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REVIEW

Surgical management of pineal region tumors in Italy: a SINch (SINch®) National Survey with systematic review

Francesca Vitulli[1] · Flavio Giordano[2,3] · Teresa Somma[4] · Pier Paolo Panciani[5] · Giuseppe Lombardi[6] · Luca Denaro[7] · Giuseppe Cinalli[1] · Luigi Maria Cavallo[4] · Tamara Ius[7] · Joint collaborative task force

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Abstract
The management of pineal gland tumors poses unique surgical challenges, with varying approaches and outcomes across centers. The existing data on surgical strategies for these tumors are limited, with conflicting information regarding treatment protocols and complications. This survey aimed to explore the current practices in the surgical management of pineal gland tumors in Italy, comparing national trends with literature. A comprehensive survey addressing treatment options, surgical techniques, and management protocols was developed on behalf of SINch® (Società Italiana di Neurochirurgia) and distributed to all Chiefs of Neurosurgical Departments across Italy, from March 2024 to March 2025. A literature review was conducted for studies published between January 2000 and July 2025 following PRISMA guidelines. A total of 67 Italian neurosurgeons participated in the national survey. Most respondents had worked in academic (53.7%) or public hospitals (41.8%). Microsurgery was universally available (100%), whereas endoscopic and stereotactic approaches were offered in 85.1% and 76.1% of centers, respectively. Hydrocephalus was treated preoperatively in 77.6% of patients, mostly via endoscopic third ventriculostomy (68.7%). The supracerebellar infratentorial route was the preferred surgical approach (68.7%), with semisitting and park-bench positions most commonly used. The literature review identified 36 studies (1744 patients). The supracerebellar infratentorial approach was most commonly employed, followed by the occipital interhemispheric transtentorial and other interhemispheric approaches. Hydrocephalus is present in more than 75% of patients, managed predominantly with endoscopic third ventriculostomy or ventriculoperitoneal shunts. The follow-up protocols varied, with early postoperative imaging within 48–72 hours and subsequent MRI at 3–12-month intervals. This study provides the first overview of surgical management trends in Italy. The heterogeneous treatment practices emphasize the lack of standardized guidelines, with a growing need for a more integrated and multidisciplinary approach. Future prospective studies are essential to further refine surgical management strategies.

Keywords Endoscopic approach · Krause · Poppen · Blood markers · Radiotherapy · Chemotherapy · Immunotherapy

✉ Francesca Vitulli
vitullifrancesca@gmail.com

1 Neurosurgery Unit, Department of Neurosciences, Santobono-Pausilipon Children's Hospital, AORN, Naples, Italy

2 Functional Neurosurgery and Epilepsy Surgery, Meyer Children's Hospital IRCCS, Florence, Italy

3 Department NEUROFARBA – University of Florence, Florence, Italy

4 Department of Neurosciences and Reproductive and Dental Sciences, Division of Neurosurgery, "Federico II" University of Naples, Via S. Pansini, Naples, Italy

5 Division of Neurosurgery, Department of Medical and Surgical Specialties, Radiological Sciences and Public Health, University of Brescia, Piazza Spedali Civili 1, Brescia, Italy

6 Medical Oncology 1, Veneto Institute of Oncology IOV-IRCCS, Via Gattamelata, Padua, Italy

7 Academic Neurosurgery, Department of Neurosciences, University of Padova, Padova, Italy

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Introduction

Pineal tumors (PTs) are rare central nervous system neoplasms, accounting for less than 1% of all primary central nervous system tumors, for which standardized, evidence-based treatment guidelines remain undefined.

PTs encompass a wide group of entities, including primary pineal parenchymal tumors, germ cell tumors (GCTs), and lesions arising from neighboring structures such as choroid plexus tumors, meningiomas, and gliomas. Less commonly, lymphomas, atypical teratoid/rhabdoid tumors (ATRTs), and metastatic tumors may involve this site. Among these tumors, pineal parenchymal tumors and GCTs collectively represent more than 70% of all pineal region neoplasms [1–12].

These tumors exhibit considerable heterogeneity in their biological behavior, clinical presentation, and prognosis, necessitating a broad spectrum of therapeutic approaches, ranging from surgical resection alone to aggressive multimodal regimens that may include radiotherapy and chemotherapy [13–16].

A recent international consensus from SNO–EANO–EURACAN emphasized the rarity and biological heterogeneity of pineal parenchymal tumors, considering the absence of standardized treatment guidelines and the need for harmonized clinical management strategies [17].

In this clinical context, a national survey has been launched to investigate contemporary surgical and postoperative care approaches for pineal region tumors (PTs) across Italy. Despite the technical progress in neurosurgery and intraoperative neurophysiological monitoring, a definitive consensus on optimal surgical management has yet to be reached. In addition, the predictive criteria for patient outcomes remain poorly defined.

This study aims to review the available evidence and address key challenges in PTs, outlining the current clinical approaches of Italian neurosurgeons in the context of recent literature.

Through this national survey, the ultimate aim is to refine diagnostic, surgical, and postoperative strategies for the management of these rare and heterogeneous tumors.

Materials and methods

Survey study design and targeted population

A survey addressing pineal tumor treatment options was designed by the Coordinators of Neuroncology (T.I.), Pediatric Neurosurgery (F.G.), and the end Neuroendoscopy Section (L.M.C.) of SINch via an online tool (Survey Monkey© Inc., San Mateo, California, USA; https://www.surveymonkey/.com). The SINch members Board gave their approval to the survey, which was subsequently sent via email to all the Chiefs of the Neurosurgical Department, requesting a single referent for each center. The survey remained open from March 1 st, 2024, until March 1 st, 2025. The data were collected anonymously. The survey included 20 queries summarized in Table 1, which explored three domains: (1) demographics and other respondents' characteristics; (2) questions on treatment options; and (3) questions on perioperative and postoperative management. Completion of the entire survey took approximately 8–12 min.

Literature review

An extensive review of published studies was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [18].

Search strategy and data extraction

A specific literature search protocol was developed to collect data from studies reporting comparisons of different surgical approaches for tumors of the pineal region in pediatric and adult populations. For the most comprehensive detection of papers, the search query was built as follows using a combination of medical subject headings (MeSH): "pineal" [MeSH] AND "tumors" [MeSH] and free text terms: "surgery" OR "endoscopic biopsy" OR "Krause" OR "Poppen" OR "SCI" OR "stereotactic biopsy" OR "radiosurgery" OR "postoperative deficits" OR "postoperative mortality" OR "postoperative morbidity" OR "outcome".

We included studies published from January 2000 to July 2025.

Case reports, review articles, meta-analyses, abstracts, reports of aggregated data and reports on multimodal therapy where surgery was not the primary treatment were excluded. In addition, the exclusion criteria included languages other than English, noncomparative studies, and nonreported quantitative data.

Two authors, V.F. and T.I., independently reviewed the paper titles and abstracts and removed duplicates. In the second review phase, they assessed papers for inclusion on the basis of specific criteria. The references of these papers were also checked (forward search) for any missed papers. The data extracted included patient demographics, clinical presentation (hydrocephalus), surgical approach (type of approach, surgical position), hydrocephalus treatment (VP shunt, ETV, EVD) and follow-up.

The investigation followed a prespecified protocol registered on PROSPERO (CRD420251159334).

