Predictive Factors for Rathke's Cleft Cyst Consistency

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OBJECTIVE: **Rathke's cleft cysts (RCCs) may have various anatomic, clinical, and radiologic characteristics, which may be related to their differences in texture or consistency. The purpose of the study was to investigate RCCs based on consistency.**

METHODS: **We retrospectively reviewed 25 cases of patients with RCCs who underwent endoscopic endonasal transsphenoidal surgery between 2008 and 2018. Cases were divided into 3 types based on cyst consistency: fluid (serous) or type A (n = 4); semi-fluid (mucoid) or type B (n = 17); and non-fluid (caseous) or type C (n = 4). Demographic, clinical, radiologic, and surgical characteristics for each group were analyzed.**

RESULTS: **All type A RCCs (100%) had visual impairment. The mean age (42.8 ± 13 years) and cyst volume (2442.5 ± 533.6 mm^3) were higher in these patients. T1-weighted images were hypointense and T2-weighted images were hyperintense on magnetic resonance imaging. Type B RCCs were more frequently encountered (68%). Although headache was the most common (82.3%) symptom, endocrine disorders were also prevalent (52.9%). T1-weighted images were typically isointense or hyperintense on magnetic resonance imaging. Type C RCCs had the youngest patient population (30.3 ± 10.2 years) and T2-weighted images were predominantly hypointense in this group.**

CONCLUSIONS: **The proposed novel consistency classification of RCCs will provide a practical tool for more accurately estimating the nature of the pathology, because each type has its own specific characteristics. Furthermore, the new classification of RCCs may aid in planning a consistency-specific surgery.**

INTRODUCTION

Rathke's cleft cysts (RCCs) are benign congenital pathologies caused by the absence of regression of the Rathke's pouch during the embryonic period.[1,2] Although RCCs are commonly identified during autopsies, they are usually asymptomatic.[3] RCCs can be presented with symptoms such as headache, endocrine disorders, visual disturbances, pituitary apoplexy, and cranial nerve paralysis,[4,5] and surgical resection may be required in these cases.[6,7]

RCCs display variable characteristics. To date, several classifications have been made based on differences in localization, histopathologic characteristics, and magnetic resonance imaging (MRI).[8-10] Likewise, different descriptions for RCC content have also been observed, and specific characteristics were reflected such as; fluid (serous, watery, or cerebrospinal fluid [CSF]-like), semi-fluid (mucinous, mucous, gelatinous, or gel-like), or non-fluid (caseous, inspissated).[9] However, there have been no studies addressing the classification of the RCCs to predict their intraoperative consistency and presenting the clinico-radiologic characteristics of each group separately.

The authors' principal aims in this study have been: 1) to elucidate the nature of the RCCs in relation to demographic, radiologic, and clinical characteristics; 2) delineate the intraoperative findings and correlate them with radiologic data, and 3) investigate the differences among various RCC groups to stress the importance of cyst consistency.

Keywords
- Classification
- Consistency
- Predictive factor
- Rathke's cleft cyst

Abbreviations and Acronyms
CSF: Cerebrospinal fluid
EETSS: Endoscopic endonasal transsphenoidal surgery
MRI: Magnetic resonance imaging
RCC: Rathke's cleft cyst
T1-WI: T1-weighted imaging
T2-WI: T2-weighted imaging

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Table 1. Characteristics of Rathke's Cleft Cyst Patients

Patient Number	Age/Sex	Symptoms	Preoperative Hormonal Features	Visual Findings	Size (mm^3)	MRI				Complications	Follow-Up (months)	Type
						T1-WI	T2-WI	Location	Nodule			
1	65/F	VI	N	+	1853	Hypo	Hyper	I+S	–	–	67	A
2	33/F	H, VI	N	+	2351	Hypo	Hyper	I+S	–	–	48	A
3	34/F	VI	N	+	3308	Hypo	Hyper	I+S	–	–	44	A
4	39/F	VI	N	+	2258	Hypo	Hyper	I+S	–	–	95	A
5	30/F	H	Hg	–	750	Iso	Hypo	I	–	–	17	B
6	31/F	ED*	Hg	+	339	Hyper	Hypo	I	+	–	24	B
7	41/F	H	Ht	–	280	Hyper	Hypo	I	–	Temp. DI	25	B
8	54/F	H	Hp	–	1498	Hyper	Hyper	I+S	–	–	52	B
9	34/F	H	Hg	+	153	Iso	Hypo	S	+	Persist. rhinorrhea	119	B
10	36/F	H	N	–	405	Iso	Hypo	I+S	+	–	17	B
11	35/F	H	Hc	–	552	Hyper	Hypo	I+S	+	–	64	B
12	20/M	H	N	+	1338	Iso	Hyper	I+S	–	–	35	B
13	37/F	H	N	+	219	Hyper	Hypo	S	+	–	48	B
14	40/M	H	Hg	–	1791	Hyper	Hypo	I+S	+	–	38	B
15	16/F	H, VI	N	+	370	Hypo	Hypo	I	–	–	79	B
16	30/F	ED†	†	+	390	Hyper	Hypo	I	+	–	105	B
17	26/F	H	Ht	–	120	Iso	Hypo	I	–	–	66	B
18	49/F	H	N	–	910	Iso	Hyper	I+S	–	–	15	B
19	53/M	VI	N	+	440	Iso	Hypo	I+S	+	–	6	B
20	34/F	H	N	–	189	Iso	Hypo	I	+	–	6	B
21	46/F	H, VI	N	+	1092	Iso	Hypo	I+S	+	–	10	B
22	24/F	VI	N	+	1860	Hypo	Hypo	I+S	+	–	55	C
23	32/M	H	Hc	–	480	Iso	Hypo	I	+	–	16	C
24	19/F	H, ED*	Hg	–	262	Hyper	Hypo	I	+	–	20	C
25	46/M	H, VI	N	+	787	Hypo	Hypo	I+S	+	–	124	C

