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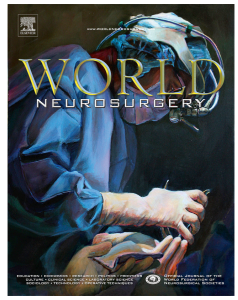


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VIDEO IS PART OF THE MS

# THREE-LAYER RECONSTRUCTION WITH ILIOTIBIAL TRACT AFTER ENDOSCOPIC RESECTION OF SINONASAL TUMORS: TECHNICAL NOTE

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**ABSTRACT**

**Introduction**

Watertight reconstruction to separate the intradural compartment from the sinonasal cavities is crucial after endoscopic resection with transnasal craniectomy (ERTC) for naso-ethmoidal tumors. Three-layer reconstruction with the iliotibial tract (TRITT) is a safe and reliable alternative when vascularized flaps are not available.

**Surgical technique**

The iliotibial tract graft is harvested on the lateral aspect of the thigh and divided in three portions, which are positioned in a multi-layered fashion to close the skull base defect. The first layer is disposed intracranial intradural, the second intracranial extradural, and the third extracranial. Fat grafts from thigh subcutaneous tissue are placed between the second and third layer to fill the dead space between them. Use of fibrin glue and intradural irrigation may help the surgeon to stabilize the layers during reconstruction.

**Conclusion**

TRITT is a feasible, highly reproducible, safe, and always available option for reconstruction of anterior skull base defects after ERTC for naso-ethmoidal tumors.

**INTRODUCTION**

In recent decades, endoscopic transnasal surgery has become the most favored approach for naso-ethmoidal cancer.[1-6] Endoscopic resection with transnasal craniectomy (ERTC) is indicated whenever the tumor is in close contact with or crosses the anterior skull base (ASB). This procedure encompasses removal of the bony layer of the ASB (ethmoidal roof, cribriform plate, and crista galli) and resection of dura mater.[3-5] Watertight reconstruction to separate the intradural compartment from the sinonasal cavities is crucial to avoid cerebrospinal fluid (CSF) leak and life-threatening complications such as meningitis and pneumocephalus.

Although the introduction of vascularized flaps has dramatically decreased the rate of CSF leak,[7,8] they are rarely available after ERTC due to either direct tumor infiltration or the need to sacrifice the vascular pedicle.

Three-layer reconstruction with the iliotibial tract (TRITT) is a safe and reliable alternative to vascularized flaps in ASB defects.

TRITT has already been proposed by our groups and preliminary experience was reported in different retrospective series.[2,4,6] However, we herein provide for the first time a detailed step-by-step description of the technique; moreover, we focus on surgical tips and pitfalls derived from 15 years of experience.

**SURGICAL TECHNIQUE**

The typical ASB defect after ERTC extends from periorbit to periorbit and from the posterior frontal wall to planum sphenoidale. The gyrus rectus of frontal lobes, orbito-frontal arteries, and residual portion of the falx cerebri are visible (Fig. 1).

**Step 1: HARVESTING OF ITT**

A 10-cm incision is performed in the middle third of the lateral aspect of the thigh, approximately 4 fingers below the line passing through the anterior-superior iliac spine and the lateral margin of the patella (fig. 2A and B). Subcutaneous fat, thinner in elderly and males, is dissected to expose the whitish ITT (fig. 2C and D). A rectangular area of ITT (about 10 x 6 cm) is taken together with pieces of subcutaneous fat (figs. 2 E, F, and G).

During the harvesting of ITT some tips should be kept in mind:

- The cranio-caudal orientation of its fibers makes the ITT very resistant to longitudinal forces, while transversal traction may tear it. This is particularly true in the elderly, where the ITT is thinner and more fragile.
- During dissection, any perforating vessel should be carefully cauterized.
- The graft is more easily cleaned from the fibro-adipose tissue that is adherent to the fascia before it is harvested (fig. 2C and D).
- The cranial cut of the graft should not injure the tensor fasciae latae muscle in order to reduce the risk of postoperative bleeding.
- Any laceration of the ITT (iatrogenic or determined by the presence of perforating blood vessels) should be sutured with re-absorbable 4.0 stitches.
- After it is harvested, the graft should be kept moist in saline solution to preserve its pliability.