Table 1 Results of the Italian survey

Query	Answer	Number	%
Indicate the type of hospital that you work for	Academic Hospital	36	53,7%
	Public Hospital	28	41,8%
	Privat Hospital	3	4,5%
Indicate your current working position	Chief	22	32,8%
	Full-time Professor	3	4,5%
	Associate Professor	8	11,9%
	Hospital Clinician	28	41,8%
	Senior Researcher	6	9,0%
What is your level of experience in the surgical management of pineal tumors?	<10 yrs	55	82,1%
	10–15 yrs	12	17,9%
	>15 yrs	1	1,5%
What is your age group?	30–35	5	7,5%
	35–45	25	37,3%
	46–55	21	31,3%
	>55	16	23,9%
Gender	Male	57	85,1%
	Female	10	14,9%
In which region do you work?	North Italy	34	50,7%
	Centre Italy	19	28,4%
	South Italy	14	20,9%
How many beds does your hospital have	<200	5	7,5%
	200–500	15	22,4%
	500–1000	27	40,3%
	>1000	10	14,9%
How many patients diagnosed with pineal tumor are treated on average each year at your center?	1–2	28	41,8%
	3–5	26	38,8%
	6–10	11	16,4%
	>10	2	3,0%
What is your primary patient population?	Adult	51	76,1%
	Pediatric	7	10,4%
	Both	9	13,4%
What treatments are currently available in your Centre? (multiple choice available)	Endoscopic surgery	57	85,1%
	Microsurgery	67	100,0%
	Stereotactic surgery	51	76,1%
Select the intraoperative tools available in your Department (multiple choice available)	Neuronavigation	67	100,0%
	Intraoperative laser	25	37,3%
	Endoscopic equipment	63	94,0%
	Intraoperative ultrasound	53	79,1%
	Exoscope	29	43,3%
	Electrophysiological monitoring/stimulation	66	98,5%
	Intraoperative CT	15	22,4%
	Intraoperative MRI	4	6,0%
Which preoperative diagnostic protocol do you use (multiple choice available)?	MRI standard	67	100,0%
	MRI venography examination	39	58,2%
	Blood markers (AFP, b-HCG, and carcino-embryonic antigen)	64	95,5%
	CT	48	71,6%
	Endocrine assessment	40	59,7%
	Lumbar puncture	31	46,3%

Table 1 (continued)

Query	Answer	Number	%
Is the clinical case usually discussed within the multidisciplinary neurooncological team?	Yes, usually after surgery	20	29,9%
	Yes, usually before surgery	42	62,7%
	Only in exceptional cases	5	7,5%
In case of obstructive hydrocephalus and increased intracranial pressure, when is it treated?	In the same setting	15	22,4%
	Prior to tumor removal surgery	52	77,6%
In case of obstructive hydrocephalus and increased intracranial pressure, what is your treatment of choice?	Endoscopic third ventriculostomy (ETV)	46	68,7%
	External ventricular drainage (EVD)	17	25,4%
	Ventriculoperitoneal (V-P) shunt	4	6,0%
Approach	Subtentorial supracerebellar approach (Krause)	46	68,7%
	Occipital transtentorial approach (Poppen)	3	4,5%
	Occipital interhemispheric transtentorial approach	4	6,0%
	Biopsy only	5	7,5%
	Biopsy and subsequent surgery via supracerebellar route	1	1,5%
	Endoscopic biopsy and subsequent surgery (Krause)	1	1,5%
	Depending on anatomical features	4	6,0%
	Neuroendoscopic transventricular transchoroid fissure approach	3	4,5%
Which position do you prefer?	Lateral	4	6,0%
	Semisitting	24	35,8%
	Park-bench	20	29,9%
	Sitting	7	10,4%
	Supine	12	17,9%
Do you perform early brain images after surgery?	Yes, CT scan	35	52,2%
	Yes, MRI	32	47,8%
Do you perform any postoperative treatment (multiple choice available)?	Radiotherapy	66	98,5%
	Whole spinal cord radiotherapy	18	26,9%
	Chemotherapy	57	85,1%
	Immunotherapy	9	13,4%
What follow-up timing is preferred in your hospital?	1 month	21	31,3%
	3 months	32	47,8%
	6 months	5	7,5%
	12 months	1	1,5%
	Depending on diagnosis	8	11,9%

Statistical analysis

The raw data were entered into Microsoft Excel (version 16.63.1 for Mac). Descriptive analysis was performed by calculating percentages and medians. Statistical analysis was performed via R (version 4.0.2, The R Foundation for Statistical Computing) and RStudio (version 1.2.1335).

This systematic review was intentionally designed as a qualitative synthesis rather than a quantitative meta-analysis.

The studies demonstrated significant variability in patient demographics, tumor classifications, surgical methodologies, and outcome assessments, with the majority lacking conventional effect metrics. Due to the absence of similar quantitative endpoints, reliable execution of pooled analyses, such as forest or funnel plots, was not feasible. To uphold methodological rigor and prevent erroneous estimations, the review was therefore conducted as a qualitative synthesis.

Results: Italian survey

A total of 67 neurosurgeons participated in the national survey on pineal tumor surgical management. The majority (53.7%) work in academic hospitals, 41.8% are employed in public hospitals, and 4.5% are employed in private hospitals. With respect to their professional roles, 32.8% are chiefs, 41.8% are hospital clinicians, 11.9% are associate professors, 9.0% are senior researchers, and 4.5% are full-time professors. The survey involved a total of 179 hospitals. Among them, the majority were AOSSN (Public Hospitals of National Healthcare System) centers (74), of which 23 participated, followed by AOU (University Hospitals) (28, with 20 participants) and IRCCS (Hospital with Research Institute) (14, with 12 participants). In contrast, participation from private hospitals was very limited (2 out of 62), and no responses were obtained from a single military hospital. Notably, some Italian centers host multiple neurosurgical units, which explains why the number of responders exceeded the number of participating institutions. In hospitals hosting more than one neurosurgical unit, each unit operates independently with its own clinical staff and caseload; therefore, responses were collected separately with no risk of patient overlap.

The respondents' age distribution revealed that 37.3% were between 35 and 45 years old, 31.3% were between 46 and 55 years old, 23.9% were over 55 years old, and 7.5% were between 30 and 35 years old. The survey sample was predominantly male (85.1%), with 14.9% female respondents.

In terms of patient caseloads, 41.8% of neurosurgeons treat 1–2 pineal tumor patients per year, 38.8% manage 3–5 cases, 16.4% treat 6–10 cases, and only 3.0% handle more than 10 cases annually. The primary patient population was adults in 76.1% of the centers, pediatric patients in 10.4%, and mixed patients in 13.4%.

The surgical treatments available included microsurgery in 100% of the centers, endoscopic surgery in 85.1%, and stereotactic surgery in 76.1%. Intraoperative tools were widely available: neuronavigation (100%), endoscopic equipment (94.0%), electrophysiological monitoring (98.5%), intraoperative ultrasound (79.1%), exoscopy (43.3%), intraoperative lasers (37.3%), intraoperative CT (22.4%), and intraoperative MRI (6.0%).

Preoperative diagnostic protocols included standard MRI in all patients (100%), blood markers (95.5%), CT (71.6%), endocrine assessment (59.7%), MRI venography (58.2%), and lumbar puncture (46.3%). Multidisciplinary neuro-oncological team discussions were performed before surgery in 62.7% of the cases, after surgery in 29.9%, and only in exceptional cases in 7.5%.

For obstructive hydrocephalus, 77.6% of neurosurgeons treated it before tumor removal, whereas 22.4% performed simultaneous management. Endoscopic third ventriculostomy (68.7%) was the preferred treatment, followed by external ventricular drainage (25.4%) and ventriculoperitoneal shunting (6.0%).

The most employed surgical approach was the supracerebellar infratentorial route (68.7%), with other approaches including occipital transtentorial (4.5%), occipital interhemispheric transtentorial (6.0%), biopsy alone (7.5%), biopsy with subsequent supracerebellar surgery (1.5%), endoscopic biopsy with subsequent supracerebellar surgery (1.5%), the neuroendoscopic transventricular transchoroidal fissure approach (4.5%), and a flexible approach based on anatomical features (6.0%).

The preferred patient position during surgery varied: semi-sitting (35.8%), park bench (29.9%), supine (17.9%), sitting (10.4%), and lateral (6.0%). Early postoperative imaging was performed with CT (52.2%) or MRI (47.8%).

Postoperative treatments included radiotherapy (98.5%), chemotherapy (85.1%), whole-spinal cord radiotherapy (26.9%), and immunotherapy (13.4%). The follow-up timing preferences were 3 months (47.8%), 1 month (31.3%), 6 months (7.5%), 12 months (1.5%), or case-dependent (11.9%).

