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HOW I DO IT - NEUROSURGICAL TECHNIQUE EVALUATION

Transcavernous sinus pituitary gland transposition: how I do it

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Abstract

Background Pituitary transposition preserving gland function is possible when approaching superior clival region tumors. Clinical experience along with detailed anatomical knowledge makes this technique safe and effective.

Method We present a step by step description of our technique based on the most recent anatomical references to get a pituitary transposition through the different compartments of the cavernous sinus. By this technique, we achieve minor gland manipulation and a better surgical view of this area. We support this technique with an anatomical analysis on cadaveric specimens and clarifying dissection images.

Conclusions Transcavernous sinus pituitary gland transposition is an easily feasible technique and allows gland shifting preserving pituitary function.

Keywords Pituitary gland transposition · Hypophysis · Transcavernous transposition · Pituitary function · Superior clivus approach

Relevant surgical anatomy

Endoscopic transnasal surgery provides a straight anatomical corridor to lesions located in superior clival region [4]. Only sellar prominence, pituitary gland, and dorsum sellae interpose in a caudo-cranial trajectory (Fig. 1). Pituitary gland transposition favors the surgical view and angle of attack to tumors located in this complex anatomical area. In this term, transposition techniques preserving its function are useful and valuable [3].

From an endoscopic point of view, we can describe three interest clival regions: superior clival region, as the space behind the dorsum sellae; middle clival region, located between the floor of the pituitary prominence and the floor of the sphenoidal sinus; and inferior clival region, located between the sphenoidal floor and foramen magnum.

The "pituitary capsule" joins the meningeal layer that surrounds the gland by small "pituitary ligaments" [1]. This meningeal layer that covers and protects the pituitary gland fixes the pituitary in its position through ligaments that cross the cavernous sinus. Carotid-clinoid ligament (CCL) (Fig. 2b) is the most important and constant of these structures. Other ligaments like superior, posterior, and inferior parasellar ligaments are, otherwise, more inconstant [2, 9].

Description of the technique

Patient positioning

Under general anesthesia, the patient is positioned in supine. Head is placed in neutral angle or mildly extended. This mild extension reduces the need of posterior ethmoidectomy and improves a better surgical view of the superior clival region.

Sphenoidal approach

Bilateral wide sphenoidotomy is mandatory for "two nostril four hands" technique. Intrasphenoidal septa are drilled and classic landmarks [6] are located. The upper portion of

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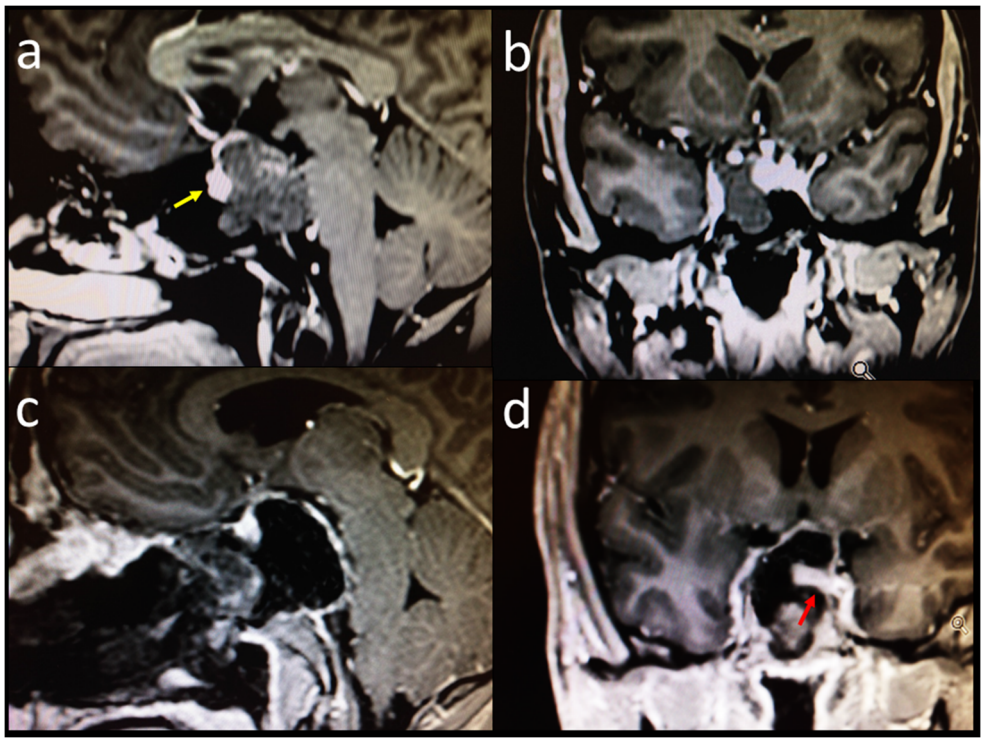

