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# Revisiting the Endoscopic vs. Microscopic colloid cysts resection battle with emphasis on endoscope assisted technique

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ABSTRACT

*Introduction:* Colloid cysts are challenging regarding their location. Surgical resection remains the therapeutic option of choice for symptomatic cysts. However, choosing the optimal surgical approach is still a subject of debate.

*Research question:* The aim of the study is to compare three surgical approaches; Pure endoscopic (PE), pure microscopic (PM) and endoscope assisted microsurgical (EA).

*Material and methods:* Retrospective data extraction from our database was done and we included patients who underwent surgical resection for colloid cysts since 2008. Patients were categorized into three groups based on the forementioned surgical techniques. Outcome measures assessed included extent of resection (EOR), morbidity using modified Rankin Scale (mRS), hospital stay duration (HSD), and complications.

*Results:* 41 patients met our inclusion criteria and were divided as follows; PM 13 patients (31.7%), PE 19 patients (46.3%) and EA with 9 patients (22.0%). Mean age (SD) was 37.4 ± 12.2. Male: Female is 1:1.05 and average follow-up was 3.9 ± 2.8 years. Gross total resection(GTR) reached 92.3% (12/13) using PM, 78.9% (15/19) with PE and 100% (9/9) under EA. Morbidity was 15.4%, 10.5% and 0% respectively (mRS >2). Hospital stay duration was significantly shorter in PE and EA ($p = 0.012$).

*Discussion and conclusion:* EA excision of colloid cysts is safe and effective. When compared to PE and PM approaches, it can combine the advantages of both tools utilizing the microscope and endoscope to achieve a safe, gross total resection while minimizing hospitalization duration. The choice of surgical approach, however, should be individualized based on the cyst's location, size, and the surgeon's expertise and preference.

## 1. Introduction

Despite the benign histological nature of colloid cysts, their location might lead to development of hydrocephalus or even sudden death (Arnaout and Elsamman, 2021; Camacho et al., 1989; Iacoangeli et al., 2014). For symptomatic cases with diameters larger than 7 mm, surgical excision is the gold standard management option (Sheikh et al., 2014; Mathiesen et al., 1997). A big challenge due to their location is the difficult surgical accessibility to colloid cysts and the third ventricle, which led Neurosurgeons to adopt different techniques to approach these cysts. Unfortunately, the popular argument between neurosurgeons favoring microscopic and neurosurgeons preferring endoscopic resection remains unsolved and every party can allegedly prove the superiority of their technique (El-Ghandour, 2009; Marx and Schroeder, 2020; Schroeder and Gaab, 2002; Zohdi et al., 2006). Few authors also described that endoscope assisted microscopic resection which can bring the advantages of both techniques (Charalampaki et al., 2006). However, and to our knowledge, there is no detailed comparative study that was performed comparing the three techniques together. We are aiming here to compare the three techniques regarding the following outcome measures; extent of resection, morbidity, hospital stay duration and complications.

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## 2. Materials and methods

We retrospectively reviewed the institutional archives of collected cases of colloid cyst patients who underwent surgical excision over the period between January 2008 and till March 2020. We included only cases that were operated with resection of the cyst where all the needed data could be completely documented and with follow-up of at least 1 year. We excluded cases that were conservatively managed or where treatment of hydrocephalus took place alone without encountering the cyst.

We extracted data on patient demographics, preoperative presenting symptoms, signs, Glasgow Coma Scale (GCS) at presentation, size of the cyst, its site, presence or absence of hydrocephalus, shunt implantation, used surgical technique and approach whether microscopic, endoscopic, or combined endoscope assisted microscopic excision.

### 2.1. Outcomes and predictors

Our Primary Outcome is the extent of resection whether total or subtotal (including aspiration/biopsy). The extent of resection was assessed both intraoperatively and through postoperative MR imaging. In cases where postoperative MR imaging indicated complete resection but a small remnant of the cyst was identified intraoperatively, the intraoperative findings were prioritized and recorded.

MR imaging sequences that were used were T1 weighted images with and without contrast, T2 and Constructive Interference in Steady State (CISS) sequences which are highly sensitive also to detect small remnants of the cysts.