All the details are summarized in Table 1.

Results: Literature review

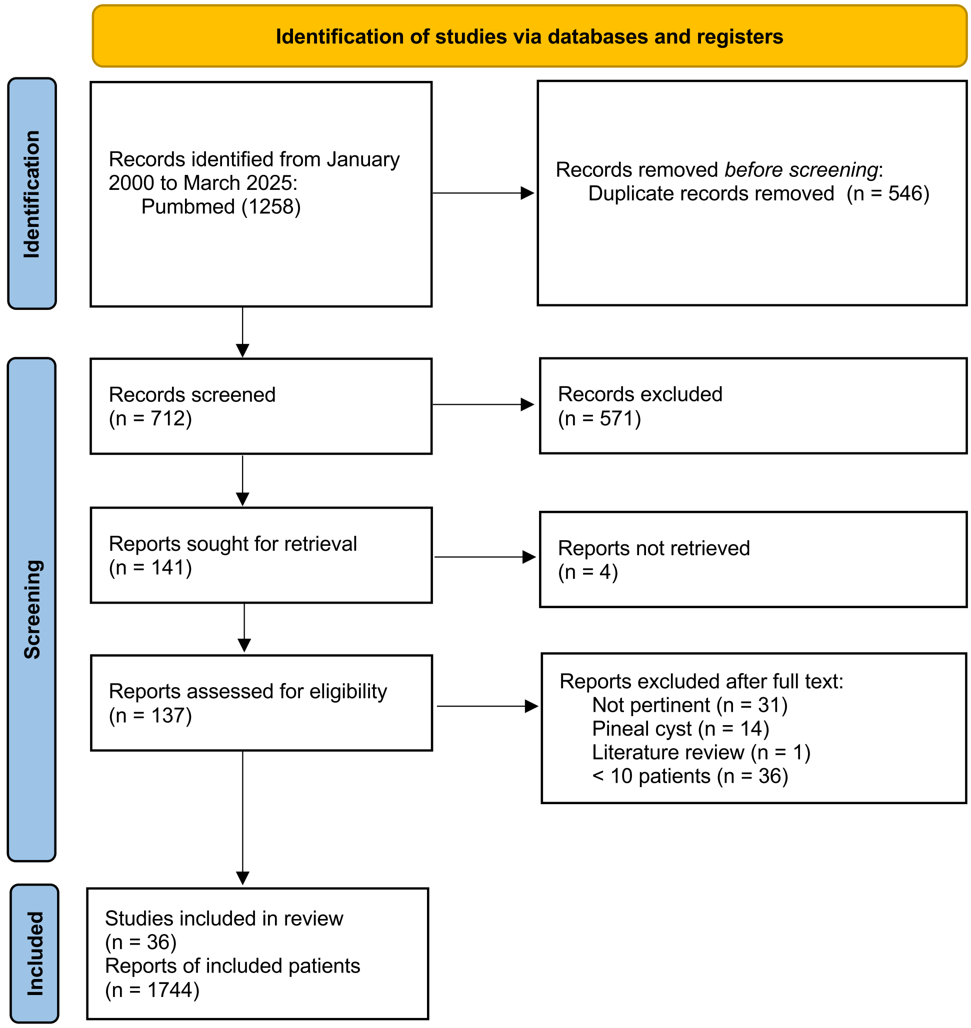
A total of 1258 records were identified from PubMed between 2000 and 2025 (Fig. 1). After 546 duplicate records were removed, 712 articles were screened, with 365 excluded on the basis of the title. Of the 347 articles that were retrieved, 210 were excluded after the abstracts were screened. The full texts of 137 reports were assessed for eligibility, leading to the exclusion of 101 studies for various reasons, including lack of pertinence (n = 31), small case series with fewer than 10 patients (n = 36), only pineal cysts (n = 14), and other reasons (n = 20).

Ultimately, a total of 36 relevant studies encompassing 1744 patients with pineal region tumors were included in this review [19–53]. The publication years ranged from 2000-−2025, with both pediatric (10) and adult (7) or mixed (19) populations represented (Table 2). The median sample size per study was 48.4 patients (range 10–232).

Tumor types

Across the studies, the most frequently reported histologies were germ cell tumors (both germinoma and nongerminomatous variants; reported in 29 studies), pineal parenchymal tumors (pineocytoma, pineoblastoma, and pineal parenchymal tumors of intermediate differentiation; reported in 27 studies), and gliomas (pilocytic astrocytoma, diffuse astrocytoma, glioblastoma; reported in 18 studies). Germinomas are the single most common entity in pediatric populations, whereas pineocytomas and low-grade gliomas are predominant among adult patients. Less common lesions include papillary tumors of the pineal region, meningioma, epidermoid cysts, teratomas,

Fig. 1 PRISMA literature review



and rare entities such as calcifying pseudoneoplasms, cavernous malformations, arachnoid cysts, lipomas, and metastatic tumors from lung and breast primary carcinomas. Several mixed-histology lesions have also been reported, particularly in large multicenter series.

Surgical approaches

The most common approach was the supracerebellar infratentorial (SCI) route (used in 23 studies), which was performed either in a midline or paramedian variant. In most series, SCI was favored for tumors confined to or predominantly in the pineal recess and was often performed in a sitting or semisitting position to optimize venous drainage and minimize cerebellar retraction. The occipital transtentorial (OTA) and occipital interhemispheric transtentorial (OITA) approaches were the second most common (reported in 16 studies), chosen for large tumors with superior extension toward the splenium or posterior third ventricle and for cases where venous anatomy (e.g., a prominent vein of Galen) limited a midline inferior route. Transcallosal interforniceal or transchoroidal approaches (9 studies) were reserved for lesions with significant intraventricular extension, enabling direct access to the posterior third ventricle. Endoscopic-assisted approaches—either purely endoscopic or in combination with a microsurgical corridor—have been increasingly reported in recent years, particularly for biopsy, cyst fenestration, and selection of small or cystic tumors.

Management of Hydrocephalus

Hydrocephalus was present preoperatively in more than 75% of patients across most series, often with symptomatic intracranial hypertension at presentation. The most frequent presurgical cerebrospinal fluid (CSF) diversion procedures were ventriculoperitoneal (VP) shunt placement (25–50% of patients in earlier series), endoscopic third ventriculostomy (ETV) (15–30%, increasingly favored in more recent reports), and external ventricular

Table 2 Literature review

First Author	N°	Population	Diagnosis	Hydrocephalus	Treatment pre surgery	Treatment post surgery	Surgical Treatment	Position during surgery	Follow-up protocol
Abecassis IJ, 2017	50	P&A	Germinoma (10); Pineocytoma (5); Papillary tumor of the pineal region (5); Pineoblastoma (5); Mixed germinoma(5); Pilocytic astrocytoma (4); Pineal parenchymal tumor of intermediate differentation (3); meningioma (3); Mature teratoma (2); Other (8)	42/50	EVD (25); ETV (15); VPS (13); Ventriculoatrial shunt (1)		SCI (16); posterior interhemispheric transsplenial (14); anterior transchoroidal (4); occipital transtentorial (3); combined SCI/OTT; ETV and biopsy (13)		
Aboul-Enein H, 2015	28	P&A	Pineoblastoma (6); germinoma (5); pineocytoma (4); pineal cyst; cavernous malformation; tectal plate glioma (12)				SCI	Prone (25); sitting (2); three quarters prone (1)	
Ahmed M, 2025	32	P&A	Pineal cysts (12); pineocytoma (4); pineal parenchymal tumors of intermediate differentiation (5); metastases (3); pilocytic astrocytoma (2); germinoma; teratoma; epidermoid cyst; meningioma; intracerebral hematoma; calcifying pseudoneoplasm of the neuraxis		2 ETV combined with biopsy		SCI	Semisitting	

Table 2 (continued)

