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Original Research

Anatomy of the sellar barrier: From magnetic resonance imaging to the operating room

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ABSTRACT

Background: The sellar barrier concept concerns the correlation between the components of the pituitary fossa roof and the risk of intraoperative cerebrospinal fluid (CSF) leak during pituitary tumor surgery. Our team previously classified the sellar barrier according to its thickness on contrast-enhanced T1-weighted magnetic resonance imaging (MRI) sections into three subtypes: strong, mixed or weak.
The purpose of this study is to complement the preoperative analysis of the sellar barrier with T2-weighted MRI sections to enhance our knowledge of the anatomical configuration of the sellar barrier and its correlation with the intraoperative findings.
Method: A retrospective descriptive study was performed in which medical records, neuroimaging and surgical videos of patients undergoing endoscopic endonasal surgery for pituitary tumors from January 2021 to January 2024 were reviewed. In all cases, the anatomy of the sellar barrier was evaluated by an expert neuroradiologist using pre-surgical T1-weighted MRI with gadolinium and T2-weighted images with sagittal and coronal cuts. Subsequently, the anatomical structures of the sellar barrier were compared with the direct endoscopic view observed in the operating room.
Results: A total of 108 patients were included in this study. According to the preoperative neuroimaging findings, an experienced neuroradiologist classified the type of sellar barrier as strong, mixed or weak. Additionally, the T2-weighted imaging study was systematically implemented to identify the anatomical components of the sellar barrier. We found a high correlation between the preoperative neuroimaging description and the intraoperative endoscopic view of the sellar barrier. We present eight illustrative cases herein.
Conclusions: The use of T2-weighted sequences in conjunction with gadolinium-enhanced T1-weighted images enhances the preoperative knowledge of the sellar barrier by discriminating its anatomical components with high precision. As in any neurosurgical procedure, a detailed preoperative neuroimaging study and evaluation is highly recommended in order to offer the best possible treatment to our patients affected by pituitary tumors.

1. Introduction

Cerebrospinal fluid (CSF) leaks are one of the most feared and frequent potential complications in transsphenoidal surgery for pituitary tumors. The interface between a pituitary tumor and suprasellar CSF is formed by three different layers: the arachnoid (the only constant structure), the dura mater of the sellar diaphragm and the pituitary gland [1].

According to this anatomical configuration, our team has previously classified the sellar barrier into three different subtypes based on the thickness of the sellar barrier on gadolinium-enhanced T1-weighted magnetic resonance imaging (MRI) images as follows: (1) strong, with a sellar barrier thicker than 1 mm; (2) weak, with a sellar barrier thinner than 1 mm and (3) mixed, in which a sellar barrier has both strong and weak areas [2,3]. It has also been demonstrated, in both retrospective and prospective studies, that the type of sellar barrier present is

Abbreviations: CSF, cerebrospinal fluid; CSS, suprasellar cistern; MRI, magnetic resonance imaging.

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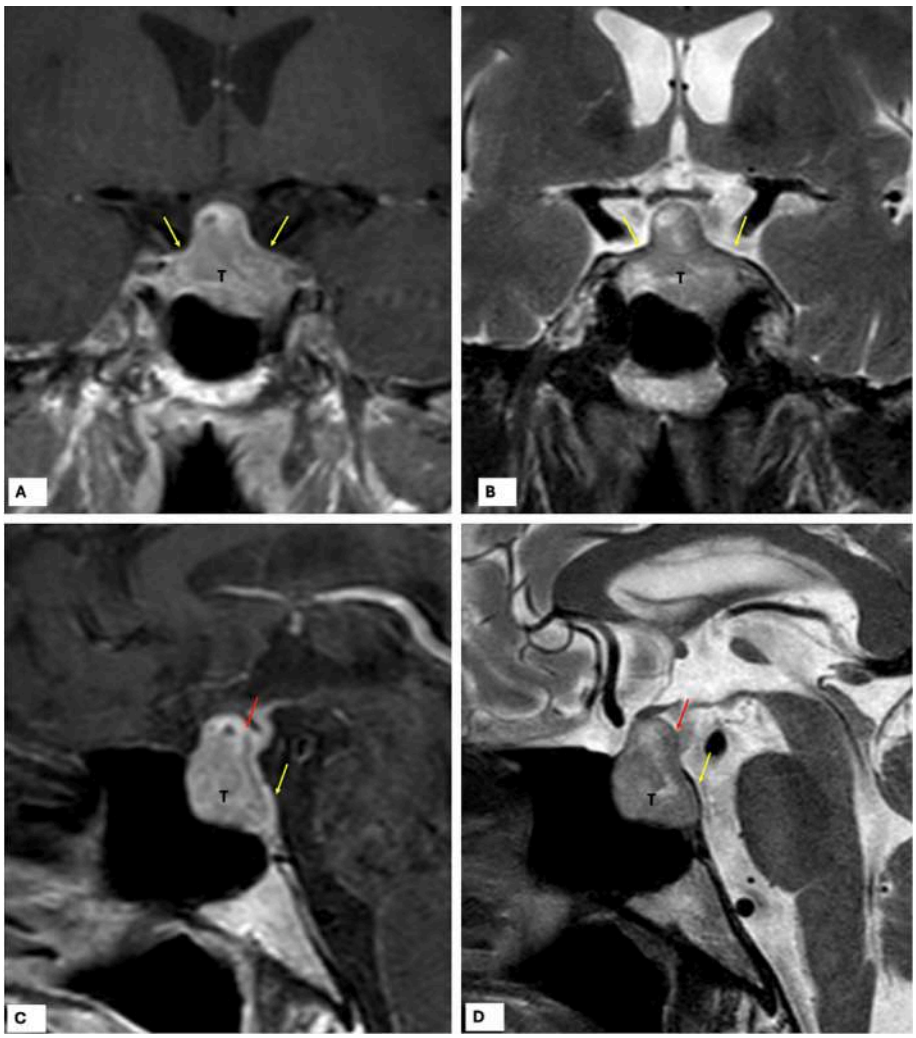

Fig. 1. Illustrative Case 1: Mixed sellar barrier. A–B, Coronal T1-weighted contrast-enhanced and T2-weighted sections are shown. **C–D,** Sagittal T1-weighted contrast-enhanced and T2-weighted slices. The tumor (T) is seen in contact with the optic chiasm. Yellow arrows—dura mater of the sellar diaphragm, red arrows—pituitary gland.

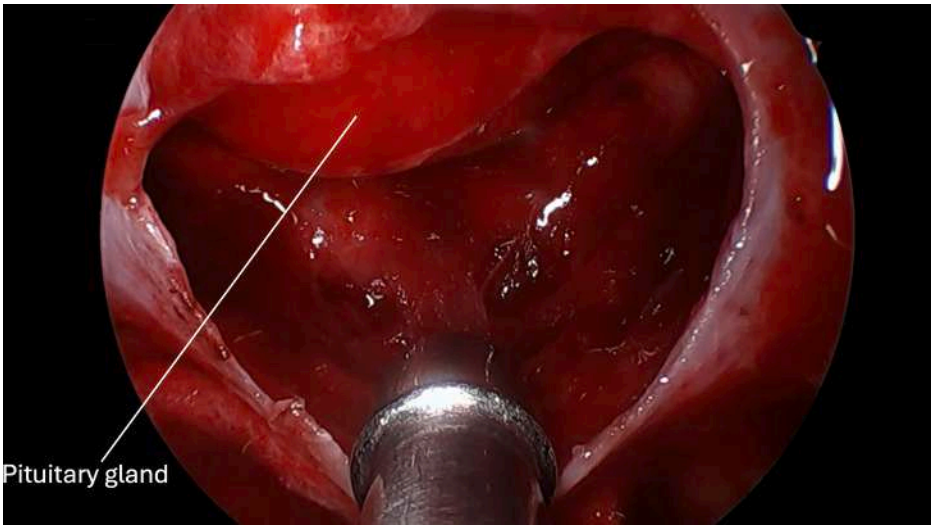

Fig. 2. Illustrative Case 1: Mixed sellar barrier. Endoscopic endonasal view of the sellar barrier. A correlation can be observed with the preoperative MRI findings, as the sellar barrier mainly comprises the pituitary gland.

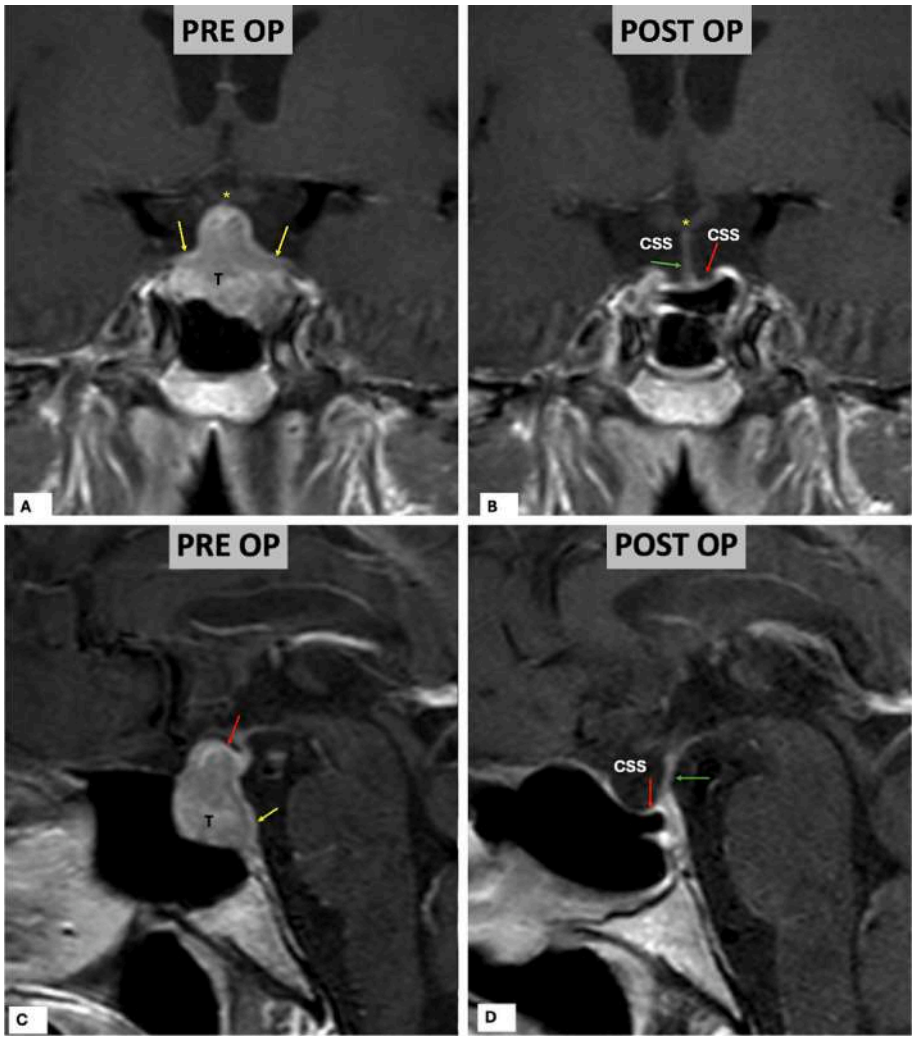

Fig. 3. Illustrative Case 1: Mixed sellar barrier. A–B, Pre- and postoperative evaluation with coronal T1-weighted contrast-enhanced sections. **C–D,** Pre- and postoperative evaluation with sagittal T1-weighted contrast-enhanced sections. A complete resection is shown. The free suprasellar cistern and the pituitary gland on the floor of the sella are also visible, as is the tumor (T). PRE OP—preoperative, POST OP—postoperative, yellow arrows—the dura mater of the sellar diaphragm, red arrows—pituitary gland, green arrows—infundibulum, CSS—suprasellar cistern, *—optic chiasm.