MRI, magnetic resonance imaging; T1-WI, T1-weighted imaging; T2-WI, T2-weighted imaging; F, female; VI, visual impairment; N, normal; Hypo, hypointensity; Hyper, hyperintensity; I, intrasellar; S, suprasellar; H, headache; Hg, hypogonadotropism; Iso, isointense; ED, endocrine deficiency; Ht, hypothyroid tropism; Temp, Temporary; DI, diabetes insipidus; Hp, hyperprolactinemia; Persist, persistent; Hc, hypocorticotropism; M, male.

*Indicates menstrual irregularity.

†Indicates diabetes insipidus.

METHODS

The study was performed in accordance with the ethical standards of the Declaration of Helsinki. Records of 800 patients treated with endoscopic endonasal transsphenoidal surgery (EETSS) between February 2008 and September 2018 were retrospectively screened and 25 patients with a pathologically definite diagnosis of RCC were identified. The demographic characteristics and case presentations were gathered from medical records. Anterior pituitary hormone levels were quantified, and the presence of endocrine disorders was noted. Visual field defects were evaluated using the Humphrey visual field test (Humphrey Instruments, Dublin, California, USA). Cyst size (calculated as height × width × length/2, in mm diameter), intensities on T1-weighted imaging (T1-WI), T2-weighted imaging (T2-WI), and location of the lesion were evaluated based on MRI.

EETSS was used in all cases and the procedures were performed using a rigid endoscope (Olympus Visera Pro CLV-S40Pro, Tokyo, Japan) with a diameter of 4 mm and at 0°, 30°, and 45° angles as necessary. Cystic contents were evacuated with aspiration and curettage and, if present, the nodule was removed and the cyst wall was partially resected. Cyst consistency was evaluated by retrospectively reviewing video recordings of the endoscopic procedures. To obtain objective classification on cyst consistency, video records of all cases were assessed by 3 double-blind observers to prevent bias in cyst fluidity results (B.O., S.A., N.T.). We have used specific criteria for grading the consistency of RCCs according to the fluidity and classified the cases into 3 types based on cyst consistency; type A (cases with the highest cyst fluidity), type B (cases with moderate cyst fluidity), or type C (cystic contents with no fluidity). Cysts with a watery, non-adhesive content—such as colorless CSF-like or light-colored fluids—in which sampling is possible with suction were included in the highest fluidity group. Viscous, mucoid, or gelatinous cyst contents with adhesive properties, in which sampling is possible with punches and endoscopic ring curettes, were included in the moderate fluidity group. Finally, caseous and inspissated cyst content, with non-dispersive property in which an en bloc resection was possible, were included in the non-fluid group.

Postoperative complications and remedial measures taken were also acquired from clinical records. Clinical and radiologic follow-ups were performed. All patients were referred to the endocrinology department during the pre- and postoperative period.

RESULTS

Characteristics of all RCC cases used in this retrospective study are shown in Table 1. Of the 25 patients, 20 (80%) were female patients and 5 (20%) were male patients. The mean age was 36.1 ± 11.3 years (mean value ± standard deviation), (age range 16–65). Although the most common symptom was headache (72%; n = 18), the other symptoms were visual impairment (56%; n = 14) and hormonal abnormality (44%; n = 11), respectively (Table 2). The mean cyst volume was 959.8 ± 835.2 mm^3 (volume range 120–3308 mm^3). The most frequent location was the intrasuprasellar region (56%; n = 14). In 72% (n = 18) of the cases, MRI showed hypointense cysts on T2-WI (Table 3). Intracystic nodules were detected intraoperatively in 56% (n = 14) of the cases. During follow-up, headache improved in 72.2% (n = 13/18) of the cases, amelioration was observed in 36.3% (n = 4/11) of the cases with hormonal abnormalities, and 92.8% (n = 13/14) of the visual disturbances improved (Table 4). Transient diabetes insipidus was observed in 1 case and reoperation was performed in 1 case due to persistent rhinorrhea. None of the patients had recurrence. Mean follow-up time was 47.8 ± 34.3 months.