First Author	N°	Population	Diagnosis	Hydrocephalus	Treatment pre surgery	Treatment post surgery	Surgical Treatment	Position during surgery	Follow-up protocol
Behari S, 2011	25	P	Pinealoblastoma (4); nongerminomatous germ cell tumor (3); germinoma (3); pilocytic astrocytoma (2); epidermoid (3); PNET; fibrillary astrocytoma; glioblastoma; teratoma; meningioma		ventriculoperitoneal shunt (8); third ventricle-supracerebellar cisternal shunt (1) and an endoscopic third ventriculostomy (3)		Infratentorial supracerebellar approach (12); occipito-trans-tentorial approach (2); endoscopic biopsy and third ventriculostomy (1); frontal parasagittal craniotomy; interhemispheric transcallosal subchoroidal approach (2); middle temporal gyrus transcortical transventricular approach (1); fronto-temporo-zygomatic combined transylvian and subtemporal approach (1) and right ventriculoperitoneal shunt and stereotactic biopsy (1)		
Bora S, 2024	11	P&A	Papillary Tumors		vp shunt (4); intraoperative external ventricular drain (2)	vp (1); ETV (1)	Krause approach (9); transcallosal interhemispheric approach (1); a transcortical transventricular approach (1)		MRI at 3 months

Table 2 (continued)

First Author	N°	Population	Diagnosis	Hydrocephalus	Treatment pre surgery	Treatment post surgery	Surgical Treatment	Position during surgery	Follow-up protocol
Bozkurt B, 2023	27	A	Pineal parenchymal tumors (13); germinomas (4); anaplastic astrocytomas (2) Glioblastoma; epidermoid cyst; rosette forming glioneuronal; pineal cyst; pleocytic astrocytoma and pineoblastoma consisted of the remaining.	12/27	vp shunt at other institutions (1)	vp shunt (1)	Parietooccipital interhemispheric transtentorial approach	Three-quarter prone position	
Broggi M, 2010	15	A	Pineocytoma		vp shunt at other institutions (2)		Interhemispheric transtentorial retrosplenial approach	Prone position	MRI day 1; and 6 months after surgery
Cai Y, 2021	18	P	germ cell tumors (11); neuroepithelial tumors (4); pineoblastoma; arachnoid cyst; and atypical teratoid rhabdoid tumor	17/18	vp shunt (3)	vp shunt (4)	Supracerebellar infratentorial approach (17); occipital transtentorial approach (1)	Sitting (17); prone (1 infant)	Every 3 months
Cavalheiro S, 2023	151	P	ATRT (5); Pineoblastoma (34); NGGCT (41); Glioma (19); Germinoma (50)	120/151			97 procedures: SCITA (52/97); OTA (24/97); interhemispheric transcallosal transchoroidal (10/97); transcortical transchoroidal approach (10/97); and transventricular endoscopic approach (1/97)	SCI in sitting position; OTA in three-quarters prone position; Interhemispheric transcallosal transchoroidal approach in supine position; Biopsy in dorsal decubitus position with the head elevated to 30°	

Table 2 (continued)

First Author	N°	Population	Diagnosis	Hydrocephalus	Treatment pre surgery	Treatment post surgery	Surgical Treatment	Position during surgery	Follow-up protocol
Choque-Velasquez J, 2019	76	P&A	PPT (3); GCT (12); meningiomas (10); pilocytic astrocytomas (10); diffuse gliomas (6); other (15)	53/76	vp shunt (24); ETV (2)		Supracerebellar infratentorial approach (90%); Occipital interhemispheric approach (10%); Other approaches: combined supratentorial and infratentorial approaches; anterior interhemispheric approach; telovelar approach; subtemporal approach; transcortical approach	Sitting position: 90%; others (supine; park bench): 10%	
Cinalli G, 2022	30	P	Teratoma (5); Germ cell tumor (1); Germinoma (5); pineal cyst (1); ATRT (3); DNT (1); Pnealoblastoma (3); JPA (5); Arachnoid cyst (1); Glioneuronal tumor (2); HGG (2); Pineal anlage tumor (1)	25/30	ETV (19); 5 oh these with EVD; vp shunt at other hospital (5) ETV at other hospital (1)		Occipital interhemispheric transtentorial approach	Prone position	
Cuccia V, 2006	12	P	Pineaoblastoma		vp shunt (11); ETV (3)		OTA (7); endoscopic biopsy		
Davidson L, 2011	27	P	PNET (7); epidermoid cyst (1); fibroconnective tissue (1); pineal cyst (1); ATRT (4); pilocystic astrocitoma (1); LGG (2); Choroid plexus carcinoma (2); DNET (1); germ cell tumor (1); hamartoma (1)				Posterior interhemispheric retrocallosal approach	Lateral decubitus position with the operative side facing down	MRI day 1; and 3 months after surgery

Table 2 (continued)

First Author	N°	Population	Diagnosis	Hydrocephalus	Treatment pre surgery	Treatment post surgery	Surgical Treatment	Position during surgery	Follow-up protocol
Desai KI, 2006	24	P&A	Pineal epidermoid cysts	24/24			Infratentorial-supracerebellar approach (20); interhemispheric posterior parietooccipital route (3);respectively.	supracerebellar approach in sitting position; interhemispheric posterior parietooccipital approach in lateral position	
Fauchon, F, 2013	44	P&A	Papillary tumor	31/44	vp shunt (22); ETV (6)		SCI; transcallosal		
Gener MA, 2015	12	A	Pineoblastoma	11/12			SCI (6); Stereotactic biopsy (3); Stereotactic biopsy + ETV (2); Endoscopic biopsy (1)		
He W, 2024	37	A	Pineal region meningiomas	26/37	ETV + EVD (3); intraoperative Torkildsen shunt (23)	not specified (3)	OTA 15 (40.5%); SIA 11 (29.7%); transcallosal lateral ventricle choroid approach 6 (16.2%); transcortical transventricular approach 5 (13.5%)		
Hernesniemi J, 2008	119	P&A	Germ cell tumors (13); pineal parenchymal tumors; pine- oblastomas (10); pineocytomas (22); pineal cysts (20); glial tumors (26); meningiomas (10); germinomas (11); pineoblastomas (10); anaplastic astrocytomas (3); ependymomas (3); teratoma (2); ganglioneuroblastoma; galenic vein malformations (6); AVMs (2); cavernomas (4)	58/119	VP shunt (27); EVD (5); ETV (2)	VP shunt (8)	SCI (111); OTA (8)	Sitting position	

Table 2 (continued)

First Author	N°	Population	Diagnosis	Hydrocephalus	Treatment pre surgery	Treatment post surgery	Surgical Treatment	Position during surgery	Follow-up protocol
Hu X, 2023	72	P&A	KRAUSE: 15 cases of germinoma (15); teratoma (6); choriocarcinoma; astrocytoma (9); meningioma (3); pineocytoma (9); cholesteatoma (2); cavernous hemangioma; POPPEN: germinoma (4); astrocytoma (3); meningioma; pineocytoma; cavernous hemangioma	34/72	EVD (21); ETV (7); VP shunt (6)		Krause approach (46); Poppen approach (10); Transcallosal-lateral ventricle-choroid fissure approach (16)		MRI 3–6 months after surgery
Hua W, 2023	25	P&A	Pineal gland tumors (8); gliomas (4); germ cell neoplasms (9); ependymomas (2); metastasis (2)	23/25	EVD + Ommaya (17); ETV (2); VP shunt (5)	ETV (2); VP shunt (2)	exoscopic infratentorial approach	"head-up" park bench position	
Jia W, 2011	150	P	Mature teratomas (58); immature teratomas (57); astrocytomas (14); glioblastomas (3); pineoblastomas (4); pineocytomas; (2) choriocarcinomas (4); cavernous hemangiomas (4); germ cell tumors (2); epidermoid cysts (2)		VP shunt (89)		Transcallosal interforniceal approach	Supine with head elevated 20°	
Jinguji S, 2015	17	P&A	Pineal nongerminomatous malignant germ cell tumors		VP shunt (4); ETV (1)	VP shunt (1); ETV (1)	Occipital trans-tentorial approach		
Katyal A, 2021	31	P&A	Pineocytomas (5); pinealoblastomas (3); pilocytic astrocytomas (5); pineal epidermoid (2); tuberculomas (7); anaplastic oligodendrogliomas (3); PNET; ganglioglioma; metastatic small cell carcinoma; pineal parenchymal tumor; meningioma				Occipital trans-tentorial approach	Prone or lateral	