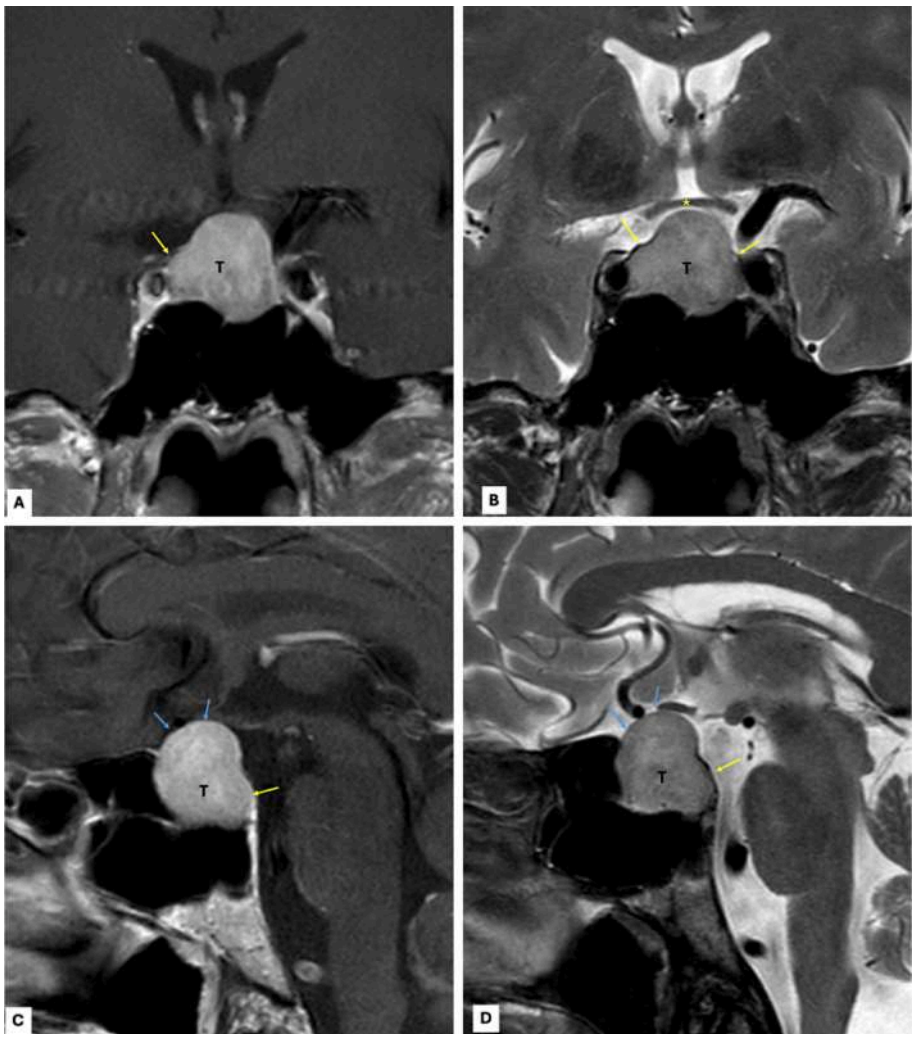

Fig. 4. Illustrative Case 2: Weak sellar barrier. A–B, Coronal T1-weighted contrast-enhanced and T2-weighted slices. **C–D,** Sagittal T1-weighted contrast-enhanced and T2-weighted sagittal slices are shown. T—pituitary tumor, yellow arrows—dura mater of the sellar diaphragm, blue arrows—arachnoid, *—optic chiasm.

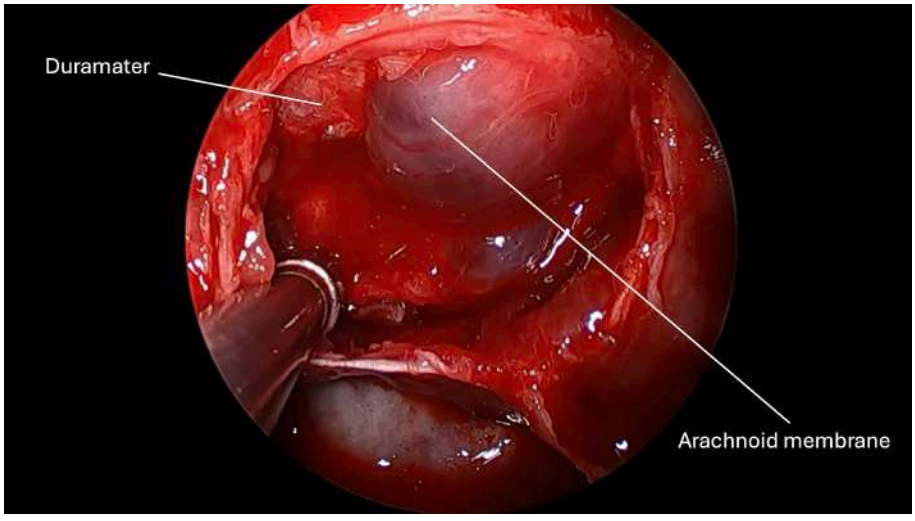

Fig. 5. Illustrative Case 2: Weak sellar barrier. Intraoperative endoscopic endonasal view of the sellar barrier, in this case composed mainly of arachnoid. The dura mater of the sellar diaphragm can be seen toward the most lateral part of the sellar barrier.

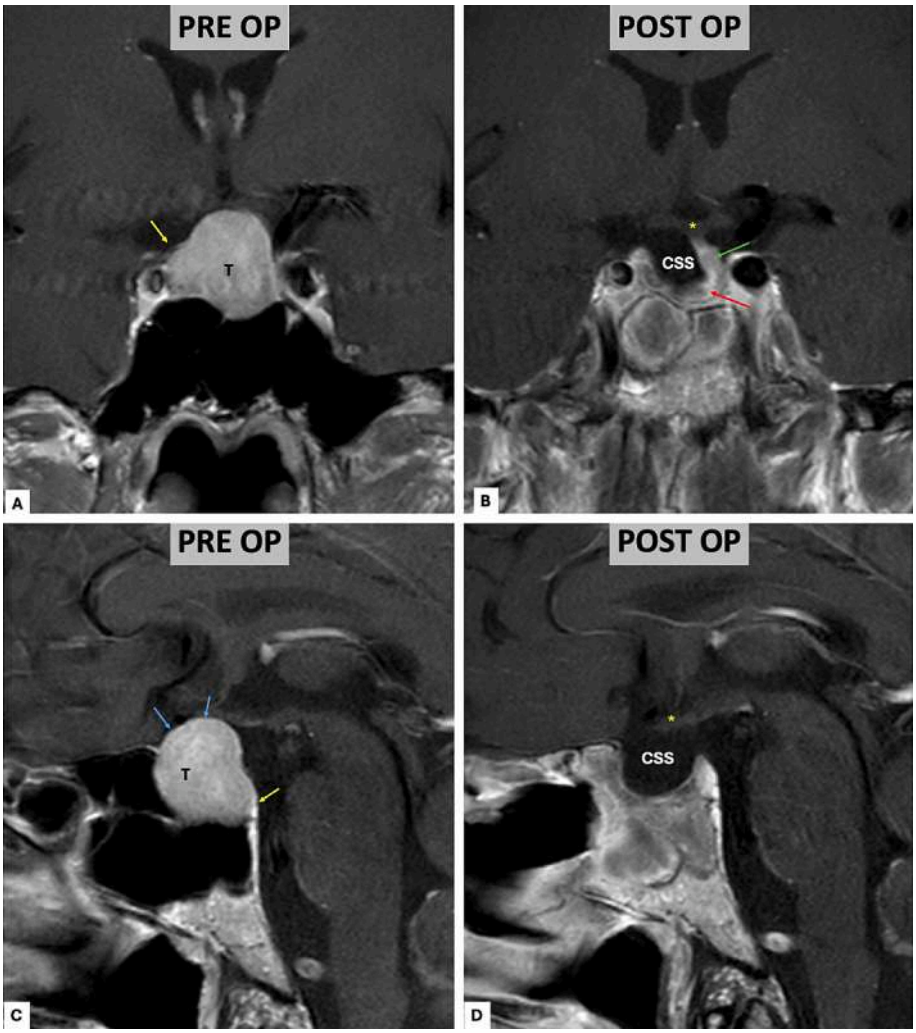

Fig. 6. Illustrative Case 2: Weak sellar barrier. A–B, Pre- and postoperative evaluation with coronal T1-weighted contrast-enhanced sections. **C–D,** Pre- and postoperative evaluation with sagittal T1-weighted contrast-enhanced sections. A complete resection is shown, with the free suprasellar cistern and the pituitary gland to the left on the floor of the sella. The tumor is marked (T). PRE OP—preoperative, POST OP—postoperative, yellow arrows—the dura mater of the sellar diaphragm, red arrows—the pituitary gland, green arrow—the infundibulum, blue arrows—arachnoid, CSS—suprasellar cistern, *—optic chiasm.