When cysts were evaluated according to their consistency, fluid contents were observed in 4 (type A), semi-fluid contents in 17 (type B), and non-fluid contents in 4 (type C). All cases were classified according to cyst consistency, and all characteristics of each type were examined individually.

RCC Type A

This group comprised cysts that were clear or yellowish, fluid (water-like), and serous in appearance. Four (16%) of the 25 patients were in this group and all were women with a mean age of 42.8 ± 13 years (age range 33–65). The most common symptom in this group was visual impairment (100%), whereas headache was reported in 1 (25%) patient and no endocrine disorders were detected. The cyst location was in the intrasuprasellar region in all cases and the mean cyst volume was 2442.5 ± 533.6 mm^3 (volume range 1853–3308), which corresponded to the highest average volume among all 3 cyst types examined. MRI of this type revealed that all cysts were hypointense on T1-WI and hyperintense on T2-WI. Additionally, no intracystic nodules were detected in any case. Visual findings in all cases improved during the postoperative period. There were no complications during follow-up.

Table 2. Demographic and Clinical Characteristics of Rathke's Cleft Cyst Types

	RCC Type A	RCC Type B	RCC Type C
Demographic Characteristics			
Age (average years ± SD)	42.8 ± 13	36 ± 10.2	30.3 ± 10.2
Sex F/M ratio	4/0	14/3	2/2
Clinical characteristics			
Headache (n, %)	1 (25%)	14 (82.3%)	3 (75%)
Visual disturbance (n, %)	4 (100%)	8 (47%)	2 (50%)
Hormonal abnormality (n, %)	– (0%)	9 (52.9%)	2 (50%)

RCC, Rathke's cleft cyst; SD, standard deviation; F, female; M, male.

Table 3. Relationship Between Consistency Types and Magnetic Resonance Imaging Characteristics

	RCC Type A	RCC Type B	RCC Type C
MRI Characteristics			
Size (average mm^3 ± SD)	2442.5 ± 533.6	637.4 ± 496.1	847.2 ± 613.7
Signal intensity (predominance)	T1-WI hypointensity T2-WI hyperintensity	T1-WI iso-hyperintensity T2-WI hypointensity	T2-WI hypointensity
Location			
I+S (n, %)	4 (100%)	8 (47%)	2 (50%)
I (n, %)	–	7 (41.2%)	2 (50%)
S (n, %)	–	2 (11.8%)	–

RCC, Rathke's cleft cyst; MRI, magnetic resonance imaging; SD, standard deviation; T1-WI, T1-weighted imaging; T2-WI, T2-weighted imaging; I, intrasellar; S, suprasellar.

Representative Case for Type A (Patient No. 3). A 34-year-old female patient presented with symptoms of persistent visual impairment for 3 months. Bitemporal hemianopsia was detected in the visual field, whereas the hormone profile was normal. Pituitary MRI revealed an intrasuprasellar T1-WI hypointense, T2-WI hyperintense cystic lesion. The optic chiasm and third ventricle were also compressed. The pituitary gland and stalk were displaced posteriorly as well (Figure 1). During the procedure, the cyst contents were found to be CSF-like. The dural opening was enlarged and the intracystic area was visualized (Supplementary Video 1). A subtotal resection of the cyst wall was performed, and the pathology confirmed the RCC diagnosis. There were no complications in the postoperative period and the visual field defect improved during short-term follow-up. No recurrence was detected at 44 months of follow-up.

Video

Video available at www.sciencedirect.com

RCC Type B

This group was characterized by semi-fluid, mucoid, mucinous, or gelatinous cysts, and 17 (68%) of the 25 patients were in this group. Further, 82.3% (n = 14/17) of the patients were female patients and the mean age was 36 ± 10.2 years (age range 16–54). The most common symptom in this group was headache (82.3%). Although 8 (47%) patients had visual deficits, 9 (52.9%) patients had various hormonal insufficiencies. Intrasuprasellar localization was observed in 8 (47%) cases, pure intrasellar localization in 7 (41.2%) cases, and pure suprasellar localization in 2 (11.8%) cases. The mean cyst volume was 637.4 ± 496.1 mm^3 (volume range 120–1791). MRI mostly revealed isointensity or hyperintensity on T1-WI, and hypointensity on T2-WI (76.4%). In 10 (58.8%) cases, intracystic nodules were detected. In all patients but 1 (87.5%), postoperative visual improvement was observed, and endocrine disorders were recovered in 4 patients (44.4%). One patient (patient no. 7) had temporary diabetes insipidus with a complete resolution before discharging from the hospital. One patient (patient no. 9) with a purely suprasellar RCC was re-operated due to persistent rhinorrhea on postoperative day 6, and CSF fistula was repaired.