Table 2 (continued)

First Author	N°	Population	Diagnosis	Hydrocephalus	Treatment pre surgery	Treatment post surgery	Surgical Treatment	Position during surgery	Follow-up protocol
Li Y, 2011	10	A	Pineal region meningiomas	9/10	Intraoperative lumbar puncture drainage in all patients	VP shunt (1)	Poppen	Lateral	CT every months and MRI during follow-up period
Mottolese C, 2015	232	P&A	primary parenchymal tumors (54); germ cells tumors (40); pineal gliomas (61); papillary tumors (10); pineal cysts (30)				suboccipital transtentorial approach (201); supracerebellar infratentorial approach (31)	Sitting position	
Oliveira J, 2013	32	P&A	Astrocytoma (6); Pineoblastoma (6); Pineocytoma (3); Teratoma (3); Germinomas (3); Pineal parenchymal tumor of intermediate differentiation (2); Glioblastoma (2); Metastasis (2); Ependymoma; Epidermoid; Cavernoma	10/32	VP shunt (5); ETV (4); EVD (1)		SCI	Semisitting position	1 week; 1 month; and every 6 months
Rosenberg DM, 2019	60	A	Pineal glad tumors				supratentorial approach (13); infratentorial approach (47)	Praying sitting position	
Sai Kiran NA, 2022	33	P&A	Germ cell tumor (4); Pineal parenchymal tumor (5); Glial tumor (15); Epidermoid (7) Meningioma; Pineal cyst	24/33	VP shunt or ETV (24)	VP shunt or ETV (4)	Occipital Interhemispheric Transtentorial Approach	Prone position with head in neutral position	

Table 2 (continued)

First Author	N°	Population	Diagnosis	Hydrocephalus	Treatment pre surgery	Treatment post surgery	Surgical Treatment	Position during surgery	Follow-up protocol
Tamaki N, 2000	36	P&A	Germinoma (24); teratoma (4); pineal cyst (3); embryonal carcinoma; choriocarcinoma; pineocytoma; pineoblastoma; metastasis		VP shunt (22)		occipital transtentorial and parieto-occipital transcallosal in three patients each; and infratentorial supracerebellar and combined infratentorial supracerebellar and occipital transtentorial in one patient each		
Tanrıkulu B, 2020	10	P	Pineal teratoma	10/10	VP shunt (2); ETV (2); consurrent ETV (1)		Occipital transtentorial approach	Prone position with heads 20° tilted to the left side	CT after surgery; MRI day 1
Thaher F, 2014	11	P&A	Pineocytoma (n=3); pineal cysts (n=4); germinoma; lipoma; medulloblastoma; glioblastoma	3/11	ETV (2); EVD (1)	ETV (1)	Endoscopic assisted paramedian infratentorial supracerebellar keyhole approach	Anti-Trendelenburg prone position	48 h MRI
Tomita T, 2023	80	P	GCTs (32) benign gliomas (22); pineal parenchymal tumors (13); ATRT (5); papillary tumor of pineal region (3); medulloblastoma (2); epidermoid (2); thalamic GBM.	74/80	ETV+EVD (9); ETV+biopsy (9); ETV (14); EVD (26); VP shunt (15)		Occipital interhemispheric transtentorial approach (OITA)	Prone position with the head turned approximately 20° in the opposite direction	

Table 2 (continued)

First Author	N°	Population	Diagnosis	Hydrocephalus	Treatment pre surgery	Treatment post surgery	Surgical Treatment	Position during surgery	Follow-up protocol
Tsumanuma I, 2009	93	P&A	Germ cell tumors (44); Pineocytoma (7); PPT of intermediate differentation (6); Pineoblastomas (4); Glial tumors (16); Cavernous angioma (4); Metastasis (2); Lipoma (2); Meningioma (1); Epidermoids (2); Pineal cyst (5)				OTA	Lateral semiprone position	
Xie T, 2022	58	A	Germ cell tumor (8); nongerminoma germ cell tumor (12); glioma (14); Pineal parenchymal tumor (7); meningioma (5) other lesions (12)	36/58	ETV or VP shunt (26)	ETV (4); lamina terminalis fenestration (3)	Endoscopic Midline and Paramedian Supracerebellar Infratentorial Approaches	Left lateral oblique position with the upper body elevated 30°	
Xin C, 2021	41	P&A	Pineal parenchymal tumor (32%); germinomas (17%)	34/41			Supracerebellar-infratentorial approach (39) occipital transtentorial approach (2)	Semisitting position	
Xing H, 2021	15	P	Germinoma (5); Teratoma (5); Astocytoma (2); Meningioma (2); Pineal cell tumor		VP shunt (1)		Transcallosal-lateral ventricle-choroid fissure approach	Supine position with head bracket fixed and head slightly raised approximately 10–15 degrees	

drainage (EVD) (10–20%, mainly as a temporary measure in the acute setting). Several studies have described the combination of ETV and tumor biopsy in the same endoscopic session as a safe and efficient strategy. Postoperative CSF diversion was required in 10–30% of patients, with the use of a VP shunt as the preferred permanent method. Pediatric series more frequently reported long-term shunt dependency than did adult cohorts.

Patient positioning

Surgical position varies according to the approach and surgeon preference. The SCI route is usually performed in the sitting or semisitting position, allowing gravity-assisted cerebellar descent but requiring rigorous venous air embolism monitoring. OTA and OITA were performed in the prone, three-quarters prone, or lateral decubitus positions, sometimes with mild head rotation, to optimize the tentorial angle. Transcallosal approaches, often with neuronavigation to minimize callosal incision length, are conducted in the supine position with head elevation. A few reports have described modified park-bench positioning for paramedian SCI to enhance working angles.

Follow-up protocols

Follow-up imaging schedules varied widely. Most series recommend early postoperative MRI within 48–72 hours to assess the extent of resection or verify biopsy targeting, followed by MRI at 3 months and then at 6–12-month intervals depending on histology, adjuvant therapy, and clinical evolution. Pediatric series tend to adopt tighter imaging intervals during the first two years, especially for high-grade or germ cell tumors treated with multimodal therapy. Several high-volume centers reported protocolized surveillance schedules, whereas smaller or retrospective series often documented heterogeneous follow-up strategies.

We recommend early postoperative MRI within 48–72 h to assess EOR/biopsy targeting, then MRI every 3 months for the first 2 years in high-risk histologies (germinoma/NGGCT under multimodal therapy, pineoblastoma, HGG), and every 6–12 months thereafter for up to 5 years. For low-risk entities (pineocytoma, LGG, benign lesions), MRI every 6–12 months for 3–5 years is reasonable; CT is only performed in urgent/unavailable MRI contexts.

Discussion

This investigation aimed to provide a comprehensive overview of the current clinical practices and attitudes of Italian neurosurgeons regarding the management of pineal tumors (PTs), comparing the findings to those in the current literature. To address the variability in study design, sample size, and endpoint analysis, this study utilized a systematic literature review approach to improve recommendations for pineal tumor management.

The survey aimed to evaluate the degree of variability in clinical practice regarding PT management by investigating different key surgical domains of care.

Specifically, the survey focused on assessing potential heterogeneity across national institutions in the following areas: (1) the management of associated hydrocephalus, including both the timing (pre- or post tumor treatment) and the modality of intervention (e.g., endoscopic third ventriculostomy, external ventricular drain, and ventriculoperitoneal shunt); (2) the choice of patient positioning and surgical approach for tumor resection; (3) the case discussion within a multidisciplinary tumor board setting prior to treatment planning; and (4) the strategies employed for patient follow-up, including imaging protocols and clinical monitoring.