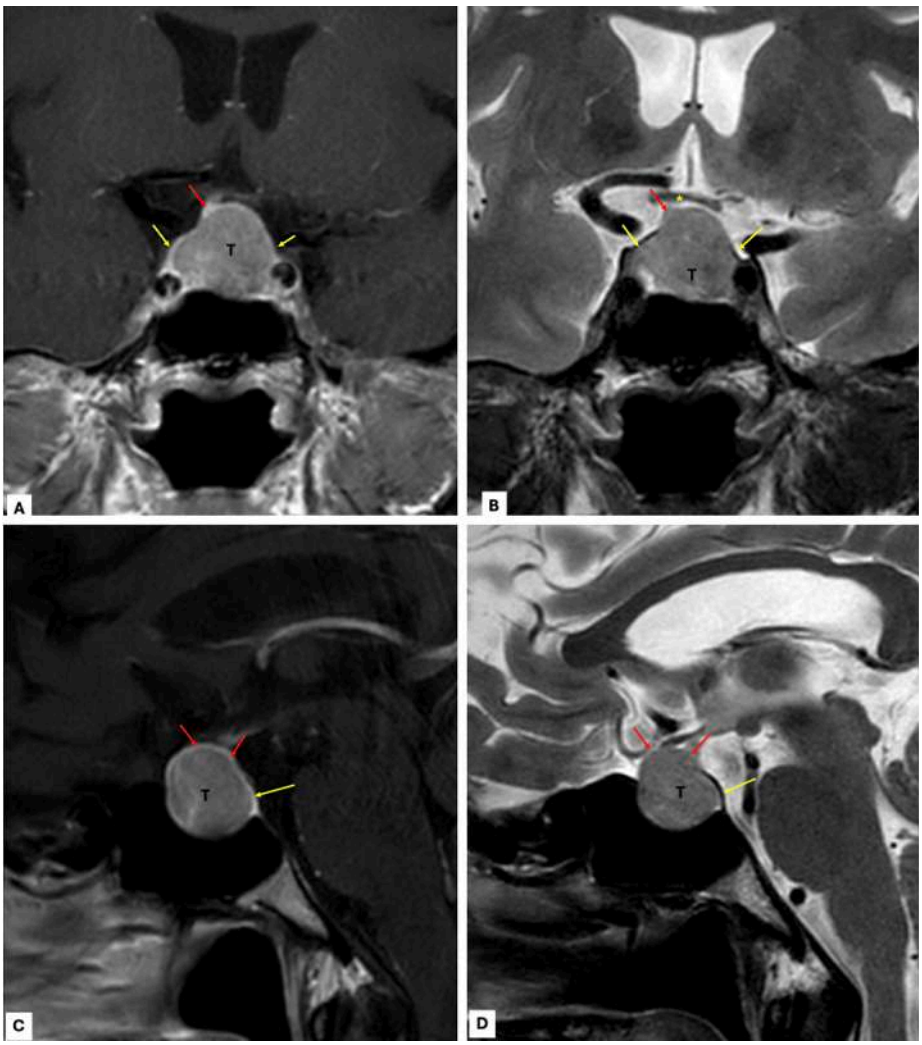

Fig. 7. Illustrative Case 3: Strong sellar barrier. A–B, Coronal T1-weighted contrast-enhanced and T2-weighted slices. **C–D,** Sagittal T1-weighted contrast-enhanced and T2-weighted sagittal slices are shown. T—pituitary tumor, yellow arrows—dura mater of the sellar diaphragm, red arrows—pituitary gland, *—optic chiasm.

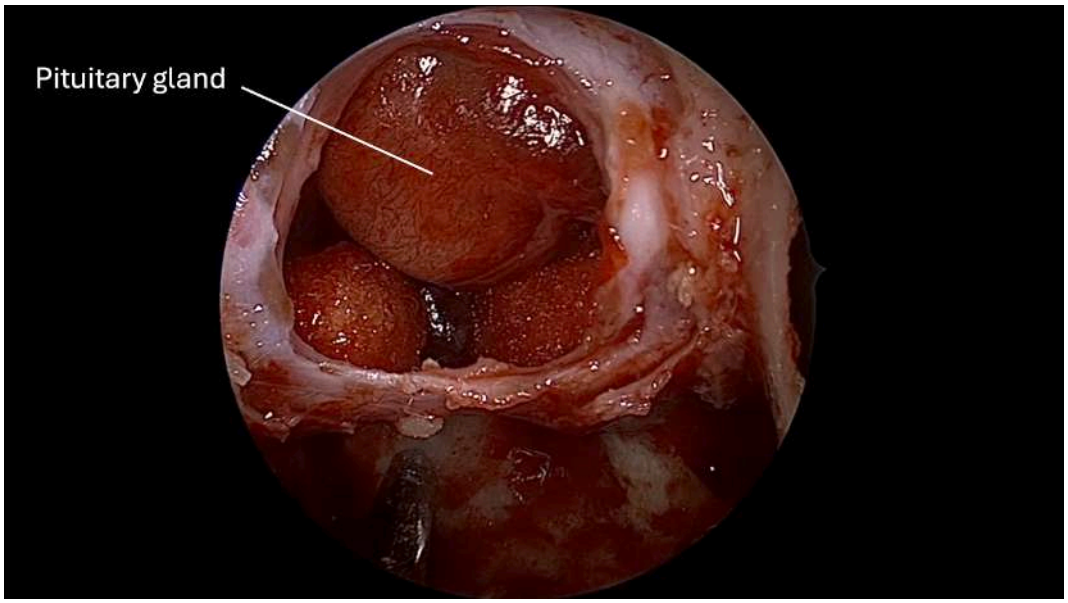

Fig. 8. Illustrative Case 3: Strong sellar barrier. Intraoperative endoscopic endonasal view of the sellar barrier, which in this case is composed mainly of the pituitary gland.

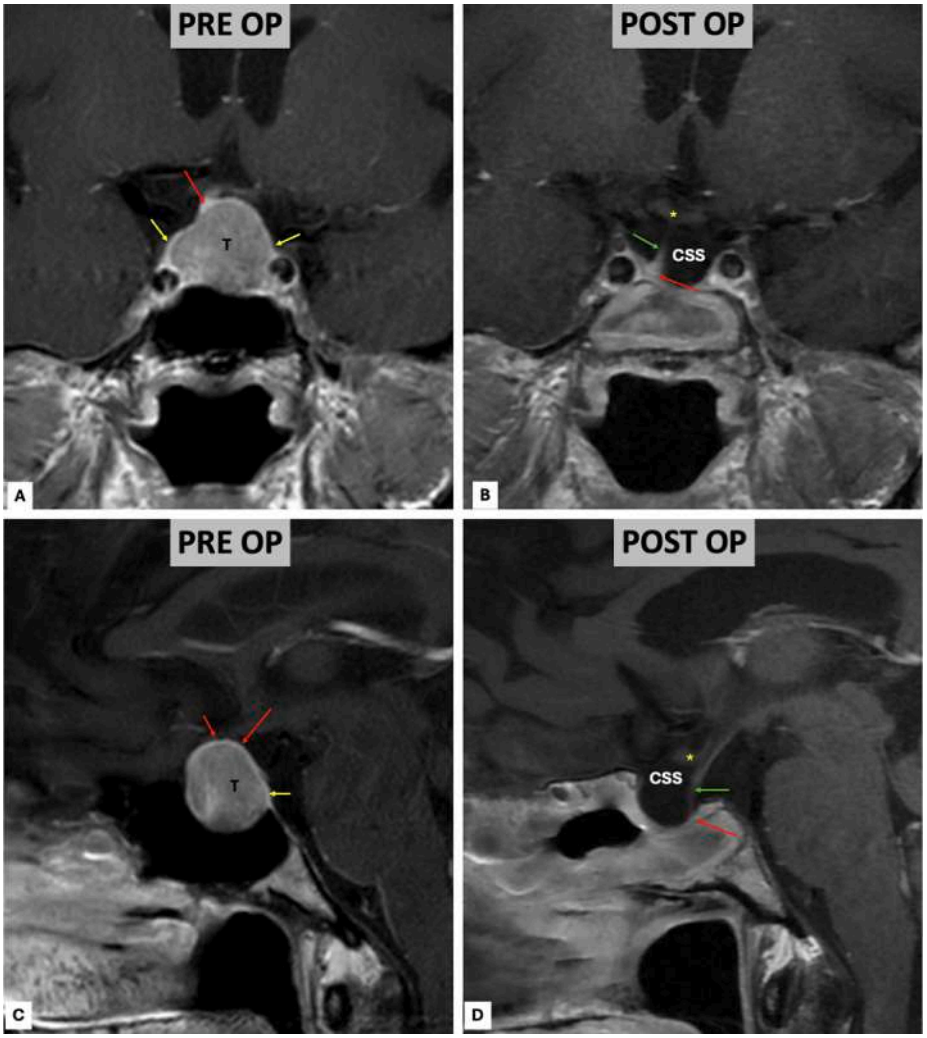

Fig. 9. Illustrative Case 3: Strong sellar barrier. A–B, Pre- and postoperative evaluation with coronal T1-weighted contrast-enhanced sections. **C–D,** Pre- and postoperative evaluation with sagittal T1-weighted contrast-enhanced sections. A complete resection is shown, with the free suprasellar cistern and the pituitary gland to the right on the floor of the sella. The tumor (T) is marked. PRE OP—preoperative, POST OP—postoperative, yellow arrows—the dura mater of the sellar diaphragm, red arrows—the pituitary gland, green arrow—infundibulum, CSS—suprasellar cistern, *—optic chiasm.

Fig. 10. Illustrative Case 4: Weak sellar barrier. A–B, Coronal T1-weighted contrast-enhanced and T2-weighted slices. **C–D,** Sagittal T1-weighted contrast-enhanced and T2-weighted sagittal slices are shown. T—pituitary tumor, yellow arrows—dura mater of the sellar diaphragm, blue arrows—arachnoid, red arrows—pituitary gland, *—optic chiasm.

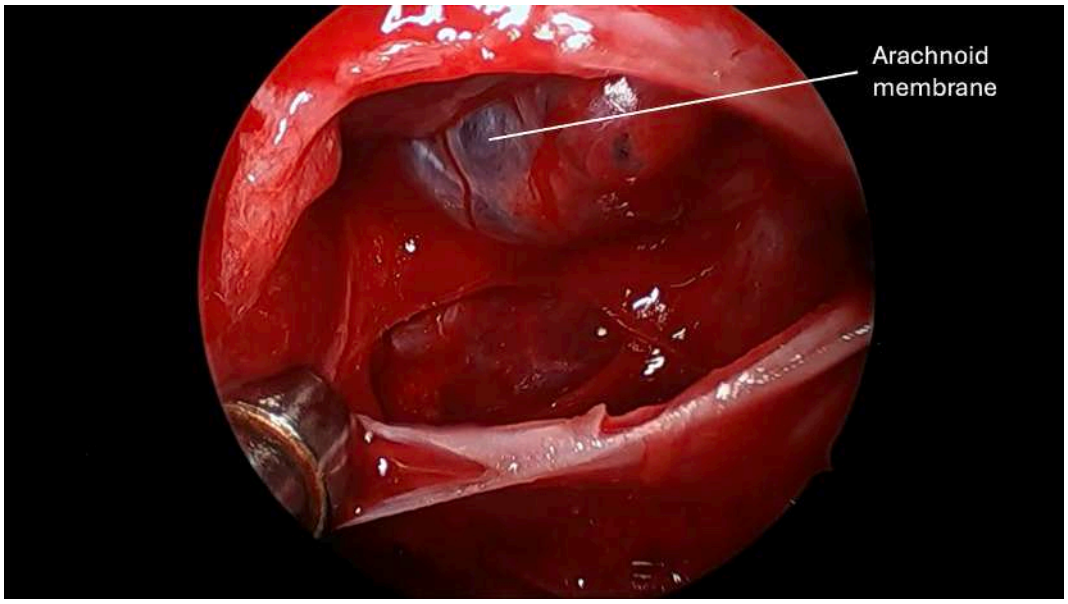

Fig. 11. Illustrative Case 4: Weak sellar barrier. Intraoperative endoscopic endonasal view of the sellar barrier, which in this case is composed mainly of arachnoid.