The surgical wound should be meticulously sutured with a double line of subcutaneous stitches to counterbalance the muscle prolapse (fig. 2H).

The TRITT technique is thoroughly shown in the supplementary video.

**Step 2: FIRST LAYER**

The first layer is oversized by about 30% larger than the dural defect and split anteriorly to adapt to the residual falx cerebri (fig. 3A). It is positioned in the subdural space with a blunt instrument (i.e. a 55° Khun-Bolger Curette – Karl Storz).

In this step, there are two possible tricky situations:

1. The presence of brain atrophy (more common, but not limited to the elderly) together with CSF loss can create a large gap between the parenchyma and the ASB; consequently, positioning of the graft can be problematic because it tends to fall behind instead of adhere to the dural layer. In this situation, the use of fibrin glue can be very helpful. It is advisable to fix first the posterior edge and then proceed anteriorly, because a possible redundancy of the graft is more easily managed at the posterior frontal wall rather than at the planum sphenoidale, in close proximity to optic chiasm (fig. 4A).
2. The presence of brain prolapse may facilitate the extrusion of ITT. Even in this situation, fibrin glue is useful to properly fix the graft.

In addition, intradural irrigation with saline solution and antibiotics can replace CSF loss and may help the graft to adhere to dura by restoring the CSF pulsation (fig. 4B; see supplementary video).

After the first layer is positioned, the onset of CSF pulsation is a simple but effective demonstration of watertight adherence of ITT to the dura.

**Step 3: SECOND LAYER**

The second layer is inserted in the epidural space. Its size must be just a few mm larger than the defect, so that it can be adequately placed between dura and the residual bony ASB (fig. 3B). For this purpose, it is of utmost importance that the epidural space is dissected and that the dura is detached from the bone before dural resection (fig. 4C; see supplementary video). Otherwise, this maneuver would be far more difficult and ineffective.

The most critical part in positioning the second layer is the posterior edge, because of the slim space for the graft. It is very important to rely on tactile feedback, by exploring with a blunt and thin instrument the space available adherent to the bone and then guiding inside the ITT (i.e. a sharp 15° tip angled spatula– Karl Storz). Otherwise, the risk is to place the graft in the subdural space and dislocate the first layer. Furthermore, ITT must be carefully laid trying to avoid the entrapment of air between the first and the second layer, which could favor extrusion of the grafts.

Of note, a watertight closure of the defect must be achieved with the first two layers; thus, at this moment the reconstruction must be carefully inspected for any sign of CSF leak.

**Step 4: FAT GRAFT**

Pieces of fat previously harvested from the thigh are placed on the contour of the bony resection to eliminate any dead space and flatten the residual bony ASB (fig. 3C). Moreover, fat is an optimal sealer and promotes graft integration.

**Step 5: THIRD LAYER**

The third layer is positioned overlay. Its main role is to protect the underlying reconstruction. Care must be taken not to block drainage of the frontal and sphenoid sinuses (fig. 3D).

Each layer and the fat grafts can be sealed with fibrin glue. The use of fibrin glue is not strictly necessary, but it may be a valid help in non-ideal situations, which have been previously described.

At the end of the procedure, the frontal sinuses can be stented with rolled silastic sheaths to allow subsequent frontal sinus debridement with no risk for the reconstruction (fig. 4D). The surgical cavity is packed with glove fingers filled with Lyofoam (Seton Health Care Group, Oldham, U.K.) (fig. 4 E,F).

**DISCUSSION**

ERTC for nasoethmoidal tumors creates a large defect of the ASB with high flow CSF leak, which should be ideally reconstructed with a vascularized flap to optimize the chance of success. CSF leak rate when vascularized flaps are used for large ASB defect is about 3.3-4.8%[3,9]. However, endonasal pedicled flaps may be unavailable for oncologic reasons, and the morbidity associated with pericranial flap limits its routine use. Historically, the exclusive use of graft reconstruction was confined to small defects (< 1 cm)[10,11], being apparently inadequate in this setting.