Secondary outcomes included morbidity which we measured using the modified Rankins Scale (mRS), hospital Stay duration postoperatively, recurrence, reoperation, complications including neurological deficits especially memory deficits and postoperative epilepsy/convulsions, intraventricular hemorrhage, infarction, CSF leak and infection. Postoperative persistent Hydrocephalus and need for CSF diversion whether, external Ventricular Drain (EVD), endoscopic third ventriculostomy (ETV) and ultimately the need for a ventriculoperitoneal (VP) shunt.

### 2.2. Surgical techniques

The purely microscopic (PM) cases were operated either through transcallosal interhemispheric approach or transcortical trans ventricular approach usually using a tube system for avoiding retraction with spatulas. The pure endoscopic PE cases were encountered through a single burr hole usually anterior and lateral to the Kocher burr hole or according to the anatomy. Selection of the burr hole was done mainly depending on the site of the cyst and usually assisted with the neuronavigation system. The endoscope assisted technique (EA) is performed initially via a classic Kocher Burr hole, through which the endoscope is introduced, and the anatomy is visualized for planning of the optimal craniotomy (Fig. 1). Then according to the intraoperative situation, a small thumb shaped mini craniotomy is planned as shown in Fig. 1. Then after this, the resection is done using the microscope and repeated visualization using the endoscope is utilized according to need (Fig. 2). The preoperative, intraoperative, and postoperative images of one patient who was operated with the EA technique is shown in Fig. 3.

### 2.3. Statistical methods

Descriptive summary statistics were done using counts, percentages, mean and Standard Deviation for categorical and continuous variables, respectively. Group comparisons were performed using Fisher's Exact test for categorical variables, while Analysis of Variance was used for comparing continuous variables. Statistics was done using R software version 3.6.3. The modified Rankin Scale was treated as a categorical variable with a score >2 considered as an indicator of disability for the purposes of this study. Statistics was done using the Finalfit package version 1.0.4 on R software version 4.1.1. Statistical significance was established at $p < 0.05$. (R. Core Team and OthersTeam and Others, 2010, 2013; R Development Core Team and Others, 2010)(Team and Others, 2010).

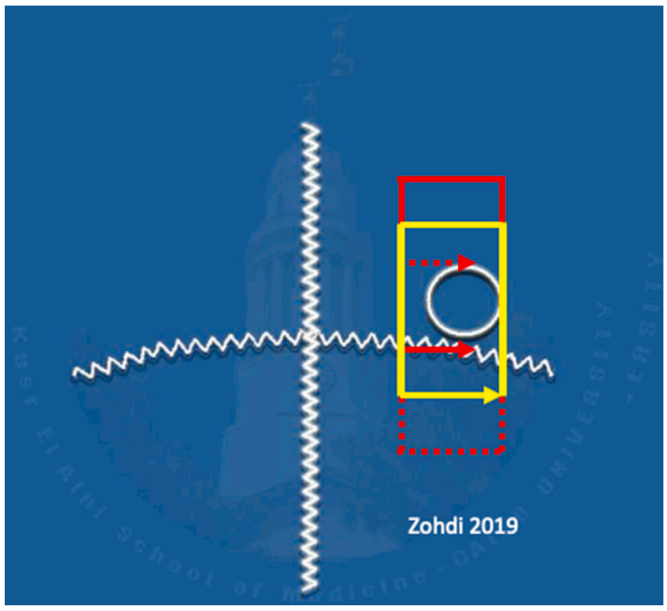


**Fig. 1.** Showing steps for planning for the craniotomy tailored according to the situation in real time. White circle showing the initial Kocher Burrhole through which the endoscope is introduced to provide the neurosurgeon with a real-time view of the cyst and guides for the best way to widen the craniotomy following endoscopic inspection.

## 3. Results

### 3.1. Patients' distribution and characteristics

41 patients matched our inclusion criteria. According to the surgical approach the patients were divided into three different groups.