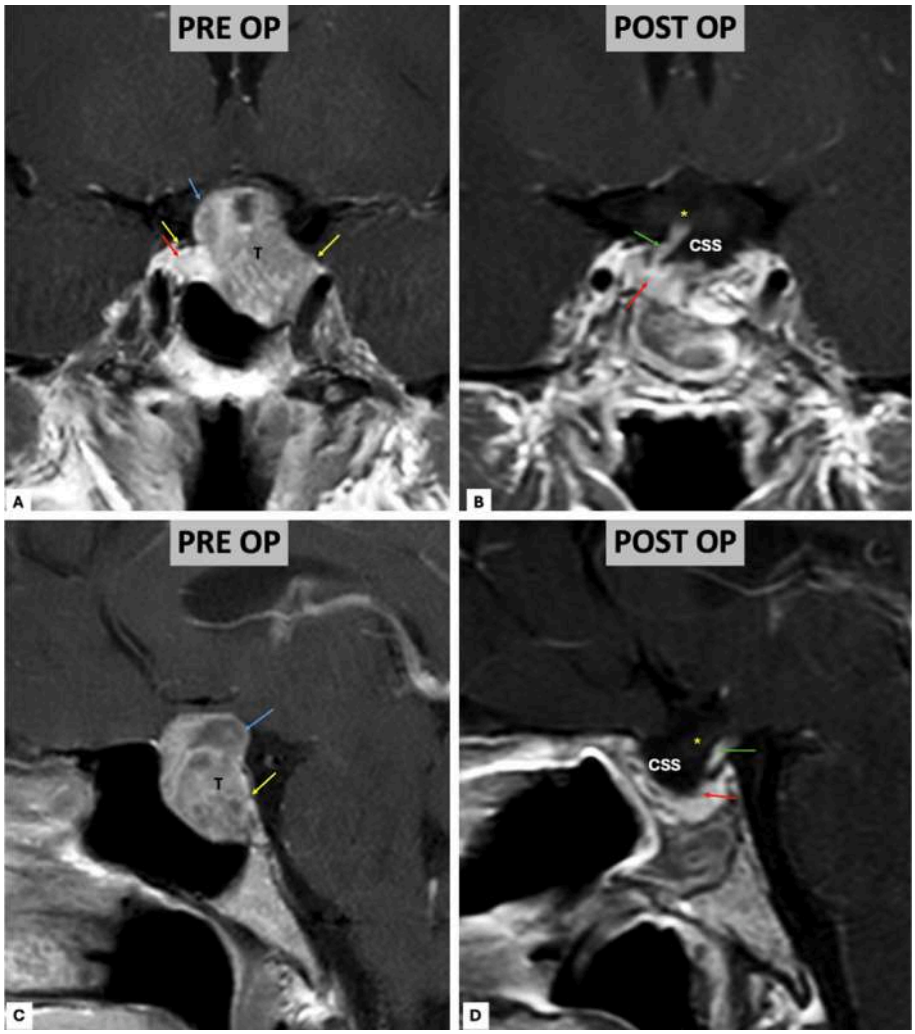

Fig. 12. Illustrative Case 4: Weak sellar barrier. A–B, Pre- and postoperative evaluation with coronal T1-weighted contrast-enhanced sections. **C–D,** Pre- and postoperative evaluation with sagittal T1-weighted contrast-enhanced sections. A complete resection is shown, with the free suprasellar cistern and the pituitary gland to the right on the floor of the sella. The preserved pituitary stalk is visible. PRE OP—preoperative, POST OP—postoperative, T—pituitary tumor, yellow arrows—the dura mater of the sellar diaphragm, red arrows—the pituitary gland, green arrow—infundibulum, blue arrows—arachnoid, CSS—suprasellar cistern, *—optic chiasm.

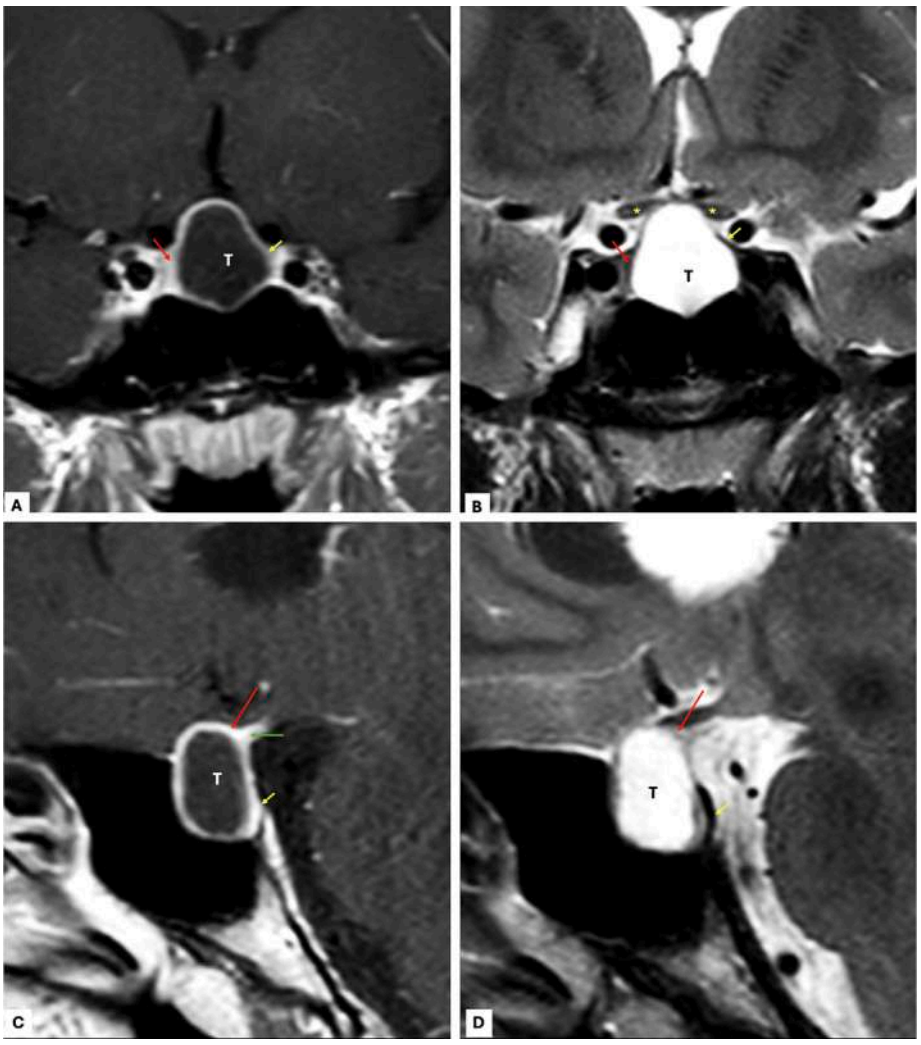

Fig. 13. Illustrative Case 5: Strong sellar barrier. A–B, Coronal T1-weighted contrast-enhanced and T2-weighted slices. **C–D,** Sagittal T1-weighted contrast-enhanced and T2-weighted sagittal slices are shown. T—pituitary tumor, yellow arrows—dura mater of the sellar diaphragm, green arrows—infundibulum, red arrows—pituitary gland, *—optic chiasm.

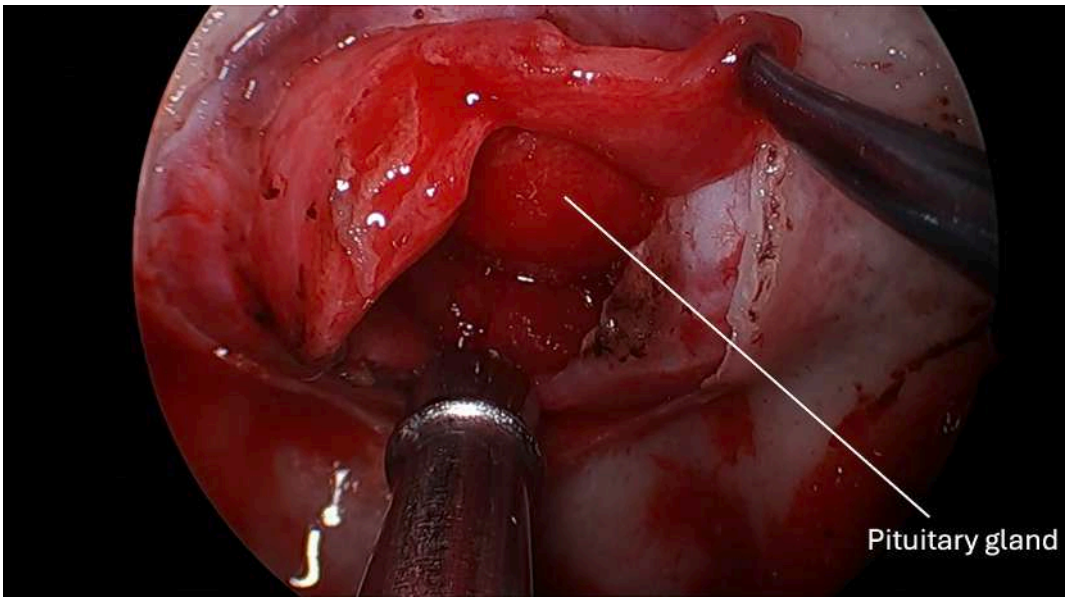

Fig. 14. Illustrative Case 5: Strong sellar barrier. Intraoperative endoscopic endonasal view of the sellar barrier which in this case composed mainly of pituitary gland.