From a technical point of view, the crucial aspect of TRITT is multilayer reconstruction: the first and second layers are inserted in the subdural and epidural spaces, respectively; the third one is positioned to protect the underlying layers. Endocranial pressure and CSF pulsation push the first 2 layers downwards to improve their adherence and integration with dura. Accordingly, we never position a lumbar drain, because the reduction of CSF pulsation could be detrimental instead of being of help.

In our hands, ITT is an ideal autologous graft, in view of its excellent pliability, strength, and capability of engraftment. This anatomic structure is a continuation of fascia lata at the lateral aspect of the thigh, extending from the iliac crest to the infracondylar tubercle of the tibia (Gerdy's tubercle), with an average length of 400 mm and average width of 90 mm. Its average thickness at the femoral condyle varies from 2.2 to 1.6 mm, and is inversely correlated with patient's age.[4,6] The distal part of ITT is thicker and stronger, while its central portion displays an optimal pliability. To perform TRITT, we suggest harvesting the graft in the middle third of the thigh, far enough from the knee to avoid any morbidity of this joint. Obviously, for other purposes (gasket-seal technique, brow suspension in ptosis surgery, facial reanimation) it can be harvested in different sites.

Preoperative lumbar injection of fluorescein can provide the surgeon with feedback in real time about the integrity of the reconstruction. In our protocol, 1 mL of 20% fluorescein is diluted in 3 mL of double-distilled water, and 1 mL of this solution is further diluted in 9 mL of the patient's CSF and then slowly injected.[4,6] We never observed any complications related to fluorescein injection.[4] However, as long as the expertise of the surgical team increases, its use can be avoided or limited to very complex cases.

Postoperative management of the patient is of paramount importance. During the first 24 hours, neurologic conditions of the patient are periodically checked for early detection of any signs of dysfunction. In the early phase of our experience, on day 1, computed tomography (CT) of the brain without contrast medium was performed to exclude the presence of a massive pneumocephalus and/or brain edema/hemorrhage.[4] CT is currently used only in patients with neurological symptoms.

During the first two days, the patient is kept in bed, with the inclination of the back not exceeding 45°. Nasal packing is removed 36-48 hours after the procedure under video-endoscopic guidance. If no signs of CSF leak are evident, the patient can stand up. Conversely, the management of CSF-leak can be either conservative (lying in bed, lumbar drain) or surgical (under local or general anesthesia) depending on its entity and patient comorbidities. The few cases of fistula we observed were mostly minimal leaks that could be fixed with conservative measures or minor revision under local anesthesia.[4] Thus, we suggest avoiding any aggressive and urgent surgical revision unless neurological complications such as hypertensive pneumocephalus are present.

Antibiotics able to cross the blood-brain barrier are administered during the first week. At discharge, the patient is instructed to clean his/her nose with nasal saline irrigations and avoid any activity that could increase thoraco-abdominal pressure (if needed, antitussive and laxative drugs can be prescribed during the first month). Regular outpatient endoscopic examinations and crusting debridement are scheduled until the healing process is completed (fig. 5). The formation of crusts can continue for some months after surgery, especially when adjuvant radiotherapy is required.

In conclusion, although series in the literature reported a lower rate of CSF leak when the skull base defect is repaired with vascularized flaps, the TRITT is a feasible, highly reproducible, safe, and always available option for reconstruction of ASB defects after ERTC.[3,9] Moreover, any failure of TRITT can be adequately and safely managed with non-invasive surgical maneuvres.[4] Preliminary data from an ongoing retrospective study of our two groups including 186 TRITT after ERTC are promising, with an overall CSF leak rate of 5.8% (unpublished data).