Fig. 1 Contrast-enhanced T1-weighted MRI of clival chordoma. Preoperative sagittal (**a**) and coronal (**b**) images. Yellow arrow shows how the pituitary gland is interposed ahead of the tumor. Postoperative sagittal (**c**) and coronal (**d**) images showing gross total resection of the tumor. Red arrow marks the contrast-enhanced pituitary gland shifted to the left after unilateral transcavernous sinus transposition

the middle clivus just below the sellar prominence is drilled to achieve clival dura mater exposure. This maneuver will facilitate subsequent removal of the dorsum sellae (Fig. 2a).

We usually perform en bloc drilling of the anterior face of sellar prominence. The bone piece will be used for sellar reconstruction afterwards. Sellar bone surrounding parasellar segment of carotid artery must be drilled until half of carotid

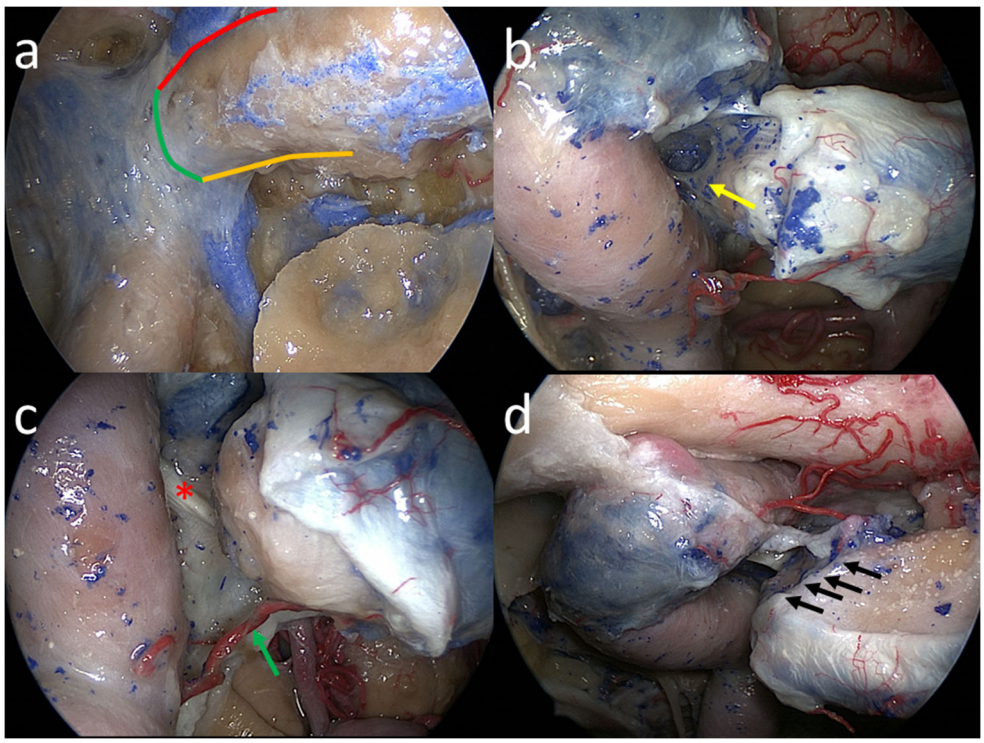

Fig. 2 Cadaveric dissection of the right unilateral transcavernous pituitary gland transposition. **a** Pituitary prominence and dural opening: First dural incision (green); second dural incision, extension of the first one inferiorly (orange); and third dural incision (red), used to increase the extradural gland rotation. **b** Parasellar ligaments and CCL (yellow arrow). **c** Pituitary medial displacement to identify the inferior hypophyseal artery (green arrow). Interclinoid ligament (red asterisk). **d** Total detached pituitary gland after the last dural incision in the diaphragm (black arrows), parallel to the interclinoid ligament

diameter is exposed. If bilateral gland transposition is planned, bone removal must be extended to both parasellar carotid prominences (Figs. 2a and 3a).

Transcavernous sinus approach