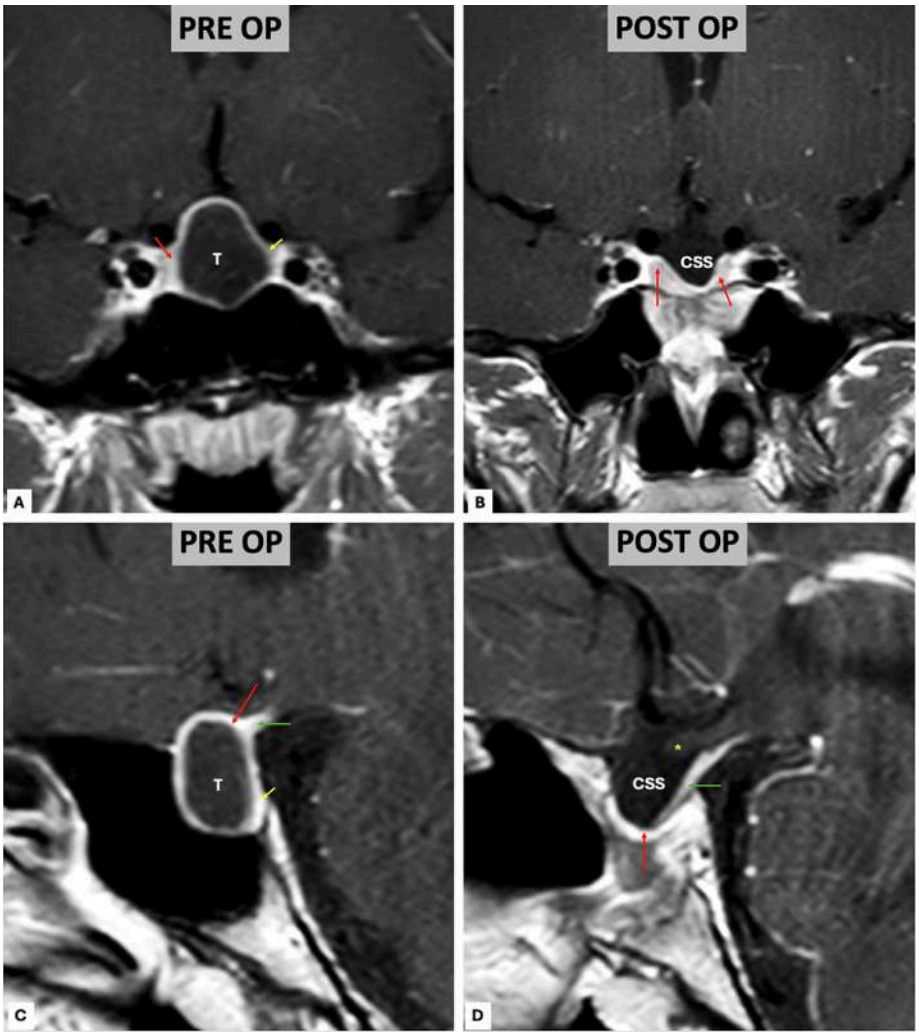

Fig. 15. Illustrative Case 5: Strong sellar barrier. A–B, Pre- and postoperative evaluation with coronal T1-weighted contrast-enhanced sections. **C–D,** Pre- and postoperative evaluation with sagittal T1-weighted contrast-enhanced sections. A complete resection is shown, with the free suprasellar cistern and the pituitary gland on the floor of the sella. The preserved pituitary stalk is visible. PRE OP—preoperative, POST OP—postoperative, T—pituitary tumor, yellow arrows—the dura mater of the sellar diaphragm, red arrows—the pituitary gland, green arrows—infundibulum, CSS—suprasellar cistern, *—optic chiasm.

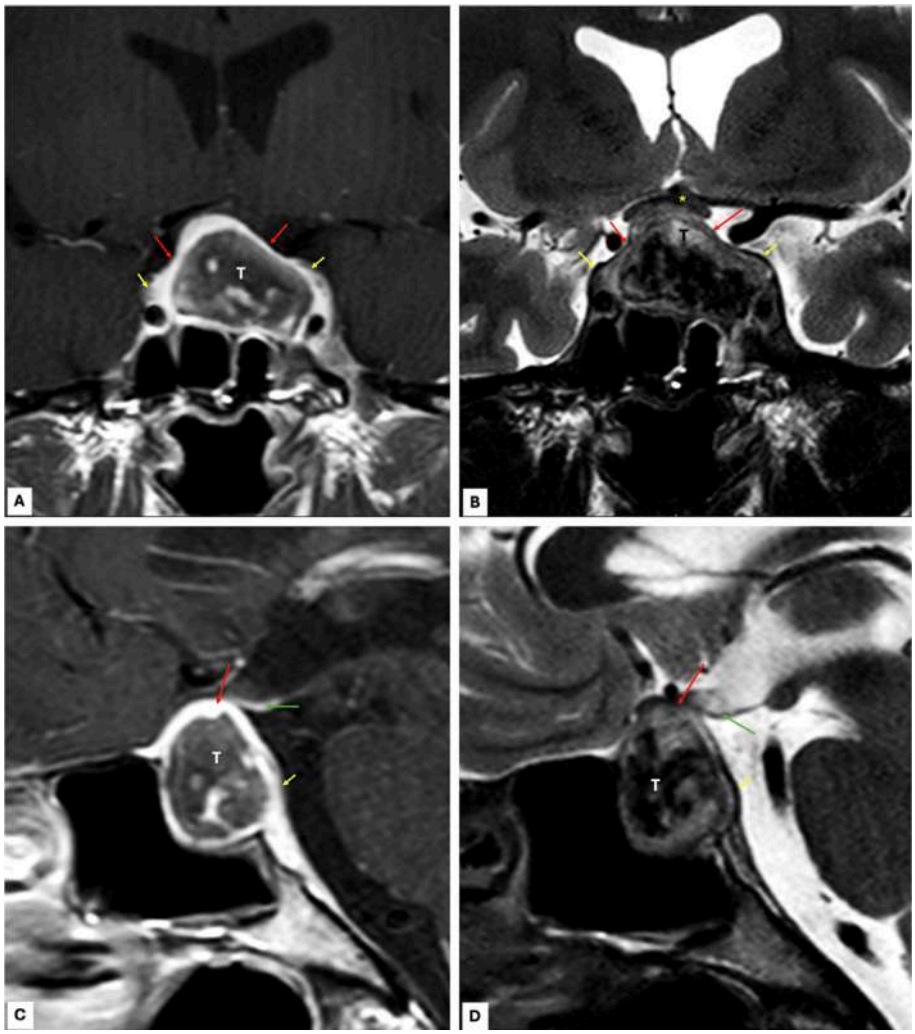

Fig. 16. Illustrative Case 6: Strong sellar barrier. A–B, Coronal T1-weighted contrast-enhanced and T2-weighted slices. **C–D,** Sagittal T1-weighted contrast-enhanced and T2-weighted sagittal slices are shown. T—pituitary tumor, yellow arrows—dura mater of the sellar diaphragm, green arrows—infundibulum, red arrows—pituitary gland, *—optic chiasm.

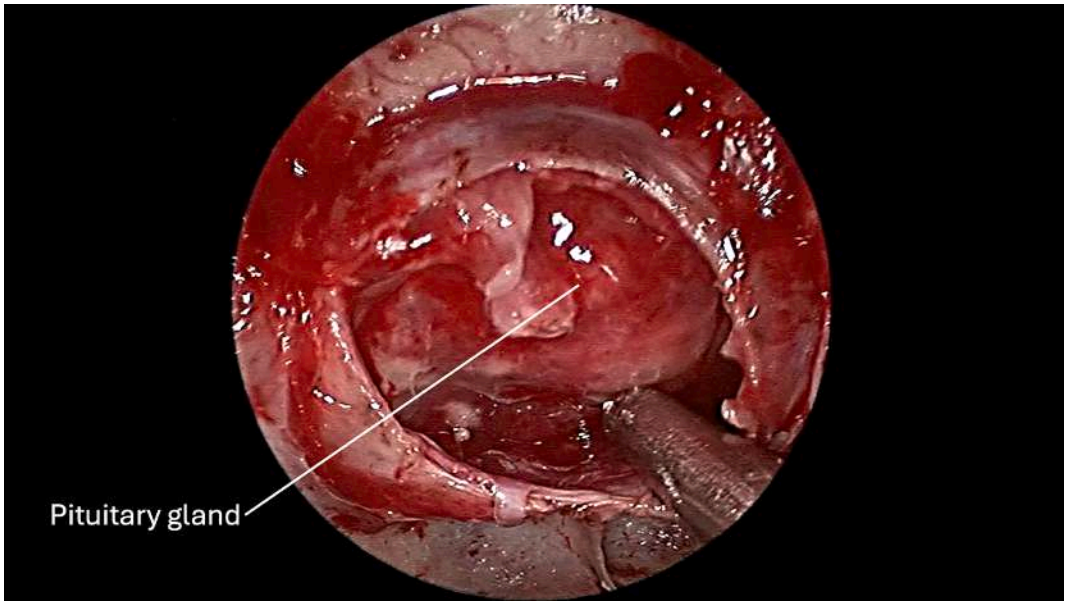

Fig. 17. Illustrative Case 6: Strong sellar barrier. Intraoperative endoscopic endonasal view of the sellar barrier, which in this case is composed mainly of pituitary gland.

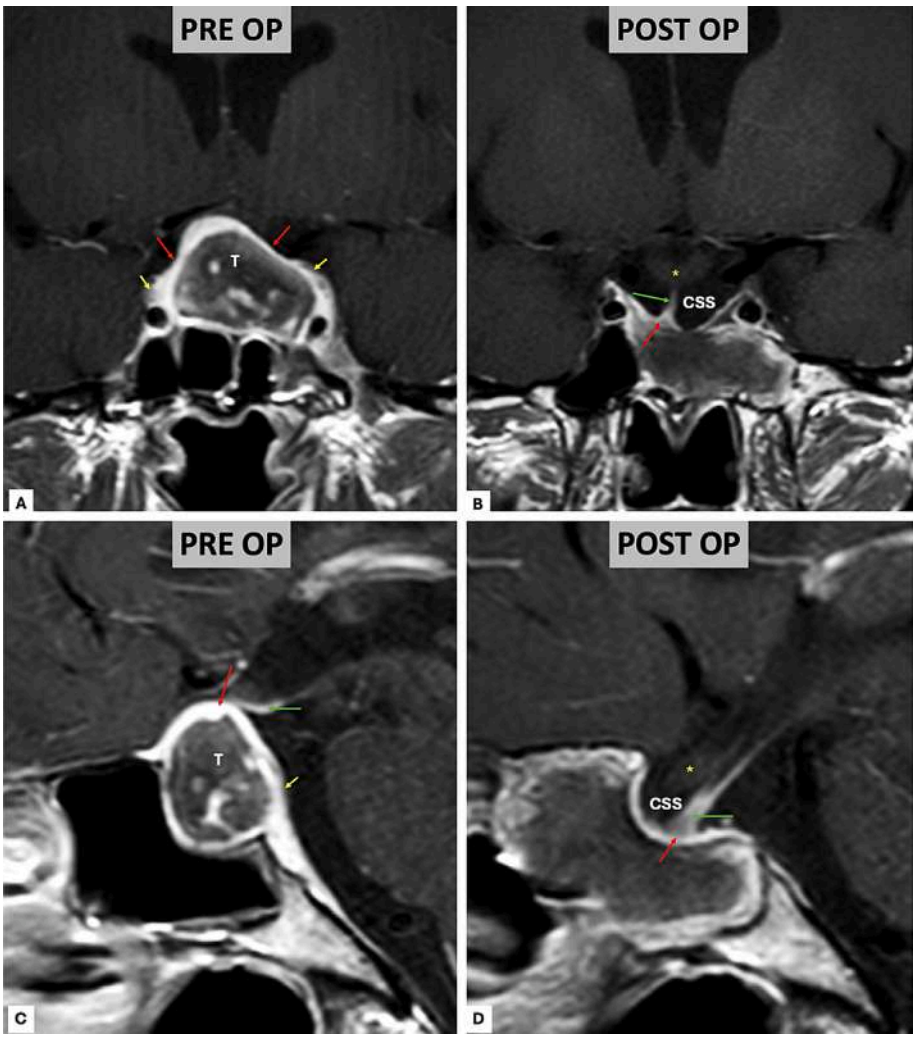

Fig. 18. Illustrative Case 6: Strong sellar barrier. A–B, Pre- and postoperative evaluation with coronal T1-weighted contrast-enhanced sections. **C–D,** Pre- and postoperative evaluation with sagittal T1-weighted contrast-enhanced sections. A complete resection is shown, with the free suprasellar cistern and the pituitary gland on the floor of the sella. The preserved pituitary stalk is visible. PRE OP—preoperative, POST OP—postoperative, T—pituitary tumor, yellow arrows—the dura mater of the sellar diaphragm, red arrows—the pituitary gland, green arrows—infundibulum, CSS—suprasellar cistern, *—optic chiasm.

significantly associated with the incidence of intraoperative CSF leak during the endoscopic endonasal approach for pituitary tumor resection [1,3].

