there was no notable difference in LOS between patients who returned to work within 6 months and those who did not ( $17.8 \pm 12.3$  vs.  $28.7 \pm 27.0$  days,  $p = 0.0721$ ). The prevalence of mental disorders was notably lower in the RTW within the 6-months group compared to the non-RTW group ( $p < 0.01^{**}$ ); however, this difference was not significant in the RTW within the 1-month group ( $p = 0.067$ ). Multidisciplinary support for RTW was more frequently provided to patients with physically demanding jobs ( $p = 0.0306^*$ ). Although no statistically significant variances were observed, multidisciplinary support for RTW was more commonly offered to patients with jobs involving night shifts ( $p = 0.0751$ ).

The mean LOS among the 44 patients was 20.55 days. Patients were divided into two groups based on whether their LOS was longer or shorter than the mean (Table 3). Compared with the shorter LOS group, the longer LOS group showed significantly higher frequencies of craniopharyngioma ( $p = 0.039^*$ ), a high Puget score preoperative and postoperative ( $p = 0.039^*$  and  $0.011^*$ , respectively), a history of mental disorders ( $p = 0.039^*$ ), extended eTSS procedure ( $p = 0.025^*$ ), postoperative hyponatremia ( $p = 0.045^*$ ), postoperative newly endocrine dysfunction ( $p = 0.039^*$ ), and the requirement for hormonal replacement ( $p < 0.01^{**}$ ) in univariate analysis. Due to the limited sample size, multivariate analysis could not be performed.



**Fig. 2.** RTW rate based on employment type. The overall RTW rate gradually increased at all periods of time. There were no significant differences between the full-time job group and the part-time job group.

Variables	RTW	Non-RTW	p value	Variables	RTW	Non-RTW	p value
N	29	15		N	29	15	
Age, years, median [IQR]	51 [21]	60 [15.5]	0.129	Clinical symptoms, N (%)			
Female, N (%)	10 (34.5)	7 (46.7)	0.521	Visual field disturbance	13 (44.8)	8 (53.3)	0.752
Diagnosis, N (%)				Double vision	2 (6.9)	2 (13.3)	0.596
Non-functional PitNET	19	10	1	Endocrinological dysfunction			
Functional PitNET	3	2	1	Preoperatively	13 (44.8)	8 (53.3)	0.752
CP	4	2	1	Postoperatively (new onset)	3 (10.3)	3 (20.0)	0.394
Rathke's cleft cyst	1	1	1	Hormonal replacement	13 (44.8)	8 (53.3)	0.752
Xanthogranuloma	2	0	0.54	DI			
Pituitary apoplexy	4	4	0.414	Transient	7 (24.1)	2 (13.3)	0.695
Surgical procedure, N (%)				Eternal	2 (6.9)	2 (13.3)	0.596
Extended eTSS/Combined surgery	5 (17.2)	3 (20.0)	1	Hyponatremia	5 (17.2)	6 (40.0)	0.144
				CSF leakage	1 (3.4)	2 (13.3)	0.264
Puget score 2, N (%)				LOS, median [IQR]	13 [7]	19 [13.5]	<0.01**
preoperative	2 (6.9)	4 (26.7)	0.159	Employment status, N (%)			
postoperative	3 (10.3)	4 (26.7)	0.207	Full time jobs (8 h/day)	20 (69.0)	9 (60.0)	0.738
History, N (%)				Night shift work	8 (27.6)	2 (13.3)	1
Revision surgery	11 (37.9)	1 (6.7)	0.035*	RTW support	4 (13.8)	3 (20.0)	0.357
Mental disorder	0 (0.0)	6 (40.0)	<0.01**				

**Table 2.** Characteristics of patients and comparisons between those returning to work within 3 months and not returning to work. IQR, interquartile range; PitNET, Pituitary neuroendocrine tumor; CP, craniopharyngioma; eTSS, endoscopic transsphenoidal surgery; LOS, length of hospital stays; DI, diabetes insipidus; CSF, cerebrospinal fluid; RTW, return-to-work.

## Discussion

This study aimed to provide essential data on RTW after eTSS for hypothalamic and pituitary tumors in Japan and to facilitate appropriate RTW for affected patients. A retrospective analysis revealed that the median duration of RTW after surgery was 5 weeks. The RTW rates at 1, 3, and 6 months progressively increased to 38.6%, 69.5%, and 75.0%, respectively. Factors significantly linked to delayed RTW at 3 months included a longer LOS, no prior TSS, and a history of mental disorders. While these factors did not exhibit statistically significant differences beyond 3 months, they tended to reduce the RTW rate at 6 months postoperatively.