- Group *A:* 13 cases who underwent pure microsurgical resection.
- Group *B:* 19 cases who underwent pure endoscopic resection
- Group C: 9 cases who underwent endoscope assisted microscopic resection.

Among the 51 included patients, 20 were males and 21 were females with male-to-female ratio of 1:1.05, mean age (SD) at surgery was 37.4 (12.2) years and average follow up (SD) period was 3.92 (2.82) years. The diameter of the encountered cysts ranged from 7 to 31 mm with an average (SD) of 17.0 (6.9) mm.

The most common presenting symptom of the studied patients was headache (82.9%) followed by attacks of altered conscious level (26.8%). Focal neurological deficits were documented at the time of presentation in 14.6%: The full presentation spectrum is tabulated in Table 1. Other less frequent presenting symptoms included dizziness, memory deficits, seizures and gait disturbance. Most of our patients 39/41 (95.1%) suffered from hydrocephalus preoperatively. The two patients who did not have hydrocephalus belonged to the PM and EA groups respectively. Percentage distribution among each group is tabulated in Table 1.

Most of the cases presented to us with colloid cysts were without previous attempts of resection. 39 patients of the total 41 patients (95.1%) were virgin cases with colloid cysts of the third ventricle. Two patients in whom the cysts could not be totally resected were reoperated

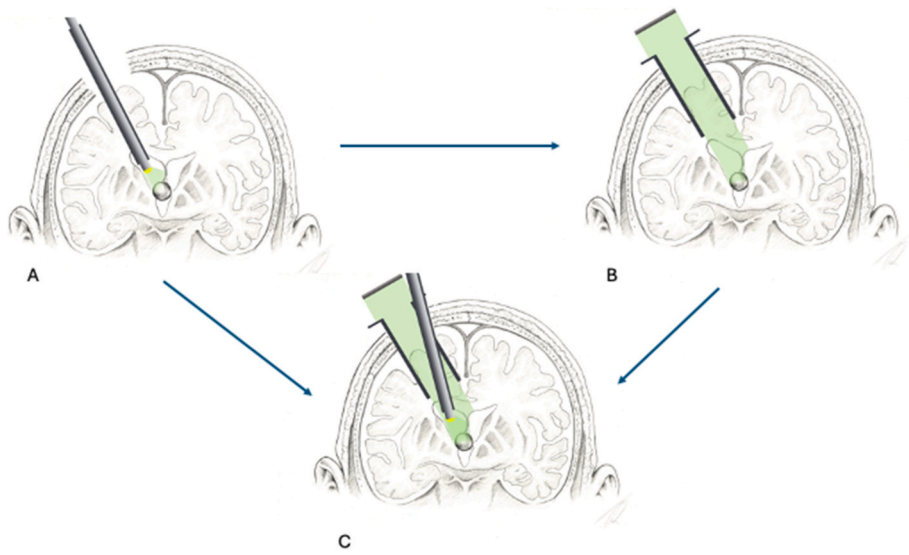


**Fig. 2.** Showing the dynamic use of the endoscope and microscope. The endoscope can initially be used for visualization and planning of the craniotomy (A). Following this, the resection could be done using the microscope allowing for more bimanual freedom (B). Or dynamic usage of both the microscope and endoscope as needed during the surgery (C).