We have previously considered the T1-weighted with gadolinium MRI process as the best single approach to use to evaluate the sellar barrier. The objective of the present study is to enhance the preoperative evaluation of the sellar barrier by additionally using T2-weighted MRI, with the aim of increasing our knowledge of the anatomical composition of the sellar barrier and its correlation with intraoperative findings.

2. Methods and materials

A retrospective descriptive study was conducted in which the medical records, neuroimaging and surgical videos of all patients undergoing endonasal endoscopic surgery for pituitary tumors from January 2021 to January 2024 were reviewed. All surgeries were performed in Argentina by the senior authors of the team (LINT, Tucumán). All procedures performed in the study involving human participants were in accordance with ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments. Written Informed consent to participate and for publication was obtained from all individual participants included in the study.

The anatomy of the sellar barrier was analyzed in all cases by an expert neuroradiologist using preoperative MRI images, T1-weighted sequences with gadolinium and T2-weighted sequences in sagittal and coronal slices (Signa HDxt 1.5 T MRI [GE Healthcare, Chicago, Illinois, USA]). Kodak Carestream PACSeClient Suite software, V10, (Kodak, Rochester, New York, USA) was used to measure the sellar barrier components. Measurements were taken in the cephalocaudal direction in different sections of the coronal and sagittal planes.

In a retrospective and blinded form, the anatomical structures of the sellar barrier described by the neuroradiologist were compared with the intraoperative endoscopic video recordings of the sellar barrier that were observed during the surgery in the operating room. Patients who did not comply with the preoperative MRI protocol were excluded from the study, as were patients without an intraoperative recording of the endoscopic view of the endonasal barrier after tumor resection.

3. Results

A total of 108 patients with pituitary tumors who underwent transsphenoidal endoscopic surgery and met the inclusion criteria were included in this study. According to the neuroimaging findings from T1-weighted gadolinium-enhanced MRI, a neuroradiologist classified the sellar barrier of all 108 patients as weak, mixed or strong.

An evaluation of T2-weighted MRI imaging was also implemented in

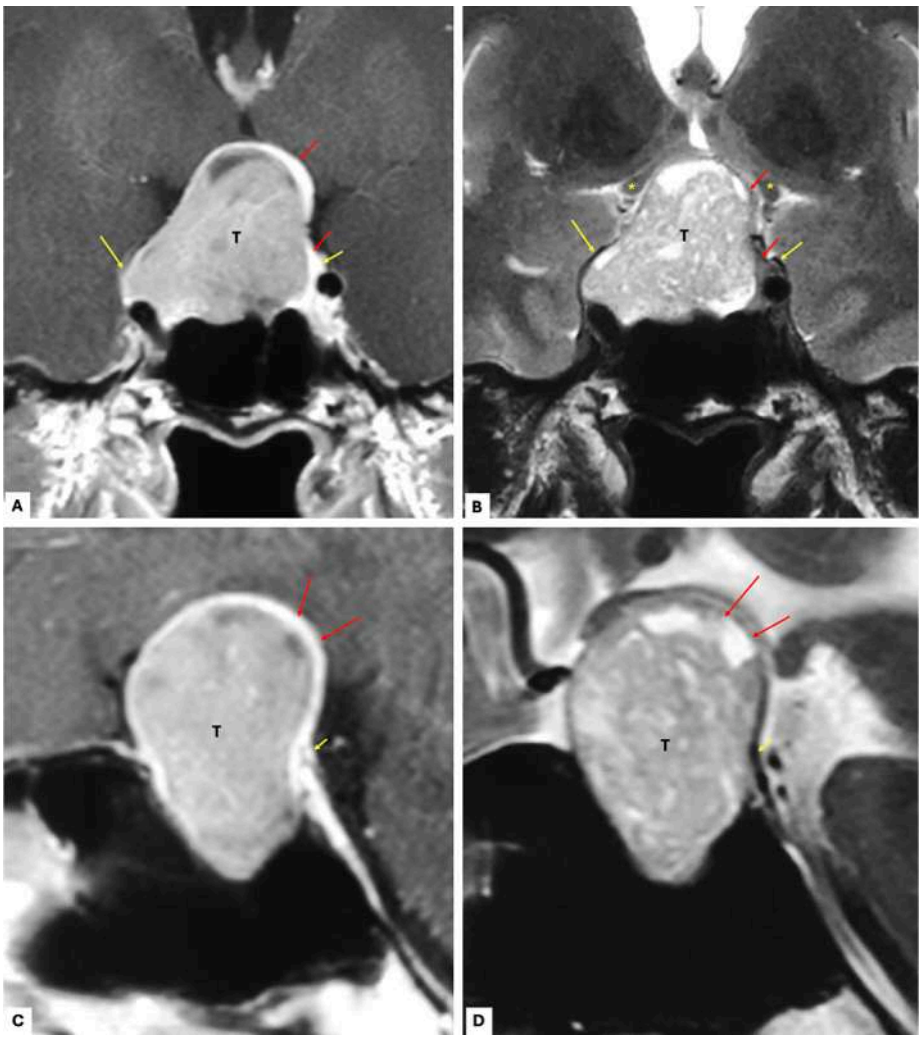

Fig. 19. Illustrative Case 7: Strong sellar barrier. A–B, Coronal T1-weighted contrast-enhanced and T2-weighted slices. **C–D,** Sagittal T1-weighted contrast-enhanced and T2-weighted sagittal slices are shown. T—pituitary tumor, yellow arrows—dura mater of the sellar diaphragm, red arrows—pituitary gland, *—optic chiasm.

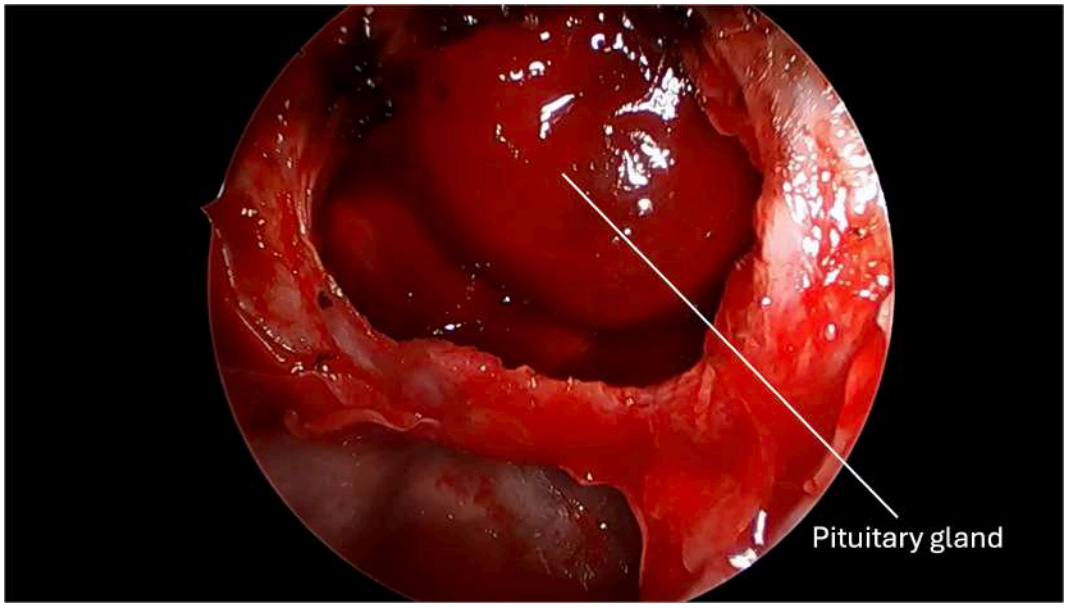

Fig. 20. Illustrative Case 7: Strong sellar barrier. Intraoperative endoscopic endonasal view of the sellar barrier composed mainly of pituitary gland.