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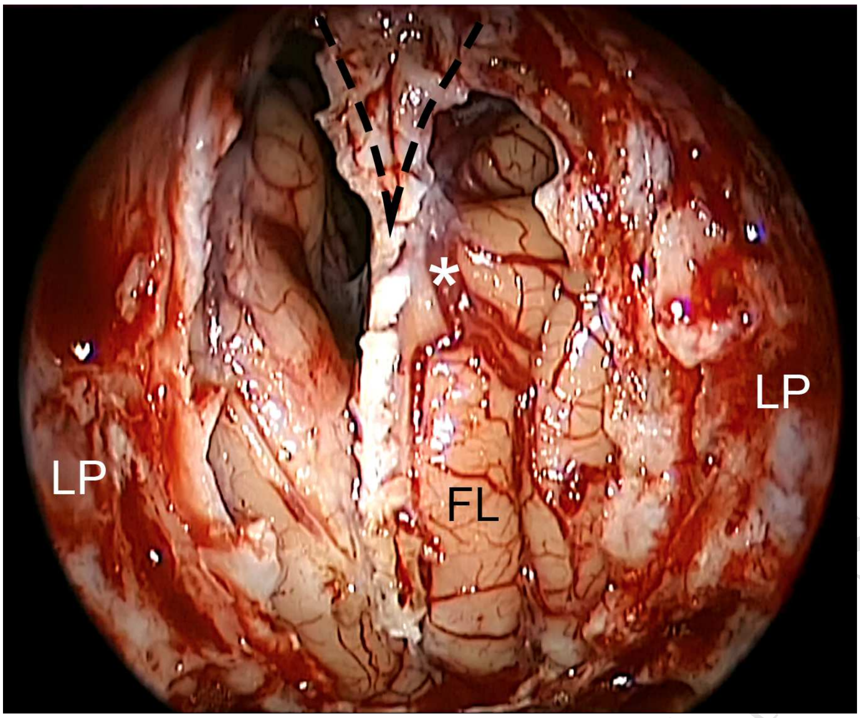
**Figure 1.** Skull base defect after endoscopic resection with transnasal craniectomy. The gyrus rectus of frontal lobes (FL), orbito-frontal arteries (white asterisks), and the sectioned falx cerebri (black dashed line) are visible. LP, lamina papyracea.

**Figure 2.** Harvesting of the iliotibial tract. A: the skin incision is placed 4 fingers below the middle third of the line joining the lateral border of the patella and the anterior-superior iliac spine. B: the skin incision should be about 10 cm in length. C: the subcutaneous fatty tissue is dissected to expose the iliotibial tract. D: the graft is cleaned from fibro-adipose tissue adherent to the fascia before harvesting (its whitish aspect and its longitudinal fibers are now clearly visible). E,F: a rectangular area of iliotibial tract (about 10 x 6 cm) is harvested. The graft should be carefully inspected to look for any possible tear; if so, it can be repaired with re-absorbable 4.0 stitches. G, a strip of subcutaneous fat is taken. H: after careful hemostasis and positioning of a drainage tube, the wound is closed by a double line of subcutaneous stitches: one deeper to counterbalance muscle prolapse, one more superficial to approximate skin margins.

**Figure 3.** Surgical technique of TRITT. A: the first layer (intracranial intradural) is split anteriorly to adapt to the residual falx cerebri (black dashed line) and fixed with fibrin glue (black asterisk). B: the second layer (intracranial extradural) is inserted in the epidural space with a blunt instrument. C: pieces of fat tissue (FT) previously harvested from the thigh are placed on the contour of the bony resection. D: the third layer (extradural) is positioned overlay taking care not to obstruct the drainage of frontal and sphenoid sinuses. EL, extradural layer; FS, frontal sinuses; IIL, intracranial intradural layer; IEL, intracranial extradural layer; LP, lamina papyracea.