This step is the key of the procedure. Vertical dural opening must be done in the space between the gland and the carotid artery [3] (Figs. 2a and 3b). We must be ready for intense bleeding of the cavernous sinus. This bleeding can be controlled with hemostasis-promoting agents (VIDEO 1). Dura mater incision is extended along the inferior part of sellar prominence to improve the gland transposition. For better gland shifting, a superior third cut is performed, parallel to superior intercavernous sinus (Fig. 2a).

Parasellar ligaments and especially CCL must be found and cut (Fig. 2b). The next step is to identify the inferior hypophyseal artery (usually located behind the pituitary gland, next to dorsum sellae) (Figs. 2c and 3c). It must be coagulated and cut [4, 5]. After these steps, anterior pituitary detachment from dorsum sellae is easy. The surrounding dural layer [10] allows en bloc gland transposition without damaging the hypophysis (Fig. 3d).

In those cases with intradural tumors with huge suprasellar extension, which could need even more gland transposition, a fourth cut can be performed over the *diaphragm* (Fig. 2d). This cut could achieve a potential complete gland rotation preserving superior hypophyseal arteries.

Indications

This technique is indicated in tumors of the skull base that affect the upper clival region, especially those attached to the posterior clinoidal processes with pituitary function preserved. Neoplasms such as chordomas, meningiomas, or selected retroinfundibular craniopharyngiomas would be good examples (Fig. 1).

Limitations

- Hard consistency tumors with wide intracavernous tumoral invasion, causing anatomical deformation of physiological structures.
- Tumoral invasion or damage of intracavernous carotid walls.

How to avoid complications

1. Plan your surgery. You must understand the anatomical relationships between the intracavernous carotid artery and the pituitary gland. Also, it is important to pay attention to potential anatomical variations.
2. Push hard! The injection of hemostasis-promoting agents, like thrombin matrix, is the key for stopping the cavernous