Representative Case for Type B (Patient No. 11). A 35-year-old woman presented with headache for 2 years and fatigue for 6 months. A pituitary MRI showed a hyperintense intrasellar cystic lesion on T1-WI. There was no chiasmatic compression, but the pituitary gland was displaced posteriorly (Figure 2). Visual field examination of the patient was normal, whereas the hormone profile revealed hypocortisolemia. Stimulation tests of the hypothalamic-pituitary-adrenal axis revealed secondary adrenal insufficiency owing to the pituitary lesion, and glucocorticoid replacement was administered in the preoperative period. The patient underwent EETSS, semi-fluid, mucoid cystic material and a small intracystic nodule were encountered after opening the sellar dura mater. The contents of the cyst were evacuated, and a partial resection of the

Table 4. Surgical Outcome of Rathke's Cleft Cysts

	RCC Type A	RCC Type B	RCC Type C
Surgical outcome*			
Headache	0%	78.5%	66.6%
Visual impairment	100%	87.5%	100%
Hormonal abnormality	–	44.4%	0%

RCC, Rathke's cleft cyst.
*Indicates improvement.

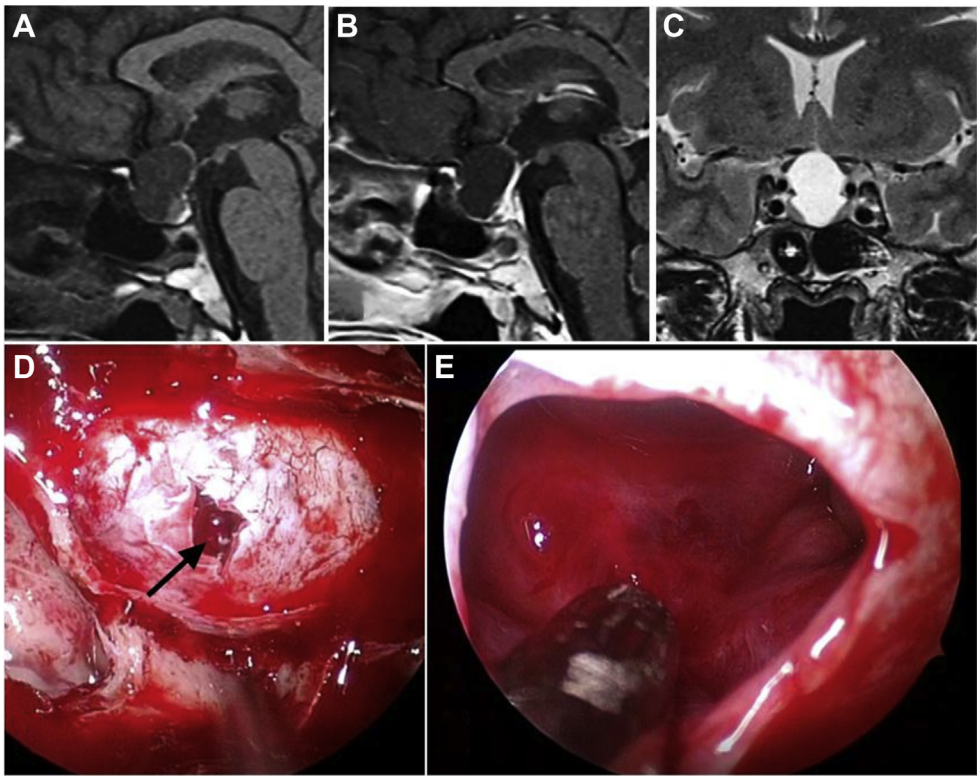

Figure 1. Representative case for type A (patient no. 3). (**A**) T1-weighted imaging exhibits hyperintense lesion compressing the chiasm and the third ventricle. The lesion (**B**) maintains minimal circumferential contrast in contrast-enhanced images and (**C**) shows hyperintense character in the T2-weighted imaging. (**D**) Intraoperative endoscopic images reveal that cerebrospinal fluid-like fluid (black arrow) is observed following the opening of the sellar dura mater and the cyst wall. (**E**) After the cyst fluid has been drained, diaphragma sellae and neurohypophysis are visualized.

cyst wall was performed (Supplementary Video 1). Pathologic examination confirmed the diagnosis of RCC. Postoperatively, there was no improvement in hormonal insufficiency and the patient was directed to the endocrinology department. There has been no recurrence of RCC during follow-up for 64 months.