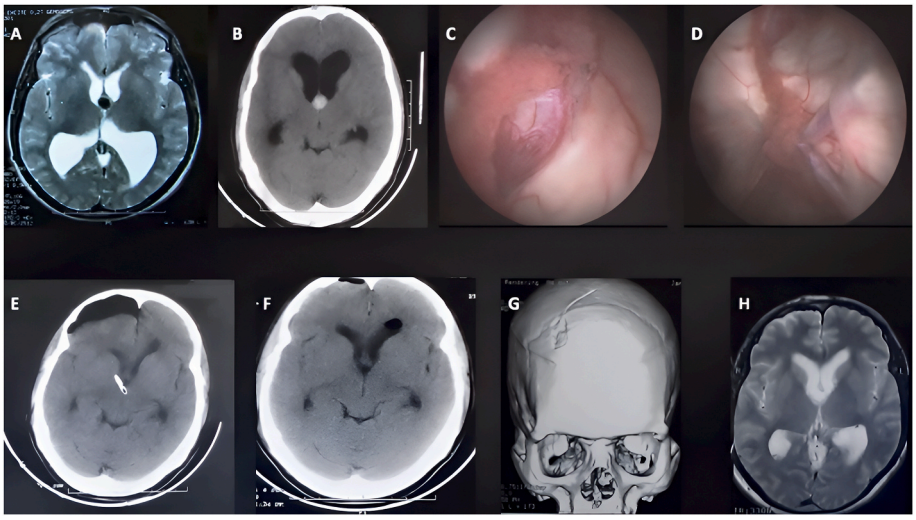


**Fig. 3.** Showing preoperative MRI (A) and CT (B) images of one of the patients operated with the endoscope assisted technique and endoscopic visualization (C and D). Complete cyst excision was achieved and immediate CT postoperatively shows resection of the cyst and position of the right EVD and pneumocephalus (E). In the CT performed before discharge of the patient from the hospital (F) the pneumocephalus improved and EVD removed. The 3D construction of the CT shows the shape of the underwent thumb shaped mini-craniotomy (G) The follow-up MRI shows no remnants or recurrence of the cyst (H).

using the endoscope assisted (EA) microsurgical resection where complete resection could be achieved. All the demographics and characteristics did not show significant difference between the three groups except for cyst size and follow up period as shown in Table 1.

### 3.2. Outcome parameters

#### 3.2.1. Extent of resection

Gross total resection (GTR) was achieved in 36/41 (87.8%) in all the patients collectively. Among the EA group, GTR was achieved in all the nine patients (100%), while only 78.9% (15/19 patients) gross total resection was achieved in the pure endoscopic group totally and 92.3% (12/13 patients) gross total resection in the pure microscopic group. Although a slight difference is witnessed in the numbers, this did not show statistical significance using Fisher's exact test (P = 0.410).

#### 3.2.2. Morbidity

Morbidity was evaluated using the modified Rankin's Scale (mRS). We identified morbidity as modified Rankin scale >2. The total morbidity reached 12.2% (5/41). In the microscopic group alone morbidity reached 15.4% (2/13 patients) while in the endoscopic group it was 10.5% (2/19 patients) and in the endoscope assisted one case of morbidity was witnessed 11.1% (1/9 patients). These differences did not show statistical significance using Fisher's exact test (P = 1.000).

#### 3.2.3. Hospital stay duration

The third criterion of outcome evaluation in our patients was the hospital stay duration. A total average of 9.5 (5.5) days was the mean duration (SD) in our patients regardless of the adopted surgical technique. In the microscopic group, the mean hospital stay duration was 12.4 days while in the pure endoscopic group it was 9.4 days and, in the endoscope-assisted group it was 5.6 days. Statistical significance was