**Figure 4.** Surgical tips. A: when positioning the first layer, it is advisable to fix first the posterior edge (black arrow) and then proceed anteriorly, because possible redundancy of the graft is more easily managed at the posterior frontal wall rather than at the planum sphenoidale, in close proximity to the optic chiasm. B: after positioning the first layer, intradural irrigation with saline solution and antibiotics can replace CSF loss and may help the graft to adhere to the dura. C: dissection of the epidural space and detachment of the dura from the bone before the dural resection. D: rolled silastic sheaths (black asterisks) are positioned as a stent in frontal sinuses to allow safe debridement of sinusotomy and favor its patency. E: glove fingers (GF) are filled with nasal packing (P). F: glove finger is secured with a stitch fixed on the skin with tape. Arrowheads, dural resection margin; ASBD, anterior skull base dura; FS, frontal sinuses; ER, ethmoid roof; IIL, intracranial intradural layer; PS, planum sphenoidale; SB, skull base

**Figure 5.** Healing process of TRITT during follow-up. A: day 3. After nasal packing removal, nasal cavities are cleaned from any blood clot; a frontal stent allows frontal sinus debridement with no risk for the reconstruction. B: 1 month. Frontal sinusotomy is perfectly healed; thus, frontal stent can be removed. Some crusting still covers the reconstruction. C: 6 months. The reconstruction is still covered by some granulation tissue; no crusting is visible; D: 12 months. The healing process is perfectly achieved: the reconstruction is resurfaced by normal mucosa.