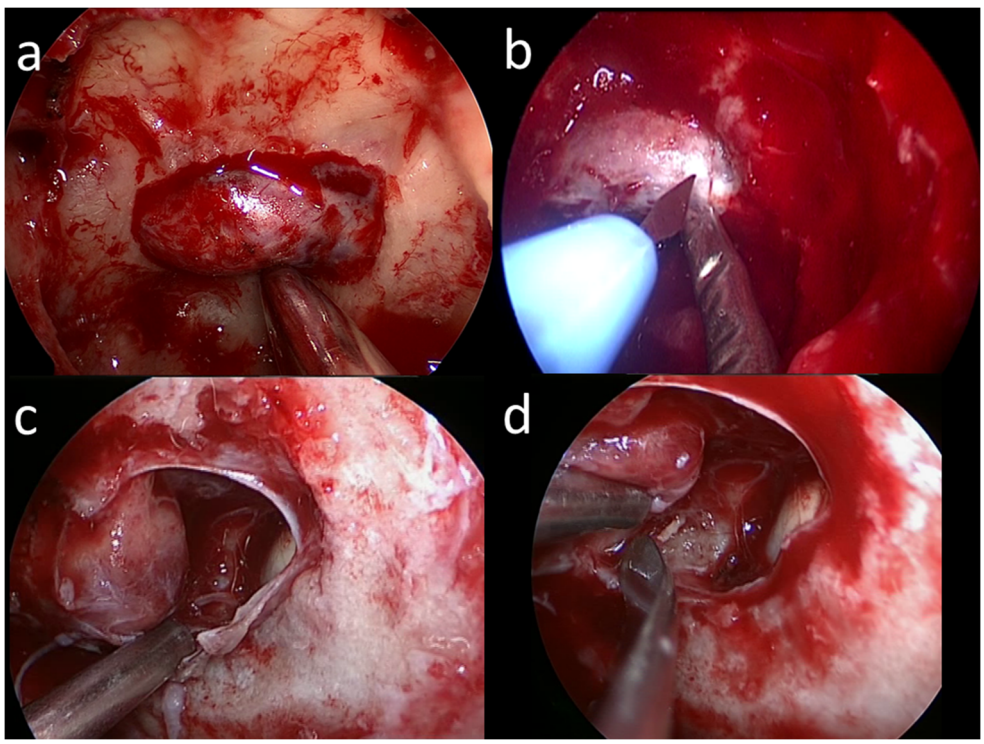

Fig. 3 Intraoperative endoscopic view of left unilateral transcavernous sinus transposition. **a** Drilling the parasellar bone carotid prominence is mandatory to achieve a good surgical view. **b** First vertical dural incision between the gland and the carotid artery. **c** After cutting the CCL, inferior hypophyseal artery is found inferiorly and deeply. **d** Coagulation of the artery and left pituitary gland transposition. This maneuver allows a wide surgical view of the dorsum sellae

sinus bleeding after dural incision. It is mandatory to practice these endoscopic hemostatic techniques in other scenarios with enough pressure and control.

3. Incredible but true! Complete pituitary transposition is not always related to gland disfunction [7, 8]. Be aggressive, pituitary gland is usually moved less than you have planned.
4. See to believe. Optic nerve blood supply by superior hypophyseal arteries is crucial. Do not forget these important arteries!

Specific perioperative considerations

Preoperative

- If tumoral extension in a coronal plane surpass the third nerve laterally, radical resection will not be possible.
- Complete hormone testing.

Postoperative

- It is mandatory to get the support of an expert endocrinologist team for the carefulness of potential postoperative hormone deficiencies.

Specific information to the patient about the surgery and potential risks

Patients must be informed about the morbidity related to the procedure, like nasal crusts in the next 3 months and potential olfactory loss.

Transitory hormone deficiencies can happen in postoperative course. Close monitoring of blood pressure or symptoms of hypocortisolism such as vomiting or headache must be watched. In case of alteration, steroid substitution must be administered at least transiently. Permanent deficiencies are uncommon (usually only one hormone deficiency). Also, in the first days after surgery, diabetes insipidus can be present. The prognosis of this deficiency is usually good, and early recovery is observed in a few days.

Key points

1- Anatomical knowledge; clival anatomy from an intra-extracranial perspective is complex [6] and demands thorough comprehension.

2- The "onion peels." The multiple layers that surround the pituitary gland have constant anatomical relationships. It is important to understand the nexus between them and the cavernous sinus.

3- A matter of maturity. If exposing parasellar segment of carotid artery, or carotid manipulation scares you, maybe you should not try gland transposition.

4- Do not be scared. Most of the pathologies located in clival region conserve the standard anatomy, at least in one of the sides.

5- The less bone, the safer. When you believe you have finished bone drilling, keep going! You do not want to work in a funnel-shaped surgical field.