By examining these domains, the survey sought to identify patterns, discrepancies, and potential areas for consensus or guideline development in the management of PTs.

Management of tumor-associated hydrocephalus

Progressive hydrocephalus is observed in approximately 70% of patients with pineal region lesions. Addressing hydrocephalus promptly is essential [28, 54] Fig. 2. In recent decades, different treatment options have been proposed for obstructive hydrocephalus, and direct removal of the lesions, endoscopic third ventriculostomy (ETV) plus biopsy, and shunt procedures (ventriculoperitoneal shunting (VPS) and external ventricular drainage (EVD)) are the most frequently performed. However, standard protocols are still not well established [28, 55]. In this survey, most centers (68.7%) stated that ETV (68.7%) was the preferred treatment, followed by EVD (25.4%) and VPS (6.0%). The placement of an a priori ventriculoperitoneal shunt has lost popularity because of the potential risk of peritoneal seeding of malignant cells and shunt dysfunctions. Moreover, many patients may no longer require CSF diversion after lesion removal [28, 35, 56]. EVD is a temporary method for the effective and temporary management of emergent hydrocephalus associated with PTs. Nevertheless, this choice is limited by high infection rates and the significant need for a second surgical procedure [57]. ETV represents a well-validated minimally invasive technique widely used for obstructive hydrocephalus associated with pineal region lesions. Moreover, tumor biopsy associated with ETV, particularly for the diagnosis of germ cell tumors, could avoid surgical resection because of its high degree of radiosensitivity [58]. In addition, the diagnostic accuracies of endoscopic biopsies are approximately 50% and 78.6% [28, 56]. According to recent case series, ETV represents the most appropriate therapeutic strategy for hydrocephalus secondary to PTs, as it has been shown to be as effective as the VPS while avoiding the disadvantages associated with both the VPS and direct lesion removal [59–62]. It is important to note that ETV has a relatively high failure rate during the early phases of the learning curve [61].

ETV is preferred because, in addition to relieving hydrocephalus, it offers the opportunity to perform a biopsy if the tumor protrudes into the posterior part of the third ventricle. The opportunity for simultaneous tumor biopsy is somewhat limited in Italy because steerable endoscopes are not commercially available in Europe because European regulations restrict the use of non-steam-sterilized instruments in neurosurgery. When biopsy is necessary for a

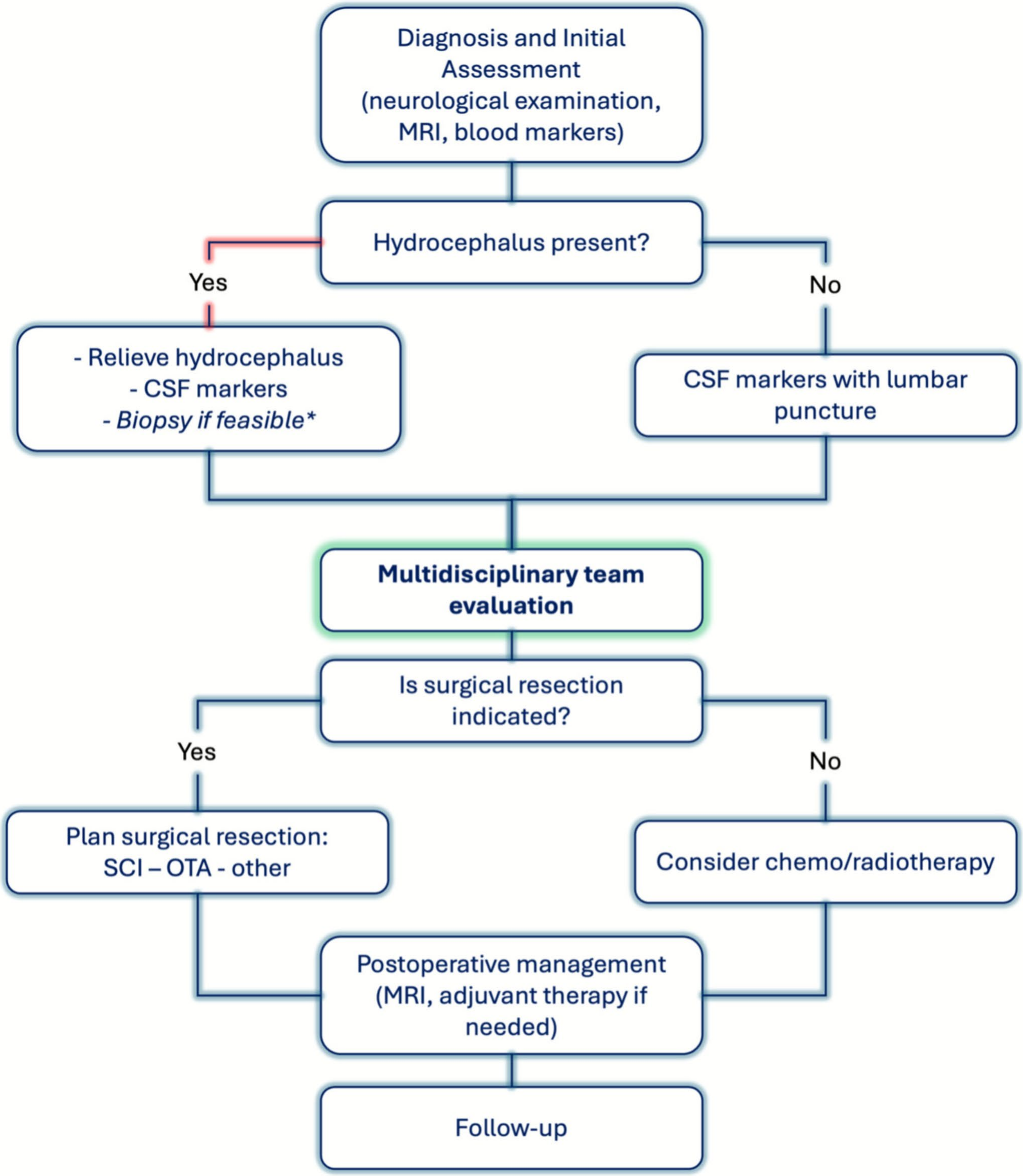


Fig. 2 Clinical decision-making flowchart for the management strategy. The red box highlights the emergency setting, where immediate action is required to relieve hydrocephalus; the asterisk (*) indicates that endoscopic third ventriculostomy (ETV) and endoscopic biopsy may not be available in all centers, especially under emergency conditions. The green box emphasizes the crucial role of multidisciplinary team evaluation, which represents a central step in defining the best therapeutic approach

posteriorly located tumor that is not accessible through the same coronal burr hole as ETV, the double burr-hole technique is necessary, allowing straightforward access to the posterior third ventricle through a more anteriorly located burr hole. ETV is a safe procedure with a very low risk of complications, mostly related to the challenging control of potential bleeding in highly vascularized lesions [63, 64]. Concerning the simultaneous versus staged surgical treatment of hydrocephalus and PT removal, in those patients with obstructive hydrocephalus, 77.6% of neurosurgeons affirmed treating it before tumor removal, whereas 22.4% performed simultaneous management. Different investigations have demonstrated that the direct removal of lesions may be an effective approach for treating hydrocephalus, as in most cases, it leads to resolution of the condition without the need for further intervention following lesion resection [56, 65]. Another case series demonstrated that a considerable proportion of patients required additional cerebrospinal fluid diversion after PT removal. Approximately 2.1% of adult patients and 10%–40% of pediatric patients developed new-onset postoperative hydrocephalus. Therefore, the decision between direct lesion resection and CSF diversion for the treatment of hydrocephalus secondary to PTs remains a matter of clinical debate and warrants further investigation [66].

To optimize the management of preoperative hydrocephalus in patients with PTs, it is also important to consider the incidence and prevalence of various tumor types. Intraoperative frozen-section biopsy is especially critical for patients with suspected germinomas, enabling early and accurate diagnosis, guiding treatment decisions and potentially avoiding more invasive surgeries [28].