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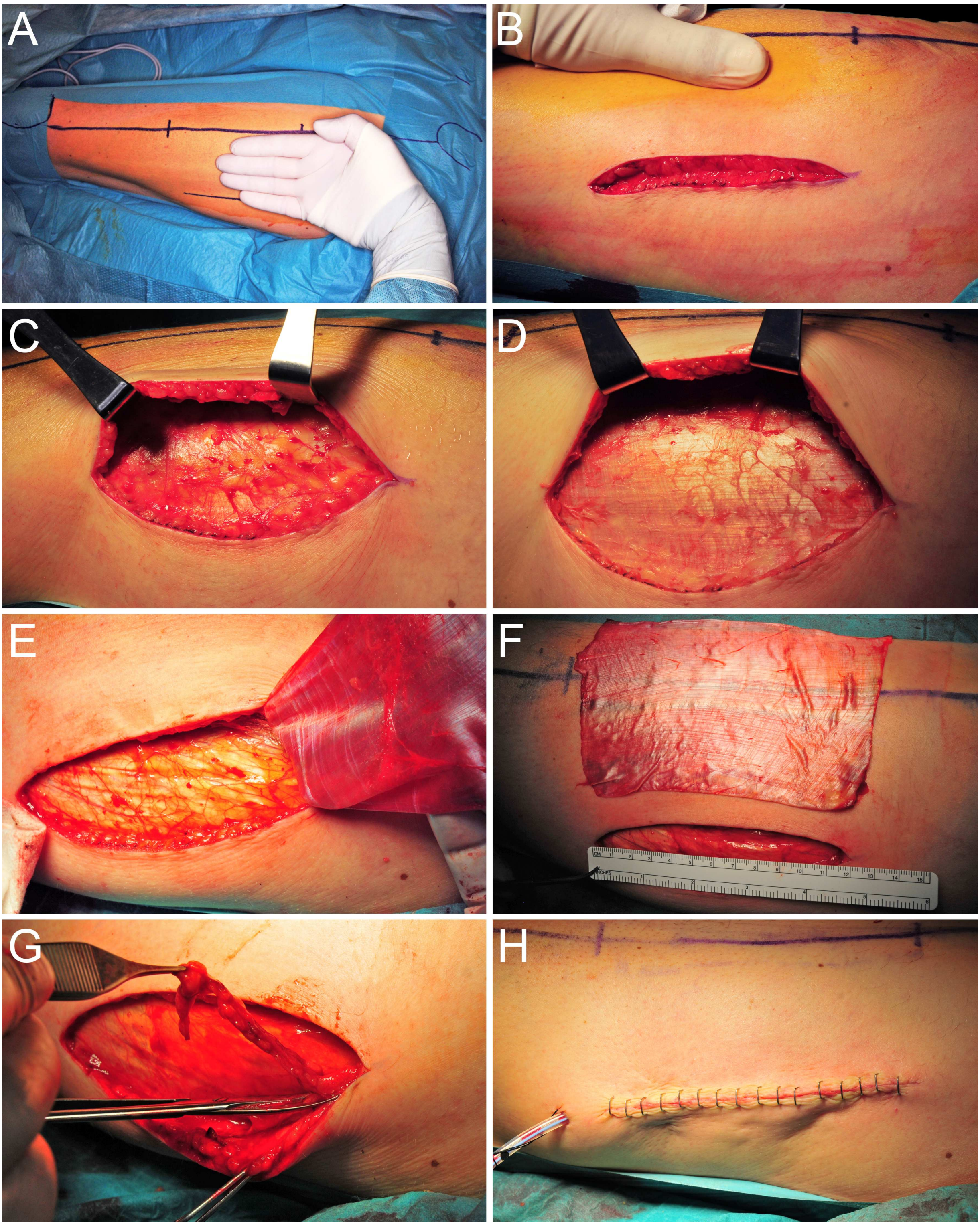
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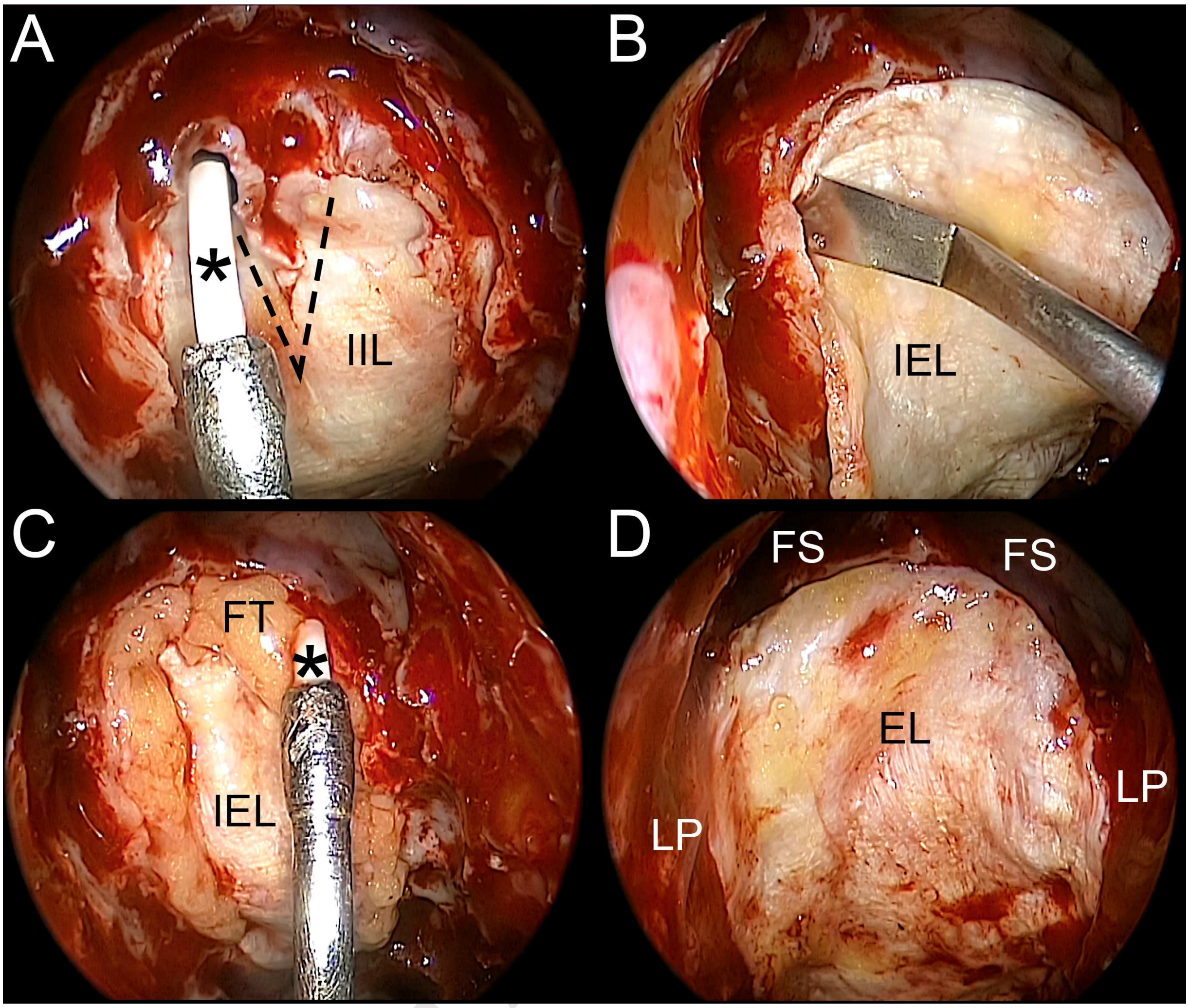
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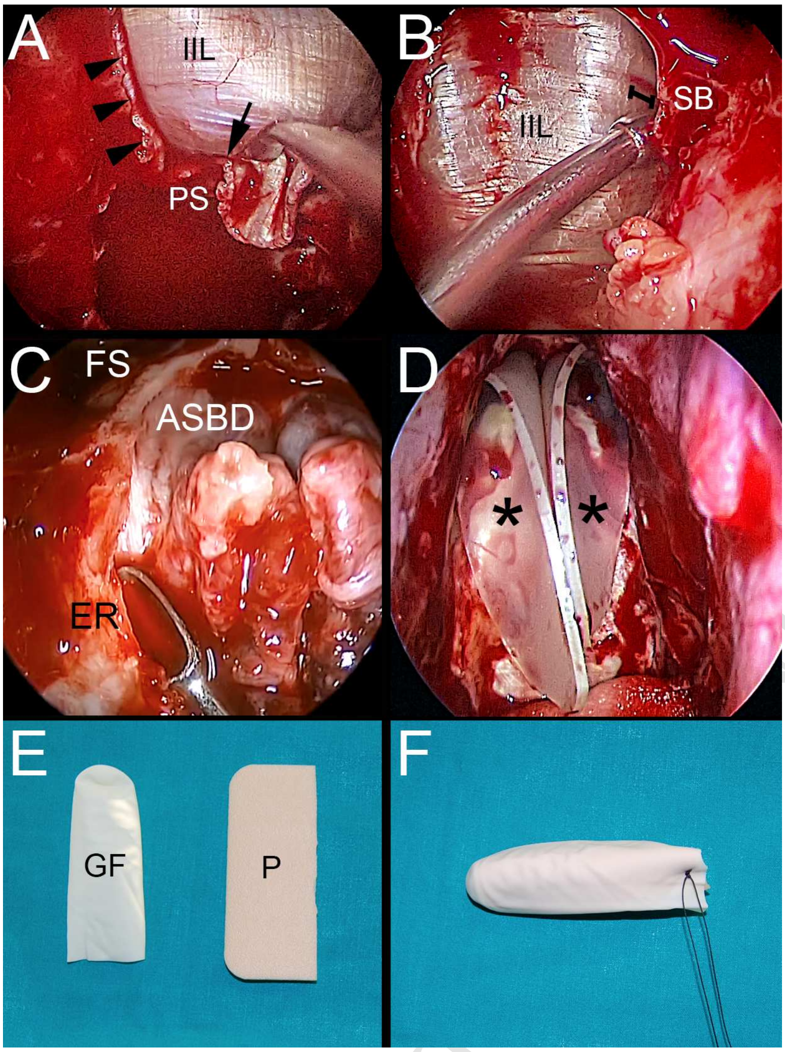