RCC Type C

This group was characterized by caseous and inspissated cysts with non-fluid content. There were 4 (16%) patients in this group, and 50% of them were women (2/4). The mean age was 30.3 ± 10.2 years (age range 19–46), and this patient group was the youngest and had the lowest male/female ratio. The most common symptoms in this group were headache (75%). Visual deficits were observed in 2 (50%) patients. Two (50%) patients had hormonal irregularities. In terms of location, 2 (50%) were intra-suprasellar and 2 (50%) were pure intrasellar. The mean cyst volume was 847.2 ± 613.7 mm^3 (volume range 262–1860). MRI was remarkable for hypointensity on T2-WI and an intracystic nodule was detected in all cases. Although no remarkable improvement was seen in patients with endocrine disorders, visual impairment improved in all patients postoperatively.

Representative Case for Type C (Patient No. 22). A 24-year-old woman presented with visual impairment for the past year. Pituitary MRI showed a cystic lesion that was hypointense on T1-WI and T2-WI with optic chiasm compression and minimal peripheral contrast enhancement (Figure 3). Hormone profile was normal and visual field examination revealed bitemporal hemianopsia. The patient underwent EETSS. After the sellar dura mater was opened, non-fluid material was encountered. Cyst evacuation was performed using endoscopic ring curettes and punches, and the cyst wall was removed (Supplementary Video 1). RCC was diagnosed pathologically from surgical samples. During follow-up, visual findings improved and there has been no recurrence in the past 55 months.

DISCUSSION

Although RCCs can be present at any age, they are particularly detected between the 4th and 6th decades of life[7] with a marked female predominance in the published series.[11,12] These lesions are mostly asymptomatic, and only a small number of them have various clinical signs,[3,13] with the most common complaints being headache, endocrine disorders, and visual disturbances.[4,5,14,15]

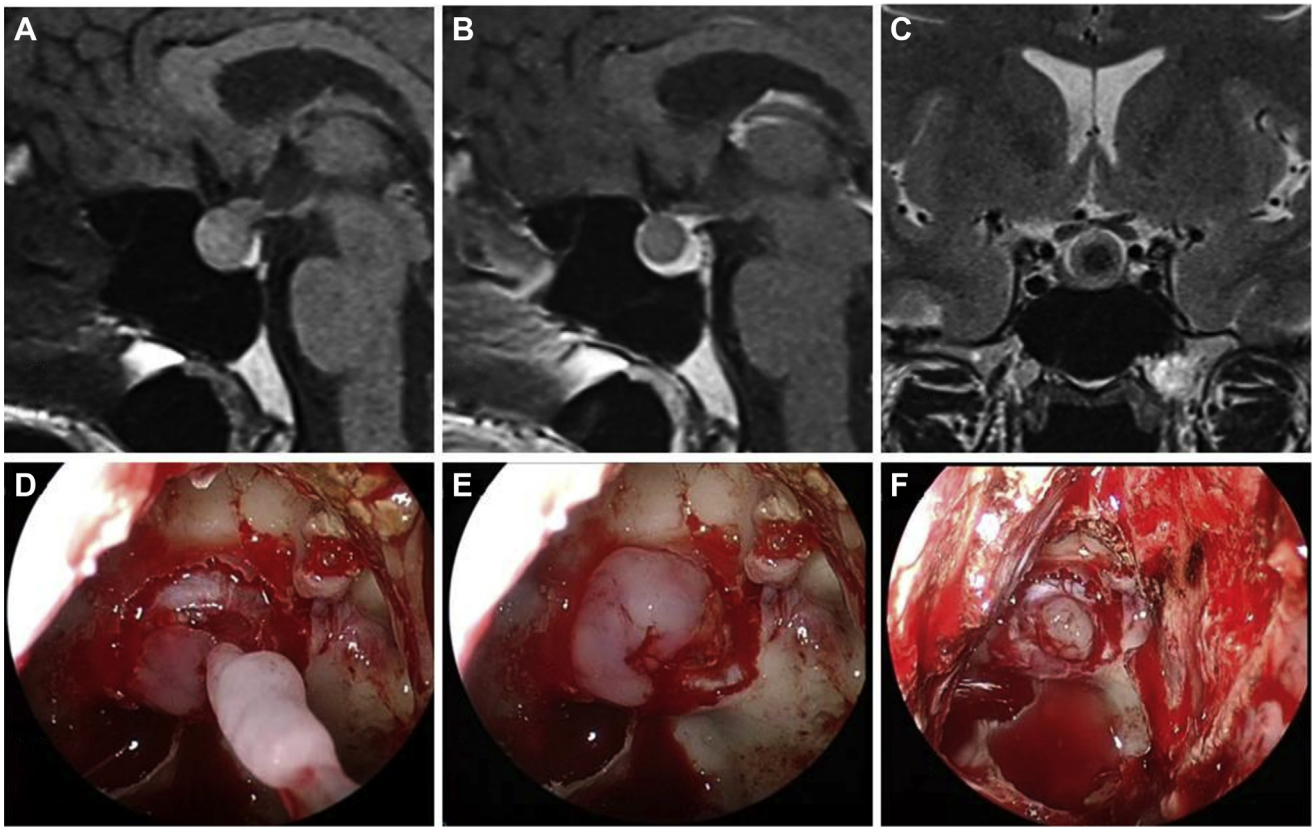

Figure 2. Representative case for type B (patient no. 11). Pituitary magnetic resonance imaging shows (**A**) T1-weighted imaging hyperintense, (**C**) T2-weighted imaging hypointense, cystic lesion with intrasellar localization that maintains minimal circumferential contrast after contrast enhancement (**B**), which does not compress the optic chiasm and propulses the pituitary tissue to the posterior. Intraoperative images, (**D**) mucinous cyst content was encountered when the cyst wall was opened. Image (**E**) reveals that cyst content is semi-fluid and acts like a slime. Also, (**F**) mural nodule is observed during the cyst removal.