**Table 1**
Showing demographics, preoperative presentation, and outcomes of the three groups.

| Factors | PM | PE | EA | Total | P Value |
|---|---|---|---|---|---|
| Total cases (%) | 13 (31.7) | 19 (46.3) | 9 (22.0) | 41 (100) | |
| Age Mean (SD) | 35.6 (8.9) | 39.5 (15.6) | 35.7 (9.1) | 37.4 (12.2) | 0.607 |
| M:F | 6:7 | 10:9 | 4:5 | 20:21 | 0.926 |
| GCS <15 (%) | 2 (15.4) | 0 (0) | 0 (0) | 3 (7.32) | 0.139 |
| Headache (%) | 11 (84.6) | 15 (78.9) | 8 (88.9) | 34 (82.9) | 1.000 |
| Nausea and vomiting (%) | 1 (7.69) | 4 (21.1) | 0 (0) | 5 (12.2) | 0.410 |
| Dizziness (%) | 3 (23.1) | 1 (5.3) | 1 (11.1) | 5 (12.2) | 0.342 |
| Memory (%) | 2 (15.4) | 0 | 0 (0) | 2 (4.9) | 0.139 |
| LOC (%) | 4 (30.8) | 5 (26.3) | 2 (22.2) | 11 (26.8) | 1.000 |
| Visual symptoms (%) | 2 (15.4) | 6 (31.6) | 0 (0) | 8 (19.5) | 0.173 |
| Siezures (%) | 1 (7.7) | 2 (10.5) | 0 (0) | 3 (7.3) | 1.000 |
| Focal Neurology (%) | 1 (7.7) | 4 (21.1) | 1 (11.1) | 6 (14.6) | 0.742 |
| Gait (%) | 0 (0) | 1 (5.3) | 0 (0) | 1 (2.4) | 1.000 |
| Hydrocephalus (%) | 12 (92.3) | 19 (100) | 8 (88.9) | 39 (95.1) | 0.282 |
| Cyst size in mm (SD) | 21.0 (7.0) | 15.3 (7.1) | 13.8 (3.1) | 17.0 (6.9) | 0.025 |
| Follow up Mean in years (SD) | 2.3 (1.0) | 4.9 (3.3) | 3.2 (1.7) | 3.9 (2.8) | 0.015 |
| Gross Total Resection (%) | 12 (92.3) | 15 (78.9) | 9 (100) | 36 (87.8) | 0.410 |
| Morbidity (mRS>2) | 2 (15.4) | 2 (10.5) | 1 (11.1) | 5 (12.2) | 1.000 |
| Hospital Stay Duration (SD) | 12.4 (5.71) | 9.4 (5.6) | 5.6 (0.5) | 9.5 (5.5) | 0.012 |
| Shunt dependent patients (%) | 2 (15.4) | 2 (10.5) | 0 (0) | 4 (9.8) | 0.802 |
| Persistent Complications (%) | 2 (15.4) | 1 (5.3) | 1 (11.1) | 4 (9.8) | 0.802 |
| Reoperation (%) | 0 (0) | 1 (5.3) | 0 (0) | 1 (2.4) | 1.000 |

witnessed (P = 0.012) as shown in Table 1.

#### 3.2.4. Reoperation

The need for a second operation was necessary only in one patient who belonged to the pure endoscopic group. Despite that 12.2% of all the patients had some remnants regardless of the approach, reoperation was only needed in 1/41 patients (2.4%) which all belonged to the pure endoscopic group.

#### 3.2.5. Complications

Immediate postoperative complications occurred in 11/41 patients (26.8%). However, these complications persisted only in 4/41 (9.8%). The rate of complications was lower in the endoscopic group compared to the microscopic group and the endoscope assisted group as shown in Table 2. However, this did not show statistical significance (P = 0.802).

The most common complications were memory deficits which occurred in 7 patients (17.1%) Postoperative Seizures occurred in 4 patients (9.8%) and hemorrhage had an incidence of 4.9%. Postoperative infections occurred only in 3 patients (7.3%).

#### 3.2.6. Shunt dependency

The total number of patients who required VP shunt dependency was 4/41 (9.8%). The percentages of patients among the microscopic and endoscopic groups were 15.4% and 10.5% respectively, while in the EA group no patient was shunt dependent.

## 4. Discussion

### 4.1. Main findings of the study

The main elaboration of this study is that endoscope assisted microsurgical resection of colloid cysts in selected cases can be an effective and safe approach combining the advantages of both the microscope and the endoscope. In comparison to the pure microscopic resection it showed in our series less postoperative morbidities, hospital stay duration and complications, while in comparison to the pure endoscopic approach it could achieve more gross total resection and avoidance of reoperation. However, this is not applicable to all the patients as some patients might still be good candidates for either pure microscopic or pure endoscopic resection.

### 4.2. The concept of endoscope assisted microsurgical resection; how and why?

There has been an ongoing debate on one hand between Neurosurgeons favoring the endoscope solely due to the superior clear visualization provided by the endoscope and its minimal invasiveness. On the other hand, other neurosurgeons prefer the microscope due to the easier maneuverability (Sheikh et al., 2014). However, this is not the main topic of discussion here. In fact, we introduce our strategy of introducing the endoscope at the beginning of the surgery through the usual Kocher Burr hole (usually right frontal) as shown in Fig. 1 to visualize the intraventricular cavity and determine the best approach to the cyst whether transforaminal when the foramen is adequately dilated or transseptal interfornicial whenever the foramen is very narrow (Charalampaki et al., 2006). This means that depending on the intraoperative real-time localization of the cyst within the third ventricle the craniotomy position can be accordingly tailored. Careful preoperative evaluation of MR images, particularly T2 CISS sequences, is valuable for accurately measuring the diameter of the Foramen of Monro. Integrating these images into intraoperative navigation can significantly enhance intraoperative guidance and precision.