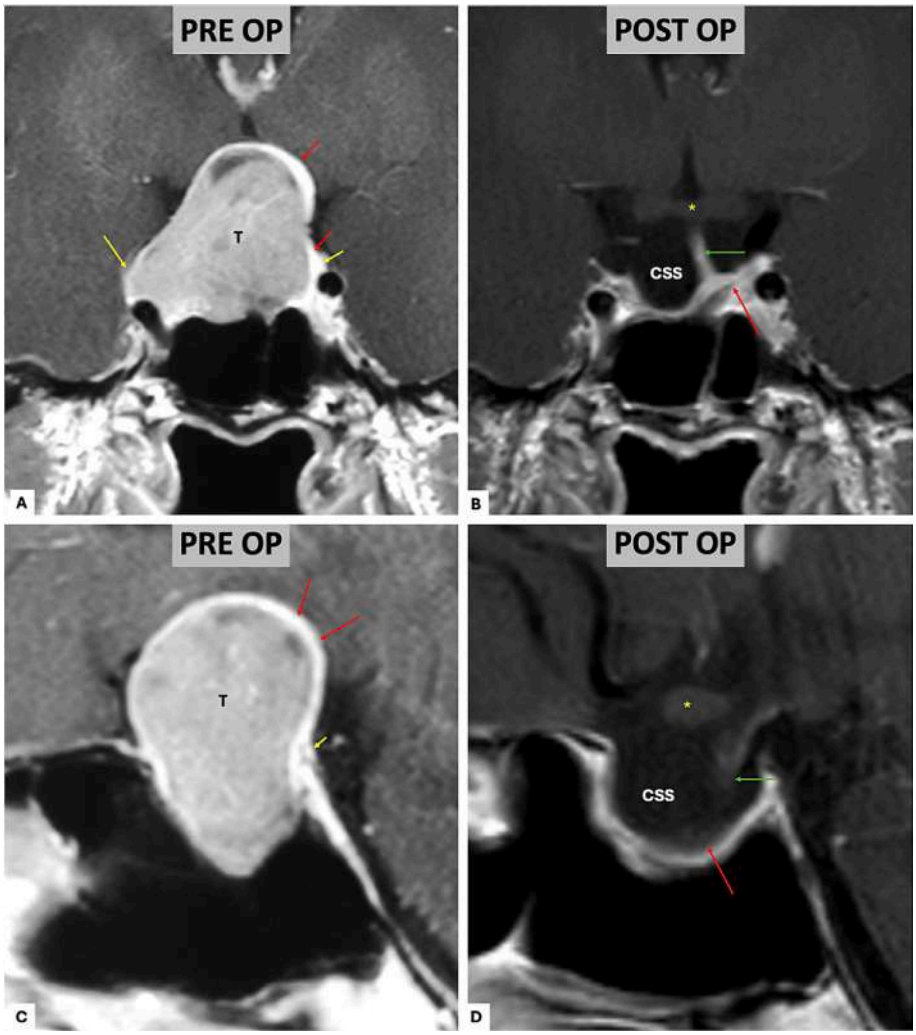

Fig. 21. Illustrative Case 7: Strong sellar barrier. A–B, Pre- and postoperative evaluation with coronal T1-weighted contrast-enhanced sections. **C–D,** Pre- and postoperative evaluation with sagittal T1-weighted contrast-enhanced sections. A complete resection is shown, with the free suprasellar cistern and the pituitary gland on the floor of the sella to the left side. The preserved pituitary stalk is visible. PRE OP—preoperative, POST OP—postoperative, T—pituitary tumor, yellow arrows—the dura mater of the sellar diaphragm, red arrows—the pituitary gland, green arrows—infundibulum, CSS—suprasellar cistern, *—optic chiasm.

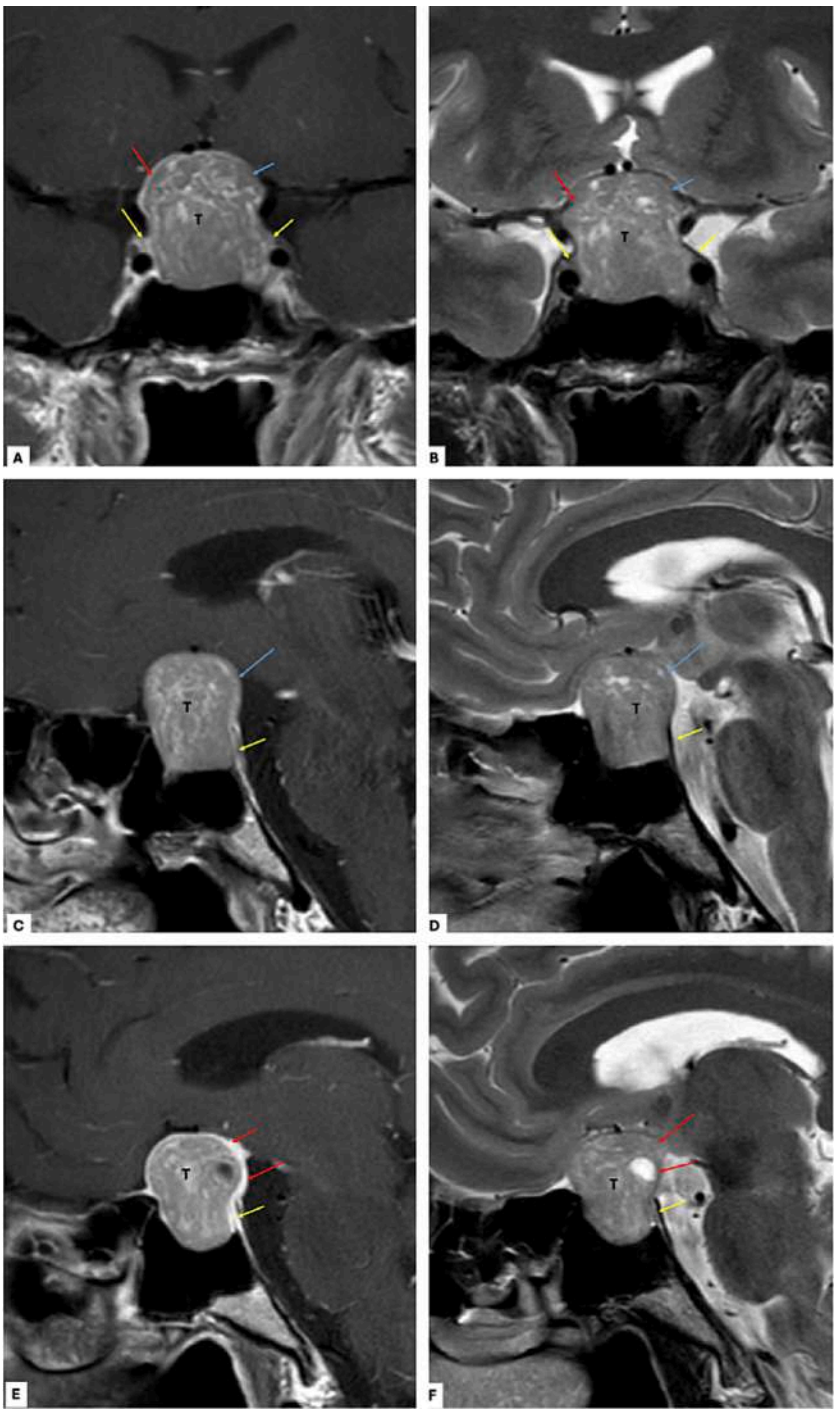

Fig. 22. Illustrative Case 8: Mixed sellar barrier. A–B, Coronal T1-weighted contrast-enhanced and T2-weighted slices. **C–F,** Sagittal T1-weighted contrast-enhanced and T2-weighted sagittal slices are shown. T—pituitary tumor, yellow arrows—dura mater of the sellar diaphragm, blue arrows—arachnoid, red arrows—pituitary gland.

all cases to characterize the anatomical components of the sellar barrier and discriminate whether it was composed of arachnoid, dura mater of the sellar diaphragm, pituitary gland or a mix of these.

In a retrospective and blinded form, the preoperative neuroimaging descriptions were correlated with the recordings obtained during endoscopic endonasal surgery of the sellar barrier, demonstrating a high degree of correlation between the findings from these two analysis.

We present here eight illustrative cases for which we discuss the type and anatomical components of the sellar barrier in the preoperative neuroimaging evaluation and the intraoperative correlation under direct endoscopic vision.

Illustrative Case 1

Patient with pituitary macroadenoma. A mixed sellar barrier is observed, which is composed mainly of the pituitary gland and the dura of the sellar diaphragm. The pituitary gland is typically contrast-enhancing and is isointense on T2 sequence, unlike the dura, which is contrast-enhancing and hypointense on T2 (Figs. 1-3).

Illustrative Case 2

Patient with pituitary macroadenoma. A weak sellar barrier is observed that is composed mainly of arachnoid. The arachnoid is

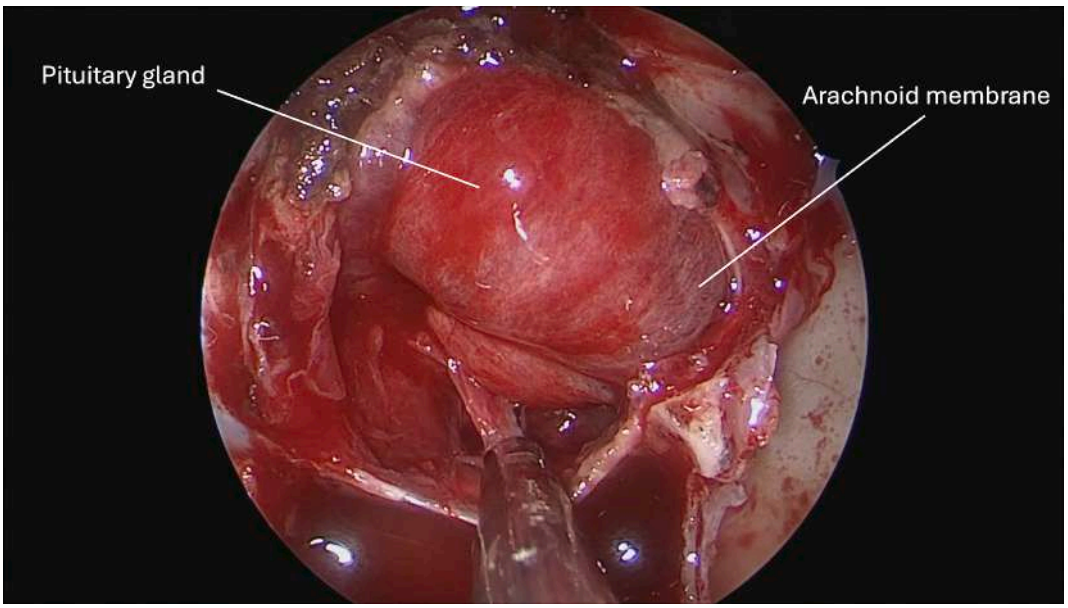

Fig. 23. Illustrative Case 8: Mixed sellar barrier. Intraoperative endoscopic endonasal view of the sellar barrier composed of pituitary gland to the right and the arachnoid membrane to the left.