The demographic characteristics of our patient group are similar to the literature.

RCCs have been categorized based on location, radiologic, and pathologic features until now (Table 5). Potts et al.[10] have classified RCCs according to cyst location as pure sellar (type 1), sellar with suprasellar extension (type 2), and pure suprasellar (type 3), and have reported on the surgical outcomes. The authors found that pure sellar RCCs were the most common (n = 76/151, 50.3%).[10] Using the same classification, Solari et al.[16] have reported that the ratio of sellar cysts to suprasellar extension (intrasuprasellar) was 72.4% (n = 21/29). Hama et al.[8] have classified RCCs according to their histopathologic characteristics, wherein epithelial cell sorting was divided into 2 types, single or stratified, and subsequently examined by dividing them into subtypes. Within the same study, the authors also classified the duration of inflammation in the RCC epithelium and pituitary as acute, subacute, or chronic.[8] Hama et al.[8] reported that the acute stages of inflammation were associated with the single epithelial group, whereas the chronic stages were associated with the stratified group. Regarding the consistency of the RCCs, the authors only noted that the contents of 18 of the 20 cysts had a high viscosity coefficient. Kim et al.[9] have examined MRI features of RCCs and divided them into 3 main patterns. The first pattern comprised MRI features with hypointensity on T1-WI and hyperintensity on T2-WI, which represent the CSF-like cysts with single-cell layer wall. The second pattern comprised MRI features with hyperintensity on T1-WI and T2-WI, suggesting that mucoid materials influence the MRI intensity of this type of cysts. In the third pattern, MRI features were hyperintense on T1-WI and hypointense on T2-WI, and these are suggested to be the evidence of the presence of old blood. Additionally, although the content and color of RCCs were reported, no categorization was attempted according to intraoperative findings.[9]

Type A cases in our study consisted of RCCs containing fluid (serous, watery, CSF-like), and the proportion of this type was 16%. Similar proportions have been reported by Kim et al.[9] (16.3%), Billeci et al.[14] (21.4%, n = 3/14), and Brassier et al.[17] (25%; n = 4/16). Although the mean age (42.8 years) was higher than those in the other groups, we observed that all cysts included in this type had suprasellar extensions and characterized by visual symptoms due to optic chiasm