Initial visualization via the endoscope guides the planned minimally invasive small mini craniotomy which usually does not exceed 30 mm in the largest diameter. This means that the endoscope is used also to plan for the surgery in the initial inspection and the craniotomy (Fig. 1) as well as whenever needed intraoperatively (Fig. 2).

This intraoperative initial endoscopic visualization can serve as a valuable adjunct to neuronavigation for planning the craniotomy and accessing the cyst. Furthermore, in situations where neuronavigation is unavailable or becomes unreliable during the procedure, this method can provide significant assistance.

Ultimately, the selection of the surgical planning approach depends on the surgeon's preference and the specific surgical scenario (Brunori et al., 2018; Marx and Schroeder, 2020).

Another important value of the endoscope assisted technique is the ability to visualize the roof and floor of the third ventricle especially with the angled endoscopes.and then resecting the cyst using the microscope with its better provision of two hand maneuverability for finer dissection and superior hemostasis options (Arnaout and Elsamman,

**Table 2**
Showing the different complications among the three groups.

| Approach | Number of Patients | Immediate Complication | Persitent complications | Memory Deficit | Seizures | Hemorrhage | Infection |
|---|---|---|---|---|---|---|---|
| Microscopic | 13 | 4 (30.8%) | 2 (15.4%) | 3 (23.1%) | 3 (23.1%) | 1 (7.7%) | 2 (15.4%) |
| Endoscopic | 19 | 4 (21.1%) | 1 (5.3%) | 2 (10.5%) | 0 | 1 (5.3%) | 1(3.4%) |
| Endoscope Assisted | 9 | 3 (33.3%) | 1 (11.1%) | 2 (22.3%) | 1(11,1 %) | 0 | 0 |
| Total | 41 | 11 (26.8%) | 4 (9.8%) | 7 (17.1%) | 4 (9.8%) | 2 (4.9%) | 3 (7.3%) |

2021; Charalampaki et al., 2006).

Some authors reported that despite complete resection of the cyst, some patients still suffer from postoperative hydrocephalus and require CSF diversion usually with a VP shunt (Cyrus, 1996; Elkheshin and Zohdi, 2022; Zohdi et al., 2006). In very few cases where ballooning of the third ventricle causes pressure on the floor leading it to become thinned out and, in some cases even translucent, performance of a third ventriculostomy might be very handy as a preemptive measure to avoid the obstructive hydrocephalus that might persist or even be temporary due to partial spillage of the colloid content. However, many neurosurgeons declare that ETV is not indicated because once totally resected, removal of the colloid cyst alleviates the obstructive hydrocephalus completely (Souweidane et al., 2008; Zohdi et al., 2006).

### 4.3. Microscopic vs endoscopic battle

Many authors emphasized on the superiority of microscopic to endoscopic techniques while others favored the endoscopic technique, and each party remains somehow fixed to their own strategy that according to their experience works best. A Meta Analysis performed by Sheikh et al., outlined clearly that microscopic resection is superior regarding degree of total resection while endoscopic techniques are generally safer and associated with less morbidities and complications (Sethi et al., 2019; Sheikh et al., 2014).

Many Neurosurgeons still favor the pure endoscopic technique where they can achieve gross total resection through an attractive minimally invasive technique (Iacoangeli et al., 2014; Marx and Schroeder, 2020; Schroeder and Gaab, 2002). Nevertheless, in few cases, even though gross total resection cannot be achieved (usually leaving behind a small remnant) and based on the benign nature of colloid cysts, if the CSF circulation is maintained the goal of surgery is achieved. However, in few cases and despite initial clearance of the ventricular system, later reenlargement/recurrence of the remnants of the cyst might still occur (Iacoangeli et al., 2014; Marx and Schroeder, 2020; Schroeder and Gaab, 2002).