Minimally invasive techniques

Minimally invasive techniques, such as endoscopic biopsy or ETV-based approaches, mainly fullfill diagnostic purposes and are particularly valuable for germ cell tumors, where histological confirmation drives multimodal therapy. In contrast, for other histological pineal tumors, GTR is associated with lower and delay recurrence rates, whereas STR carries a higher risk of residual progression, particularly in pineocytomas and low-grade gliomas [67]. Given the anatomical constraints and venous complexity of the pineal region, the pursuit of GTR must be balanced against potential morbidity. For low-grade lesions where STR is unavoidable, close radiological surveillance is recommended, with MRI every 3–6 months during the first two years and annually thereafter for at least five years. Long-term follow-up is essential because late progression of residual tumors has been reported in several series. Overall, minimally invasive techniques should be considered primarily diagnostic modalities or for carefully selected small or cystic lesions, whereas microsurgical resection remains the principal strategy for definitive tumor management when achievable with acceptable surgical risk.

Positioning and surgery

Surgical approaches to the pineal region are mainly classified into infratentorial and supratentorial approaches, with the tentorium as the main anatomical constraint. The infratentorial approach most frequently employed is the supracerebellar route. The suboccipital transtentorial, transcallosal interhemispheric, and transcortical transventricular routes are among the main approaches [68, 69].

The selection of the appropriate intervention is dictated by tumor pathology, growth pattern and its relationship with adjacent neurovascular structures and the tentorial angle, patient age, and the surgeon's preference/experience. Each of these approaches has its own advantages, indications, constraints, and potential complications [27, 29, 70–74]. Table 3.

This national survey revealed that the supracerebellar infratentorial approach was the most commonly employed (68.7% of the respondents). This finding is consistent with the literature, which identifies the supracerebellar infratentorial approach as a standard and widely preferred route due to its direct midline trajectory and minimal cortical disruption, especially for tumors located inferior to the vein of Galen [27, 35, 70].

Alternative approaches were less frequent and typically reserved for superiorly extending or laterally displaced lesions: occipital transtentorial (4.5%) and occipital interhemispheric transtentorial (6.0%) [76, 77].

A subset of respondents reported using biopsy alone (7.5%) or biopsy followed by definitive surgery via the supracerebellar route (1.5%).

Additionally, endoscopic biopsy with subsequent supracerebellar resection was adopted in 1.5% of cases, while the neuroendoscopic transventricular transchoroidal fissure approach accounted for 4.5%, reflecting a growing interest in minimally invasive alternatives for both diagnosis and resection, especially in well-selected cases [75, 78, 79].

Personalized planning, which is based on tumor morphology, venous anatomy, and ventricular involvement, was reported by 6.0% of surgeons, underscoring the importance of a flexible, anatomy-tailored approach. In the context of complex bulky lesions, a tailored surgical strategy may be necessary. This could include tentorial or falcine fenestration, staged operations, or the combined use of endoscopic assistance to enhance visualization and improve the extent and safety of tumor resection.

Practices differed significantly regarding patient positioning.

Table 3 Overview of surgical approaches for pineal tumors: Indications; Pros & Cons [19, 22, 27, 40, 53, 75]

Approach	Indications	Advantages	Disadvantages	Patient Position	Major Surgical Risks & Complications	Approximate Incidence/ Data from Literature
Endoscopic Third Ventriculostomy (ETV) & Biopsy	Pineal region tumors with obstructive hydrocephalus and elevated tumor markers; diagnostic need in suspected germinoma	Minimally invasive; useful for hydrocephalus relief and biopsy; low morbidity; avoids callosal/cortical injury	Limited to small lesions; risk of biopsy-induced bleeding may compromise ETV. risk of sampling error notable	Supine (head slightly flexed)	- Intraventricular hemorrhage- Infection (meningitis; ventriculitis)- Failure to obtain diagnostic tissue- CSF leakage	Hemorrhage: ~5–10% Infection: 2–5% Nondiagnostic biopsy: up to 20%
Posterior Interhemispheric Trans-callosal Approach (PITA/PITCA)	Posterior third ventricular tumors, large pineal tumors with anterior/superior extension	Direct approach to posterior third ventricle; good access for intraventricular extension; good midline exposure	Visual deficits due to calcarine infarction; memory loss from fornical injury; callosal disconnection syndrome; Requires meticulous venous preservation	Prone or lateral	- Callosal injury (disconnection syndrome)- Venous infarction due to bridging vein injury- Hemiparesis- Seizures	Callosal syndrome: 5–15% Venous infarction: 10–15% Hemiparesis: ~5%
Endoscopic-Assisted Paramedian SCIT (PM-SCITA)	Preferred for large or contralaterally extended tumors; steep tentorial angles; tumors displacing deep veins superiorly	Combines direct microsurgical access with enhanced endoscopic visualization; avoids Galenic injury; good for oblique trajectories. Endoscopic assistance reduces brain retraction; balanced exposure and invasiveness	Technically complex; requires endoscopic proficiency and neuronavigation; limited training centers use it routinely	Semisitting or lateral decubitus	- Cerebellar contusion or edema- Injury to deep venous structures (internal cerebral veins, vein of Galen)- Cranial nerve IV palsy- Postoperative hemorrhage	Cerebellar edema/ contusion: 10–12%IV nerve palsy: 5–7%Venous injury: rare but serious
Midline Supracerebellar-Infratentorial Approach (M-SCITA)	Classic approach for midline pineal tumors below the vein of Galen; best in open quadrigeminal cistern	Excellent exposure of inferior tumors; uses gravity-assisted cerebellar retraction; avoids cortical retraction	Steep tentorial angle and low-seated torcula may obstruct view; risk of air embolism in sitting position; limited lateral reach venous anatomy critical;	Sitting, Concorde, or prone	- Injury to Galenic venous complex- Cerebellar edema or hemorrhage- Air embolism- Parinaud's syndrome (vertical gaze palsy)	Venous injury: 10–20%Cerebellar edema/ hemorrhage: 10%Parinaud's syndrome: 10–15%
Occipital Transtentorial Approach (OTA)	Large vascular tumors with superior/posterior/inferior extension	Broad exposure of pineal region; superior control of vascular supply; avoids sitting complications; useful for multicompartment tumors Preferred for lesions with supratentorial extension;	Risk of occipital lobe damage and homonymous hemianopia; limited access to contralateral side; tentorial dissection required	¾ prone, head rotated contralaterally	- Occipital lobe contusion- Visual field deficits (homonymous hemianopia)- Tentorial sinus injury- Brain swelling and hemorrhage	Visual field deficits: 20–25%Tentorial sinus injury: ~10%Hemorrhage: 5–10%

The semisitting position was the most commonly used (35.8%), followed by the park bench (29.9%), supine (17.9%), sitting (10.4%), and lateral decubitus (6.0%) positions. Many neurosurgeons continue to favor semisitting and sitting positions because of their advantages in venous drainage and enhanced surgical visualization of the pineal region, despite the risk of venous air embolism [80]. Positioning strategies depend on both surgeon preference and institutional protocols, as well as patient-specific anatomical considerations (Table 4).

Multidisciplinary tumor board

The institutionalization of a multidisciplinary tumor board (TB) for the treatment of brain tumors is fundamental to ensure consistent, high-quality oncological care [13, 17]. The recent SNO–EANO–EURACAN consensus emphasized the crucial role of a multidisciplinary integrative approach even in managing pineal tumors (PTs), recommending TB discussion to synergistically optimize both surgical planning and postoperative adjuvant strategies.