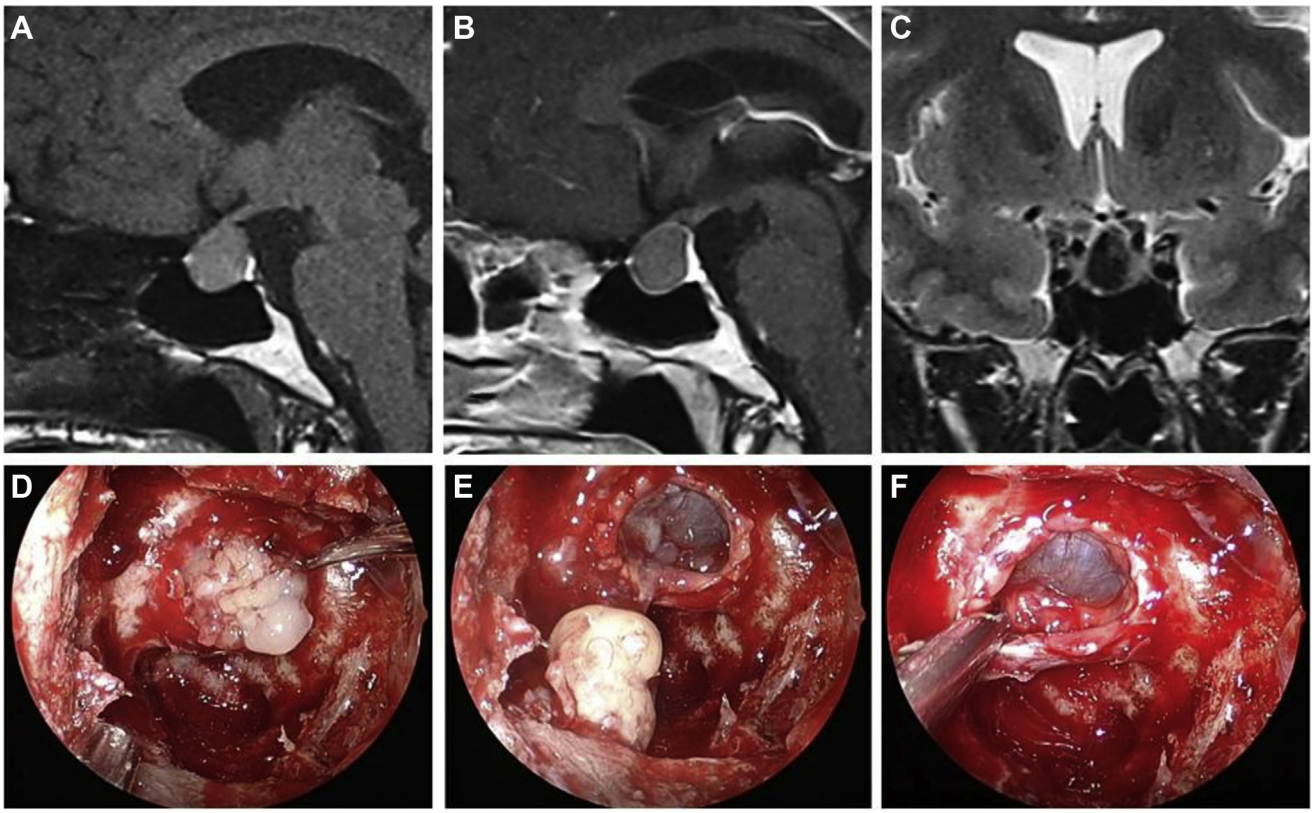

Figure 3. Representative case for type C (patient no. 22). Pituitary magnetic resonance imaging reveals (**A**) T1-weighted imaging hyperintense, (**B**) minimal circumferential contrast-enhanced cystic lesion. (**C**) The lesion is hyperintense on T2-weighted imaging and compressed to the optic chiasm. (**D**) Non-fluid, caseous content was encountered when the cyst wall was opened during the surgery. (**E**) The lesion was not dispersed and was removed as one piece after dissection. (**F**) After the cyst was removed, it was observed that the diaphragma sellae protruded into the field.

compression. Typically, no endocrine disorders were detected in any patient. Radiologic features of these cysts with fluidic-serous content were consistent with the first pattern according to the Kim et al.[9] classification and are similar to CSF with hypointensity on T1-WI and hyperintensity on T2-WI.[18] The mean volume of this type of cyst (2442.5 mm^3) was higher than that of the other types. These observations suggest that there is a significant correlation between large cyst size and visual impairment in our type A RCC. Further, visual impairment was seen in all cases in type A patients and the rate of visual deficits was significantly higher than that seen in other types. This is thought to be because the cystic contents do not contain proteinaceous material, which compresses the surrounding tissue without causing inflammation.[16] Therefore, without clinical or laboratory signs such as headache or endocrine disorders, compression of the optic chiasm leads to hidden visual disorders. The reason for the comparatively higher cyst volume may be because the cyst does not result in a clinical sign without reaching a significant size. Further, for the same reason, it is also possible that such cysts will be detected in the later years of life.

Type B, which included semi-fluid (mucoid, mucinous, and gelatinous) RCCs, was the most common type (68%) in this series. The proportion of this type, defined as RCC with high protein content, was 66.2% (n = 100/151) in the series of Potts et al.[10] In the series reported by Kim et al.,[9] the proportion of RCCs described as mucoid with gelatinous contents was 73% (n = 36/49). In the series by Nishioka et al.,[19] this ratio was 74% (n = 20/27), and in the series by Byun et al.,[20] it was 77% (n = 10/13). In the majority of these types of cases, the presenting symptom was headache (82.3%). Nonetheless, surgical resection of RCCs with headache as the only clinical finding still remains controversial as headache is a common symptom in the general population, and it is a subjective complaint with no guarantee of resolution after surgery.[21-23] A meta-analysis by Altuwaijri et al.,[21] which examined the results of 10 studies, reported that headache was relieved in about 70% of the patients after surgery for RCCs.

There are various theories explaining the symptomatology of type B RCCs in our study. One of them is that the mucoid contents lead to inflammation, subarachnoid infiltration, and a type of chemical meningitis; all of these lead to headache, chronic inflammation, and potential endocrine disorders in the long-term.[19,20,24] Therefore, we speculate that chronic headache due to RCCs is a predisposing factor for endocrine disorders. Importantly,