Although we declare in this study the effectiveness of the endoscope assisted technique to pure microscopic, we still do not recommend this blindly for all patients with colloid cysts. For example, patients who present with narrow ventricles and cases with cavum septum pellucidum might be better candidates for transcallosal microscopic approach. The neurosurgeon should be well oriented with what will be faced intraoperatively and insights on the nature of the contents' viscosity can be obtained through the T2 weighted MR images (Brunori et al., 2018; Aggleton et al., 2000). Cavum Septum Pellucidum would provide a natural corridor between the two fornices to the roof of the third ventricle (Azab et al., 2014, 2017, 2019). On the other hand, a smaller cyst projecting clearly unilaterally in the lateral ventricle and enlarging the foramen of Monroe could be pure endoscopically resected without the need for using the microscope (Arnaout and Elsamman, 2021).

We recommend comprehensive consideration of different approaches and techniques before decision making for every patient and tailoring the approach individually with great concentration on the size of the ventricles, cyst size, nature of the contents, size of the foramen of Monroe, septum pellucidum and veins anatomy. The neuroendoscopic training has a steep curve and if the surgeon does not have the adequate training referring the patient or asking for assistance from a more specialized surgeon should be done (El et al., 2022).

### 4.4. Postoperative hydrocephalus between prevention and treatment

One important serious manifestation of colloid cysts is the associated hydrocephalus that usually accompanies the presentation and causes most of the symptoms such as headache, nausea and vomiting (Horn et al., 2008). Theoretically speaking, by complete removal of the cyst the risk for developing obstructive hydrocephalus is nullified. However, the fact is that some patients still develop postoperative hydrocephalus even following complete resection of the cysts. Usually, this hydrocephalus is transient and most probably due to spillage of the cyst contents or associated intraventricular minor bleeding. For this reason, some neurosurgeons consider the insertion of a ventricular drain before closing might be the safety measure that would preserve the life of the patient especially over the first night in the intensive care unit (Charalampaki et al., 2006; Horn et al., 2008; Ayasa et al., 2020). This EVD could be removed after 48 h. Other neurosurgeons are against this measure to avoid the risk of CSF infection that can be increased with insertion of a drain. Another alternative could also be performance of a third ventriculostomy only in cases where the floor of the third ventricle is thinned out in order not to induce damage in an otherwise healthy floor. Some neurosurgeons will claim the importance of performing these two maneuvers and may even avoid the need for a later VP Shunt or CSF diversion while others will clearly debate the necessity of such procedures and that's why more studies should be conducted to evaluate whether performing ETV or inserting EVD or both would be beneficial or risky for colloid cyst patients (Sribnick et al., 2014; Zohdi et al., 2006).

### 4.5. Limitations

Despite the good total number of patients and since this is a retrospective study, the number of patients is not evenly divided between the different groups, and it still lacks the randomization. However, it still provides a valuable view of the three different techniques and their outcomes. The endoscope assisted group contained only nine patients which might not reflect the real effectiveness of the technique. But this still provides a good comparison of the three approaches. Also, the study was performed over a long-time frame which on one hand is good for the long-term follow-up of the patients but on the other hand represent relatively different eras where both the equipment and surgeons' experience markedly developed. For these reasons we recommend performance of more prospective studies on the endoscope assisted technique to support and validate the results we are presenting in the future.

## 5. Conclusions

Endoscope assisted microscopic resection could be an effective approach for resecting colloid cysts of the third ventricle combining the advantages of both the endoscope and the microscope but requiring adequate experience of the surgeon and could result in satisfactory outcomes with favourable GTR and low morbidities and complications. However, the surgical approach to colloid cysts should be still individually tailored according to the anatomy of the cyst, ventricles and experience of the surgeon.

## Authors' contributions

All authors contributed equally to the manuscript and read and approved the final version of the manuscript.

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## Declaration of competing interest

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the

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