Basic data on the RTW rate and time to RTW after eTSS in patients with hypothalamic and pituitary tumors remain unclear. In Germany, experts in pituitary surgery provided recommendations regarding RTW following routine TSS<sup>16</sup>. According to this recommendation, patients are generally advised to resume mentally demanding

Variables	Longer LOS	Shorter LOS	<i>p</i> value	Variables	Longer LOS	Shorter LOS	<i>p</i> value
N	12	32		N	12	32	
Age, years, median [IQR]	55.5 [18]	54 [16]	0.362	Clinical symptoms, N (%)			
Female, N (%)	5 (41.7)	12 (37.5)	1	Visual field disturbance	4 (33.3)	17 (53.1)	0.318
Diagnosis, N (%)				Double vision	2 (16.7)	2 (6.3)	0.297
Non-functional PitNET	4 (33.3)	25 (78.1)	0.105	Endocrinological dysfunction			
Functional PitNET	3 (25.0)	2 (6.3)	0.116	Preoperatively	8 (66.7)	13 (40.6)	0.179
CP	4 (33.3)	2 (6.3)	0.039*	Postoperatively (new onset)	4 (33.3)	2 (6.3)	0.039*
Rathke's cleft cyst	1 (8.3)	1 (3.1)	0.476	Hormonal replacement	11 (91.7)	11 (34.4)	<0.01**
Xanthogranuloma	0 (0.0)	2 (6.3)	0.297	DI			
Pituitary apoplexy	4 (33.3)	4 (12.5)	0.185	Transient	5 (41.7)	4 (12.5)	0.089
Surgical procedure, N (%)				Eternal	3 (25.0)	1 (3.1)	0.056
Extended eTSS/Combined surgery	5 (41.7)	3 (3.1)	0.025*	Hyponatremia	6 (50.0)	5 (15.6)	0.045*
				CSF leakage	2 (16.7)	1 (3.1)	0.176
Puget score 2, N (%)				Employment status, N (%)			
Preoperative	4 (33.3)	2 (6.3)	0.039*	Full time jobs (8 h/day)	7 (58.3)	22 (68.8)	0.722
Postoperative	4 (33.3)	3 (9.4)	0.011*	Night shift work	5 (41.7)	7 (21.9)	0.259
History, N (%)				RTW support	3 (25.0)	4 (12.5)	0.369
Revision surgery	2 (16.7)	10 (31.3)	0.461				
Mental disorder	4 (33.3)	2 (6.3)	0.039*				

**Table 3.** Characteristics of patients and comparisons between those with longer LOS and those with shorter LOS. IQR, interquartile range; PitNET, Pituitary neuroendocrine tumor; CP, craniopharyngioma; eTSS, endoscopic transsphenoidal surgery; LOS, length of hospital stays; DI, diabetes insipidus; CSF, cerebrospinal fluid; RTW, return-to-work.

work after 2 weeks and physically demanding work after 4 weeks. For patients undergoing an extended transsphenoidal approach, the recommended time intervals until RTW are approximately twice as long as 3 weeks for mentally demanding work and 6 weeks for physically demanding work. The authors also stated that these recommendations might vary depending on the patient's postoperative neurological, endocrinological, and ophthalmological status. However, the Actual RTW tends to be delayed beyond these recommendations. Another study from Korea reported that 73.3% of patients RTW within 4 months after surgery; however, 26.7% of patients did not resume work until that time<sup>13</sup>. In this study, 50% of the patients took approximately 1 month to return to their part-time jobs and approximately 2 months to return to their full-time jobs (8 h/day). The median time to RTW was approximately 4 weeks (29 days) in part-time jobs and approximately 9 weeks (65 days) in full-time jobs. Patients with a history of prior surgery (revision surgery group) returned to work earlier than those in the primary surgery group. There were sex differences in RTW for non-physically demanding work, and RTW was more difficult for female patients. Interestingly, more patients than expected independently decided the time to RTW; therefore, the study recommended providing patients with an "appropriate return period" for their activities. A Swedish report compared microsurgery and endoscopy in terms of postoperative RTW rates and sick leave periods<sup>14</sup>. In the report, the overall median duration of sick leave from work was 6 weeks, regardless of the surgical procedure. However, in the endoscopic approach group, 13% of the patients did not resume work permanently. The duration of RTW differed between male and female patients, and the median RTW was 4 and 8 weeks in the male and female groups, respectively. The authors reported that female patients aged 40–49 years had a significantly lower employment rate than the regional average. These results support that female sex may be associated with prolonged sick leave and reduce RTW rates. In a study conducted in the context of chronic pain rehabilitation, male sex was identified as an independent predictor of RTW<sup>17</sup>. In that study, male patients tended to exhibit higher RTW rates, potentially reflecting differences in social roles, occupational flexibility, and financial stability during medical leave. Although this finding was derived from a different clinical population—not patients with hypothalamic or pituitary tumors—it suggests that sex-related factors may influence RTW and should be considered when developing RTW support strategies. However, in our cohort, no significant sex difference was observed, possibly due to the limited sample size.

In the present study, the median time to RTW was 5 weeks (range: 1–67 weeks). This result was equivalent to or shorter than that reported in previous studies, whereas some groups required more time to RTW in which the mean time of 11.3 weeks. The RTW rates at 1, 3, and 6 months gradually increased to 38.6%, 69.5%, and 75%, respectively, with an overall rate of 84.1%. These findings suggest that both the time to RTW and RTW rates vary across studies, potentially reflecting differences in national social security systems, such as Japan's Universal Health Insurance System. Although it remains difficult to draw definitive conclusions due to variations in social insurance frameworks and cultural contexts across countries, the observed gradual increase in RTW rates over time highlights the importance of ongoing support to facilitate return to work among patients with hypothalamic and pituitary tumors following eTSS.