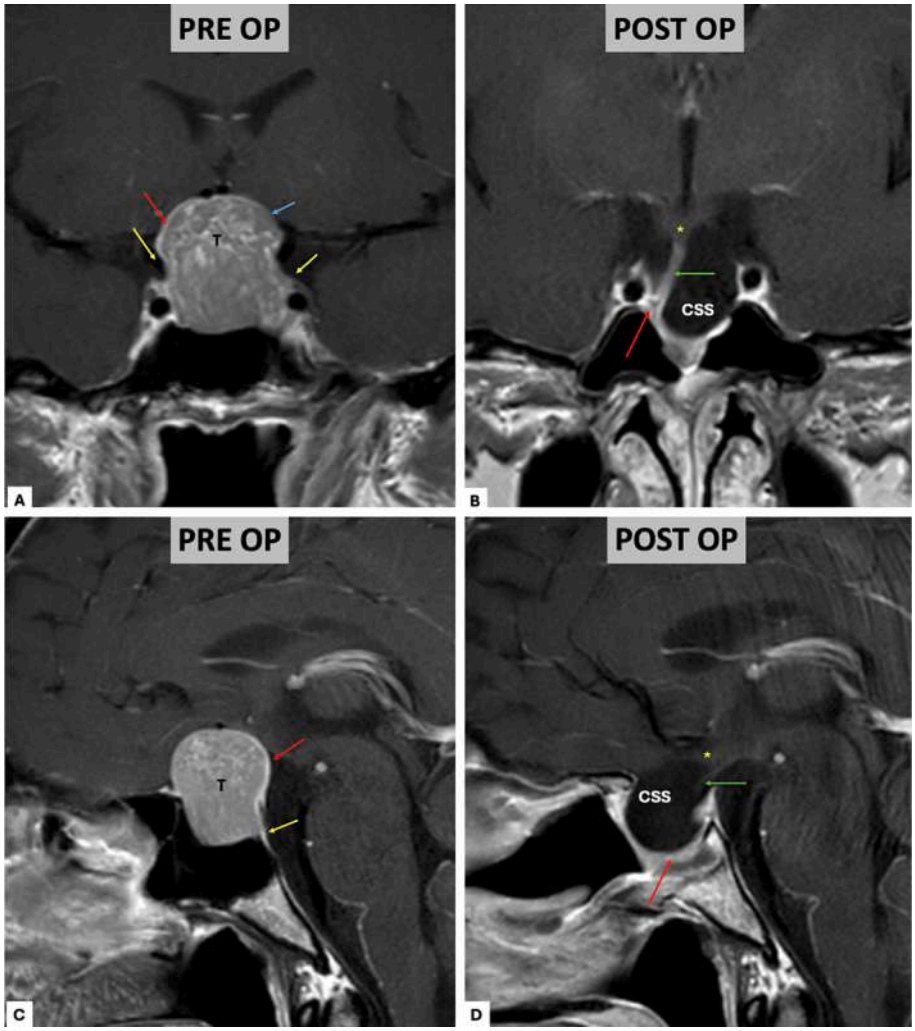

Fig. 24. Illustrative Case 8: Mixed sellar barrier. A–B, Pre- and postoperative evaluation with coronal T1-weighted contrast-enhanced sections. **C–D,** Pre- and postoperative evaluation with sagittal T1-weighted contrast-enhanced sections. A complete resection is shown, with the free suprasellar cistern and the pituitary gland on the floor of the sella to the right side. The preserved pituitary stalk is visible. PRE OP—preoperative, POST OP—postoperative, T—pituitary tumor, yellow arrows—the dura mater of the sellar diaphragm, blue arrows—arachnoid, red arrows—pituitary gland, green arrows—infundibulum, CSS—suprasellar cistern, *—optic chiasm.

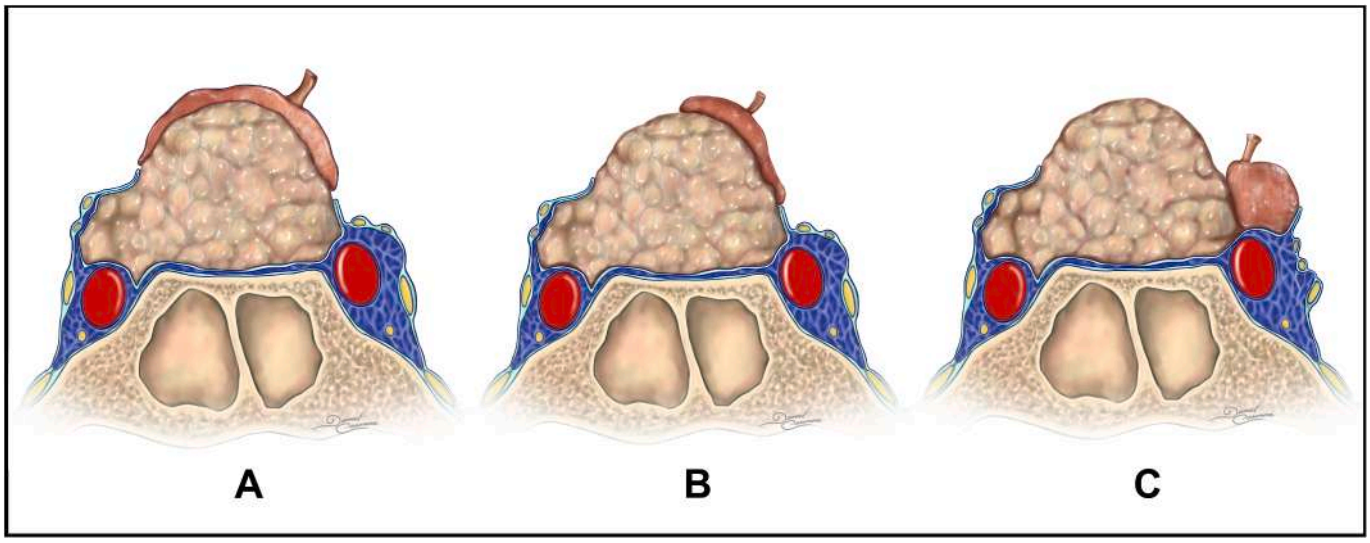

Fig. 25. Different types of sellar barrier. Schematic diagram. **A,** Strong sellar barrier. The pituitary gland and/or duramater stands between the tumor and the arachnoid with the CSF. The example in the figure shows a strong selar barrier consisting of gland alone. **B,** Mixed sellar barrier. The tumor hits the arachnoid of the cistern directly in one sector, while in another sector it hits the pituitary gland. **C,** Weak sellar barrier. The tumor hits the arachnoid cistern in all the surface of the roof.

characterized by no contrast enhancement in the sellar barrier and is isointense in T2 (Figs. 4-6).

Illustrative Case 3

Patient with pituitary macroadenoma. A strong sellar barrier is seen, which is composed of the pituitary gland; the gland typically enhances contrast and is isointense on the T2 sequence (Figs. 7-9).

Illustrative Case 4

Patient with pituitary macroadenoma. The pituitary gland is seen to the right, displaced by the tumor. The sellar barrier is weak, composed by arachnoid. The arachnoid is characterized by its lack of contrast enhancement and it is isointense in T2 (Figs. 10-12).

Illustrative Case 5

Patient with pituitary cystic macroadenoma. A strong sellar barrier is seen, which is composed of a contrast-enhancing structure in the T1 sequence and isointense in T2, concordant with the pituitary gland (Figs. 13-15).

Illustrative Case 6

Patient with pituitary macroadenoma in the context of a pituitary apoplexy. A uniform enhancement of the sellar barrier that was isointense on the T2 sequence was interpreted as a strong sellar barrier composed of the pituitary gland (Figs. 16-18).

Illustrative Case 7

Patient with solido-cystic pituitary macradenoma. Strong sellar barrier composed by pituitary gland, showing avid contrast enhancement in contrasted T1-weighted sequences and isonintense in T2-weighted sequences (Figs. 19-21).

Illustrative Case 8

Patient with pituitary macradenoma. A mixed sellar barrier is shown that is composed of pituitary gland to the right and arachnoid to the left (Figs. 22-24).

4. Discussion

The CSF leak is one of the leading causes of morbidity in transsphenoidal surgery for pituitary tumors, regardless of the technique utilized (microscopic, endoscopic-assisted or purely endoscopic) [4,5]. The incidence of intraoperative CSF leak can be addressed by using autologous grafts like fat and/or fascia lata during the same procedure [6,7]. Incidence rates of CSF leaks in the immediate postoperative period range from 0.1 % to 17 % [1]. As previously described, there exists between the pituitary tumor and the CSF a "barrier" composed of three possible anatomical structures: the arachnoid, the dura mater of the sellar diaphragm and the tissue of the pituitary gland. We have called this barrier the sellar barrier [1,8].

Previous retrospective and prospective studies have shown that the type of sellar barrier present is significantly associated with the risk of intraoperative CSF fistula during an endonasal endoscopic approach for pituitary tumor resection [1,2,3,9,10]. To our knowledge, the present study is the first to analyze the anatomical composition of the sellar barrier through preoperative MRI and directly correlate this preoperative neuroimaging study with the intraoperative endoscopic view.

To date, the preoperative evaluation of the sellar barrier has been focused only on its measurement in coronal and sagittal T1-weighted gadolinium-enhanced sections, defining the type of sellar barrier according to its thickness (strong, weak or mixed). In the present work, we propose to integrate the coronal and sagittal T2-weighted MRI sections in the analysis of the sellar barrier in order to identify the anatomical composition of this barrier.

In general, structures that enhance contrast in T1 sequences with gadolinium and are isointense in T2 correspond to pituitary gland tissue. On the other hand, structures that enhance contrast but are hypointense in T2 represent dura mater of the sellar diaphragm. Finally, the components of the sellar barrier that do not enhance contrast and are isointense in T2 correspond to the arachnoid [10]. Following this simple radiological algorithm, in our study we have observed a 100 % concordance between the anatomical composition observed in the preoperative MRI and the intraoperative findings in the operating room.

A thorough preoperative MRI examination is a cornerstone of pituitary surgery, offering essential information about tumor location, extension, vascularity, and its relationship to vital neurovascular structures. This detailed imaging approach enhances the surgeon's ability to select the most appropriate technique, minimize risk, and improve patient outcomes [11–13].

Along these same lines, we believe that detailed preoperative study of the sellar barrier type (Fig. 25) and its anatomical components is critical for predicting the risk of developing an intraoperative CSF leak; this allows us to anticipate the risk of fistula during the intra- and postoperative period. This issue is also relevant for surgical planning as it enables anticipation of the autologous or heterologous materials that would be needed for the reconstructive stage. This is especially important in developing countries due to the limited availability of certain resources. Along these same lines, this detailed preoperative study can

guide the choice of approach and other technical considerations such as the surgeon's decision whether or not to harvest a vascularized flap during the approach [4].

In addition, understanding the type and composition of the sellar barrier is a valuable tool that improves the patient–physician relationship. It allows us to preoperatively discuss with the patient and his or her family the potential risk of developing an intraoperative CSF fistula, the potential extent of surgical resection, and the possible related complications, according to the preoperative patient's individual anatomy.

5. Conclusion

The use of T2-weighted sequences in conjunction with gadolinium-enhanced T1-weighted images enhances the preoperative knowledge of a patient's sellar barrier by discriminating its anatomical components with high precision. We hope that such detailed preoperative neuroimaging assessment of the sellar barrier will significantly enhance the preoperative evaluation, treatment and care of our patients.

Declarations — Compliance with ethical standards

Details of previous presentation(s)

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Ethics approval

All procedures performed in the studies involving human participants were in accordance with ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments.

Consent to participate and consent for publication

Written Informed consent to participate and for publication was obtained from all individual participants included in the study.

CRediT authorship contribution statement

Mauro Suárez: Writing – original draft. **Mario Gomar-Alba:** Writing – review & editing. **Juan F. Villalonga:** Writing – review & editing, Writing – original draft, Supervision, Investigation, Conceptualization. **Paula Alonso:** Visualization, Supervision, Resources, Methodology, Investigation. **Matías Baldoncini:** Visualization, Validation, Supervision. **Alvaro Campero:** Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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