Table 4 Comparative advantages and disadvantages of the main surgical positions for pineal region tumor surgery

Surgical Position	Indications/ Typical Approaches	Advantages	Disadvantages/Risks	Ideal Patient/Notes
Sitting Position	SCIT	• Excellent venous drainage → reduced bleeding • Gravity-assisted cerebellar descent → wide operative corridor • Optimal visualization of deep midline pineal region • Minimal cerebellar retraction	• Highest risk of venous air embolism (VAE) • Requires advanced anesthesiologic monitoring (TEE, Doppler) • Risk of hemodynamic instability in predisposed patients • Not suitable in PFO or cardiopulmonary disease	Best for experienced centers. Avoid in pediatric patients with high VAE sensitivity or in patients with cardiac anomalies.
Semi-sitting Position	SCIT	• Maintains advantages of sitting but with reduced VAE risk • Good access and visualization • Effective venous drainage	• VAE risk still present (though reduced) • Requires specialized anesthesiology • Skull-pin positioning more complex	Balanced compromise between exposure and safety; widely used in Europe.
Park-bench/ Lateral Oblique	Paramedian SCIT	• Good exposure for paramedian lesions • Reduced VAE risk • Less cerebellar retraction than prone positions	• Positioning more complex • Less gravity-assisted cerebellar fall compared to sitting • Neck torsion may increase risk of venous congestion	Useful for laterally displaced tumors or when midline venous structures limit exposure.
Supine Position	OTA/OITA	• Stable, safe, widely tolerated • Anesthesiologically simple • Optimal for lesions with superior extension (toward splenium/posterior ventricle) • Easy neuronavigation setup	• No gravity-assisted cerebellar relaxation • Limited exposure for midline inferior lesions • May require greater retraction for deep targets	Ideal for lesions extending superiorly or laterally; commonly preferred for OTA/OITA corridors.
Prone Position/Three-quarter Prone	OTA/OITA	• Good access to tentorial angle • Reduced risk of VAE • Symmetric exposure of posterior fossa	• Risk of venous congestion and reduced cerebellar compliance • Potential increased intracranial venous pressure • Longer positioning time	Useful in bulky posterior tumors requiring wide tentorial exposure. Not ideal for SCI.
Lateral Decubitus	Select OTA/ paramedian approaches	• Lower VAE risk • Smooth venous return • Good stability	• Less widely used → limited team experience- Narrower surgical corridor • Less favorable visualization of deep midline	Good alternative for selected cases; often used depending on surgeon preference.
Concorde/ Modified Prone Concorde	Posterior fossa midline approaches	• Symmetric exposure of cerebellar hemispheres • Good access for posterior fossa decompression	• Suboptimal for pineal region unless combined with tentorial opening • Limited space in deep midline	Rarely used for pineal surgery; more common in posterior fossa tumor surgery.

VAE venous air embolism; *SCIT* supracerebellar infratentorial approach; *OTA* occipital transtentorial approach; *OITA* occipital interhemispheric transtentorial approach; *PFO* patent foramen ovale; *TEE* transesophageal echocardiography

Overall, the heterogeneity in tumor biology, appearance, and prognosis requires personalized therapy strategies customized to individual patient profiles [13, 17, 81, 82].

Despite increasing acknowledgment in the current literature of the pivotal role of MTB discussions in PTs' decision-making practices, this survey highlights significant variability in clinical discussion. Notably, although consensus guidelines advocate for coordinated MTB involvement, multidisciplinary neuro-oncological team discussions have been reported to occur preoperatively in only 62.7% of cases, postoperatively in 29.9%, and rarely in 7.5% of cases.

The gap between clinical practice in our country and guideline recommendations underlines persistent barriers to the full integration of multidisciplinary care in neuro-oncology. These obstacles may result from inadequate institutional support, logistical complexities, heterogeneity in local clinical protocols, and a lack of standardized care pathways.

All patients should ideally be discussed preoperatively to optimize surgical objectives with a comprehensive oncologic strategy and postoperatively to analyze histological results and establish tailored adjuvant treatment plans. Standardizing TB across institutions may facilitate decision-making, assure adherence to guidelines, and thus improve survival and quality of life for these patients.

Given the rarity of these tumors, patients who do not require urgent intervention may benefit from virtual tumor boards consisting of a national panel of experts.

This approach could overcome geographic and local resource limitations, guaranteeing access to highly specialized MTB [83]. In addition, the virtual platform for the MTB could underpin the creation of a national pineal tumor registry, improve data collection and advance research.

The implementation of virtual discussion strategies may improve adherence to personalized evidence-based treatment, facilitating timely expert consultations in the clinical setting of rarities in neuroncology.

Follow-up recommendations

On the basis of our experience with these patients, the follow-up time is strictly dependent on the histology and should be performed preferentially via MRI.

Indeed, CT remains a widely available and rapid imaging option, mainly in urgent or resource-limited settings, but it lacks adequate tissue resolution and should be considered inadequate for elective follow-up imaging owing to significant limitations in detecting small and early recurrences. Moreover, for all high-grade lesions, whole spine MRI should be considered standard practice together with brain imaging. Instead, MRI benefits from superior soft tissue contrast and provides greater sensitivity and specificity in the detection of residual disease, thereby guiding immediate clinical decisions and potentially enhancing patient outcomes [57].

In this scenario, it is important to define the time of follow-up, which could be as follows:

six months to 5 years for germ cell tumors, pineoblastomas and high-grade gliomas;
Annual to 5 years for pineocytoma, low-grade glioma and other low-grade tumors.

Limitations and strengths

Although the survey was disseminated across various neurosurgical departments in Italy, participation was voluntary, potentially leading to a nonrepresentative sample and bias in treatment preferences. This could have resulted in a nonrepresentative group of responders, which could be biased toward treatment options. Nevertheless, given the high response rate, this study provides meaningful insights into the current surgical management strategies for pineal gland tumors among Italian neurosurgeons. The present survey was conceived to evaluate national management attitudes, surgical preferences, and perioperative strategies rather than to retrospectively collect patient surgical and outcome data. However, considering the rarity of pineal tumors, a clinical investigations represents a crucial forthcoming step. The SINch Neuroncology Section is actively developing a national registry for these rare tumors, facilitating prospective outcome gathering and future evidence-based guideline formulation.

The quality of the results is limited by the lack of prospective studies on this topic. Additionally, the included studies cover nearly 15–20 years, a period during which brain tumor surgery and anesthesiologic techniques have advanced. Although statistical pooling of outcomes would have been desirable, the included studies displayed substantial heterogeneity in population characteristics, surgical techniques, reporting of complications, and clinical endpoints. The majority of the studies did not provide standardized effect sizes (e.g., odds ratios, hazard ratios, confidence intervals), thereby preventing the generation of meaningful forest or funnel plots. For these reasons, and to avoid misleading interpretations, a formal quantitative meta-analysis was not performed. Instead, a structured qualitative synthesis was provided, summarizing the most consistent patterns across the literature.

Conclusions

This national survey, integrated with a systematic literature review, offers the first structured overview of surgical management practices for pineal region tumors in Italy. The results revealed substantial variability in key aspects of care—hydrocephalus management, surgical approach selection, patient positioning, multidisciplinary tumor board integration, and postoperative imaging strategies. While the predominance of the infratentorial supracerebellar approach and the preference for endoscopic third ventriculostomy are consistent with international trends, significant gaps remain, particularly in the standardized use of early MRI and preoperative multidisciplinary planning. These findings underscore the need for national, evidence-based guidelines and collaborative models—such as virtual tumor boards and a dedicated pineal tumor registry—to harmonize practices, guide clinical decision-making, and improve both short- and long-term patient outcomes.

Recent advancements in the molecular and clinical comprehension of pineal parenchymal tumors highlight the essential need for worldwide collaboration, supported by high-quality tumor biobanking and patient registries, to facilitate the development of these rare CNS neoplasms. In closing, the definition of standardized treatment protocols could also provide personalized and evidence-based care for these rare tumors, optimizing therapeutic options, enabling the comparability of outcomes across centers, and improving the overall understanding of PT biology and evolution over time.

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All the authors have read and agreed to the published version of the manuscript.

Data availability No datasets were generated or analysed during the current study.

Declarations

Ethical approval This study did not involve direct patient data collection and was exempt from SINch review board approval and consent was obtained from all participants involved in the review.

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