Table 5. Literature Review of Rathke's Cleft Cyst Classifications

Histopathologic Characteristics					
	Type of RCC Epithelium		**Duration of Inflammation in the RCC Epithelium**		
Hama et al., 2002[8]	Single	Stratified	Acute	Subacute	Chronic
Radiologic characteristics					
Kim et al., 2004[9]	First pattern (hypointensity on T1-WI and hyperintensity on T2-WI)		Second pattern (hyperintensity on T1-WI and T2-WI)		Third pattern (hyperintensity on T1-WI and hypointensity on T2-WI)
Anatomic localization					
Potts et al., 2011[10]	Type 1 (pure sellar)		Type 2 (sellar with suprasellar extension)		Type 3 (pure suprasellar)
Intraoperative consistency					
Present study	Type A (fluid)		Type B (semi-fluid)		Type C (non-fluid)

RCC, Rathke's cleft cyst; T1-WI, T1-weighted imaging; T2-WI, T2-weighted imaging.

endocrine disorders (52.9%) were most commonly seen in this type in our cohort, which may be related to the nature of the cystic contents. Additionally, as clinical symptoms manifest earlier than type A RCCs, type B cysts are relatively smaller in size than the other types. Not surprisingly, 41.2% of the type B cases had no suprasellar extension during the surgical intervention. These cysts are hyperintense on T1-WI and T2-WI and correspond to MRI features seen with the second pattern of the Kim et al.[9] classification.

The proportion of type C group, which included non-fluid (caseous, inspissated) RCCs, was 16% (n = 4/25). This proportion was 6.1% (n = 3/49) in the series reported by Kim et al.[9] The lower average age and lower female predominance, compared with the other types, are the most characteristic features in this subgroup. Another characteristic feature is the presence of intracystic nodules in all cases. Although hypointensity on T2-WI usually suggests the presence of blood,[9,25,26] we believe that similar radiologic features can be seen in solid-form RCCs, as seen here in our series.

It is known that intracystic nodules are encountered in some RCCs, and it has also been suggested that intracystic nodule is a distinct feature in establishing a correct radiologic diagnosis.[17] Pathologic examinations of intracystic nodule contents show that it is composed of mucin piles and it is biochemically composed of protein and cholesterol structures.[17,20,25] Further, the incidence of intracystic nodules increases as the fluidity of the cystic content decreases in our series (0% in type A, 58.8% in type B, and 100% in type C). Therefore, it is possible that the increase observed in nodule formation is due to greater viscosity or thickness of the cystic content, that is, cysts with water-like fluidity are poor in terms of intracystic material, and thus do not produce an intracystic nodule.

Occasionally, definitions of hemorrhagic, xanthochromic, or engine oil-like, are used when describing the contents of RCCs, and these may not provide sufficient information on cyst fluidity. Studies have reported that T1-WI hypointense, T2-WI hyperintense cysts have CSF-like content, whereas T1-WI hyperintense or isointense cysts generally have mucoid content with variable viscosity.[9,13,19,26] Here, MRI results and contents of RCCs were compared and validated through intraoperative endoscopic visualization. Furthermore, 3 neurosurgeons in our study retrospectively carried out a blinded examination of the cyst consistency through surgical videos, without having any additional radiologic information. The results of RCCs were integrated with MRI findings and cystic content analysis, and clinico-radiologic characteristics of each group were then delineated. Previous studies on RCCs, on the contrary, specifically investigated the MRI results without providing further information on their intraoperative data regarding the cyst consistency. Likewise, Billeci et al.[14] depicted 2 distinct MRI patterns of RCCs; T1-WI hypointense but T2-WI hyperintense oily cysts were considered as type A, whereas T2-WI iso-hypointense, hemorrhagic, and cholesterin-containing cysts were considered as type B. These authors described the cyst contents as citric oily fluid, yellowish mucinous, necrotic-hemorrhagic fluid, cholesterinic, purulent material and CSF-like, and they also used a wide range of colors to interpret the nature of the fluid.[14] As cystic contents in different colors could be seen in both type A (serous) and type B (mucoid) RCCs, we did not place special emphasis on the color difference of the cystic content and disregard this color change as a potent factor in our classification. Above all, Billeci et al.[14] did not classify the RCCs according to their consistency and present the clinico-radiologic characteristics of each group.

The proposed preoperative prediction scale for consistency of RCCs may provide a practical tool for more accurately estimating the nature of the pathology. Furthermore, we speculate that proposed predictive scale of RCCs may aid in planning a consistency-specific surgery, because most type A RCCs may only need a limited sellar opening when compared with that of type C RCCs.

Our study has some limitations including the drawbacks of a retrospective data analysis that can cause bias. In addition, a limited number of patients in a single tertiary center were included because of the low incidence of RCC. We accept that future works

might address the validation of our classification and the observations reported here be confirmed in longitudinal large-scale population series.

CONCLUSIONS

Our series describes one of the largest groups of RCC patients treated using EETSS. Although multiple studies have evaluated the characteristics of RCCs, to our knowledge, intraoperative validation of the cystic content and a classification based on these findings have not been reported so far. Here, consistency differences that can be observed intraoperatively were examined and 3 distinct patterns have been proposed. According to the consistency, it is observed that each type has its own specific demographic, clinical, and radiologic characteristics.

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