The factors influencing RTW after eTSS for hypothalamic and pituitary tumors remain uncertain. In this study, history of mental disorders, and prolonged LOS, absence of a history of previous TSS were associated

with RTW within 3 months postoperatively. Although not statistically significant, these factors also tended to influence RTW within 6 months. These associations, derived from univariate analysis, should be interpreted with caution, as limited sample size precluded multivariate analysis to control for potential confounding variables. Although the exploratory nature of this study should be acknowledged, the findings may warrant further investigation in future research.

Although we observed associations between the history of mental disorders and delayed RTW, this finding may not be specific to patients undergoing eTSS. Mental disorders are a well-established factor in delayed RTW across various surgical populations, and mechanisms may include anxiety regarding recurrence, altered recovery expectations<sup>18,19</sup>. Furthermore, the mental disorders in our study (depression, panic disorder, and severe delirium) were heterogeneous and defined based on physician documentation consistent with DSM criteria. This diagnostic variability should be considered when interpreting these results. Nonetheless, previous studies have indicated that patients with severe anxiety or depressive symptoms may have reduced motivation for RTW<sup>11</sup>. Therefore, proactive employment support may have to be considered for this group of patients.

We also identified prolonged LOS as a factor associated with delayed RTW. Major reasons for prolonged hospitalization included CP pathology, a high Puget score, history of mental disorders, extended eTSS procedures, postoperative hyponatremia, postoperative newly endocrine dysfunctions, and the requirement for hormonal replacement—all of which may delay discharge readiness and prolong the recovery period. Notably, the postoperative Puget score appeared to have a stronger association with prolonged LOS compared to the preoperative score. However, these findings are also based solely on univariate analyses due to the limited sample size and should therefore be interpreted with caution. Previous study has shown that patient education and early mobilization programs can reduce LOS and facilitate smoother transitions. In addition, according to reports from Korea, expanded surgical approaches have been associated with longer durations before returning to work<sup>13</sup>. In our study, although expansion surgery appeared to be associated with prolonged hospitalization, no direct impact on RTW was observed. This discrepancy may be attributable to the limited sample size, and further studies with larger patient cohorts are warranted to clarify the effects of surgical approach on RTW outcomes.

The higher RTW rate noted among patients who underwent revision surgery may be attributed to a better understanding of the disease and its postoperative progression. This is consistent with a previous report showing that the RTW time in patients who underwent primary surgery for the hypothalamus and pituitary was longer than that in patients who underwent revision surgery<sup>13</sup>. Therefore, it is crucial to provide RTW assistance tailored to patients with risk factors that impede RTW. In this study, no significant disparity in the RTW duration was evident between patients who received RTW assistance and those who did not; however, the time to RTW tended to be longer in the supported group. This tendency could be due to the more frequent provision of RTW assistance to patients anticipated to encounter challenges in resuming work. A previous study emphasized the importance of establishing and improving RTW support systems that take into account the variability in RTW timing and the influence of individual factors, particularly for small- and medium-sized companies<sup>10</sup>. Building this perspective, proactive RTW support interventions during hospitalization may be especially beneficial for patients at increased risk of delayed RTW, such as those undergoing initial surgery, individuals with a history of mental health conditions, or those with an extended LOS. Moreover, early support may facilitate a smoother transition to workplace-based RTW programs after discharge, thereby enhancing the overall effectiveness of reintegration efforts.

This study has several limitations. First, it was a single-center retrospective analysis, which may limit generalizability of findings. Second, of the 135 surgical cases, only 44 patients were included in this study due to their employment status and availability of RTW data. This selection raises the possibility of selection bias, as these individuals may not be representative in term of tumor burden, job demands, or recovery trajectories. The small sample size reduced statistical power and prevented the use of multivariate analysis to control confounding. All associations are based on univariate findings and should be interpreted cautiously. Third, the small sample size reduced statistical power and prevented the use of multivariate analysis to control for potential confounders. All associations reported are base on univariate analysis and should therefore be interrupted with caution. Fourth, we did not assess work-related outcomes such as absenteeism or presenteeism, which are important indicators of work quality. Finally, the study relied on data extracted from medical records, which may have introduced information bias due to variability in documentation. Given the potential influence of hypothalamic dysfunction on cognition, behavior, and volition, this omission represents a significant limitation that future studies should address.

In conclusion, this study identified the absence of prior TSS, a history of mental disorders, and prolonged LOS as factors potentially delaying RTW after eTSS for hypothalamic and pituitary tumors. Despite the study's limitations, our findings underscore the need for tailored RTW support, particularly in patients with known risk factors. Further multicenter studies with larger samples and structured assessments of hypothalamic and psychosocial function are warranted.

## Data availability

The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

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## Author contributions

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## Declarations

### Competing interests

The authors declare no competing interests.

### Additional information

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