6- Dural incisions are the key. If first dural layer is not widely opened, the pituitary gland cannot be shifted nor manipulated.

7- Attention! It is going to bleed! The first dural incision between the gland and the carotid artery is followed by an intense cavernous sinus bleeding [3]. This bleeding is easily controlled with thrombin matrix injection. This is the master key of the surgery (VIDEO 1).

8- Instability exists. Parasellar ligaments and carotid-clinoid ligament are attached to the cavernous sinus [2, 9]. Find them and cut them!

9- Blood supply is not the major problem. Inferior hypophyseal artery must be found, coagulated, and cut [4].

10- Give shape to your transposition! Pituitary gland transposition can show some differences between procedures, depending on the pathology to treat. Dural incisions can be modified to increase the gland shift if needed.

Compliance with ethical standards

The study with cadaveric specimens was approved by the Research Ethics board in our hospital.

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Cárdenas Ruiz-Valdepeñas E, Kaen A, Perez PG (2016) Endoscopic radical hypophysectomy: how I do it. Acta Neurochir 158(11):2159–2162
2. Cohen-Cohen S, Gardner PA, Alves-Belo JT, Truong HQ, Snyderman CH, Wang EW, Fernandez-Miranda JC (2018) The medial wall of the cavernous sinus. Part 2: selective medial wall resection in 50 pituitary adenoma patients. J Neurosurg 1:1–10
3. Fernandez-Miranda JC, Gardner PA, Rastelli MM Jr, Peris-Celda M, Koutourousiou M, Peace D, Snyderman CH, Rhoton AL Jr (2014) Endoscopic endonasal transcavernous posterior clinoidectomy with interdural pituitary transposition. J Neurosurg 121(1):91–99

4. Kassam AB, Prevedello DM, Thomas A, Gardner P, Mintz A, Snyderman C, Carrau R (2008) Endoscopic endonasal pituitary transposition for a transdorsum sellae approach to the interpeduncular cistern. Neurosurgery 62(3 Suppl 1):57–72 discussion 72–4
5. Montaser AS, Revuelta Barbero JM, Todeschini A, Beer-Furlan A, Lonser RR, Carrau RL, Prevedello DM (2017) Endoscopic endonasal pituitary gland hemi-transposition for resection of a dorsum sellae meningioma. Neurosurg Focus 43(VideoSuppl2):V7
6. Peris-Celda M, Kucukyuruk B, Monroy-Sosa A, Funaki T, Valentine R, Rhoton AL Jr (2013) The recesses of the sellar wall of the sphenoid sinus and their intracranial relationships. Neurosurgery 73(2 Suppl Operative):ons117–ons131 discussion ons131
7. Taussky P, Kalra R, Coppens J, Mohebali J, Jensen R, Couldwell WT (2011) Endocrinological outcome after pituitary transposition (hypophysopexy) and adjuvant radiotherapy for tumors involving the cavernous sinus. J Neurosurg 115(1):55–62
8. Truong HQ, Borghei-Razavi H, Najera E, Igami Nakassa AC, Wang EW, Snyderman CH, Gardner PA, Fernandez-Miranda JC (2018) Bilateral coagulation of inferior hypophyseal artery and pituitary transposition during endoscopic endonasal interdural posterior clinoidectomy: do they affect pituitary function? J Neurosurg 1:1–6
9. Truong HQ, Lieber S, Najera E, Alves-Belo JT, Gardner PA, Fernandez-Miranda JC (2018) The medial wall of the cavernous sinus. Part 1: surgical anatomy, ligaments, and surgical technique for its mobilization and/or resection. J Neurosurg 1:1–9
10. Yasuda A, Campero A, Martins C, Rhoton AL Jr, Ribas GC (2004) The medial wall of the cavernous sinus: microsurgical anatomy. NeurosurgerYl 55(1):179–189 discussion 189-90