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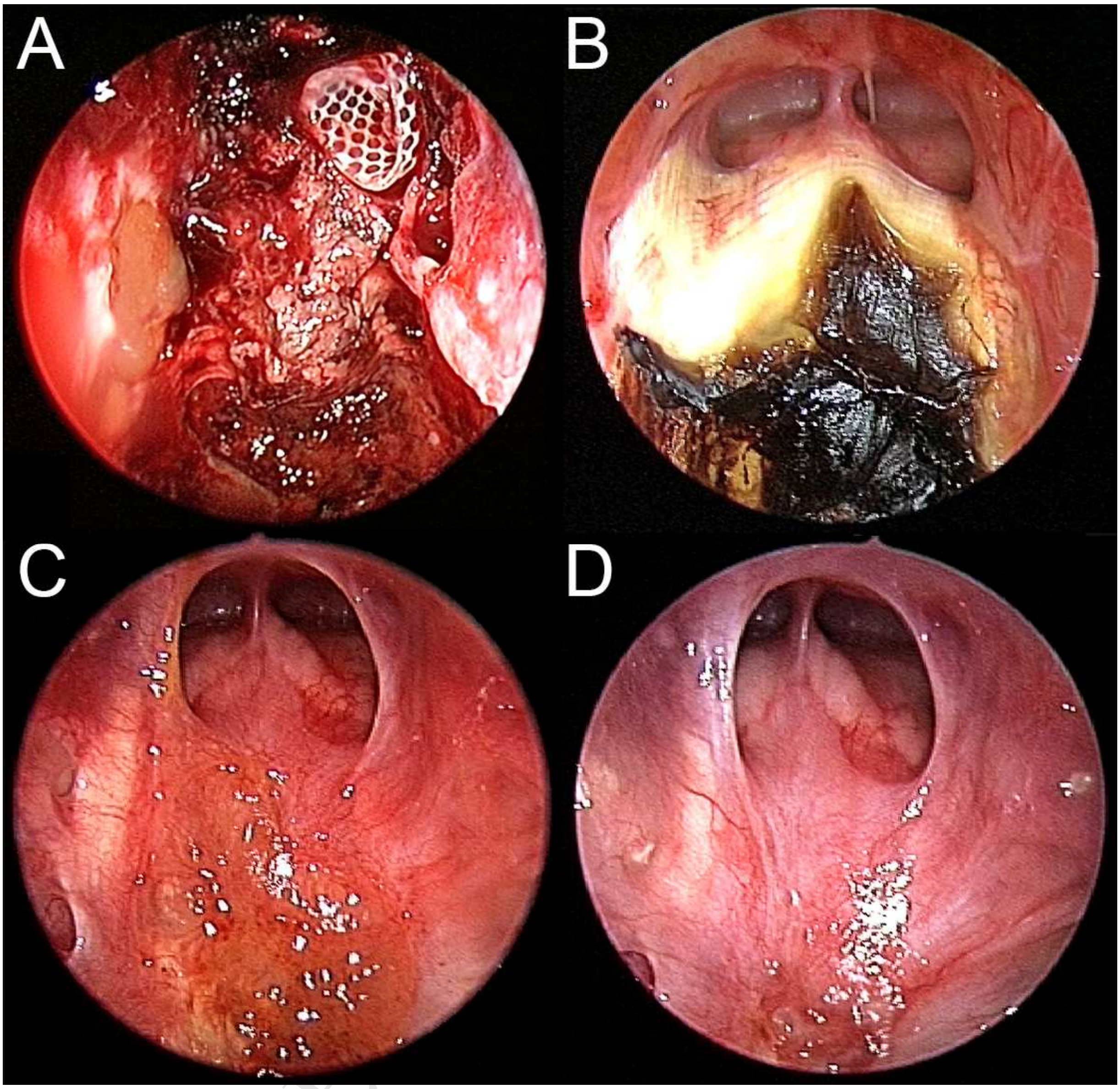
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**Highlights**:

- A detailed description of three-layered reconstruction with iliotibial tract
- A video showing the main phases of reconstruction technique is provided
- Tips and tricks, pitfalls, and refinements of the surgical technique are described

**List of abbreviations**:

ASB – Anterior skull base

CSF – Cerebrospinal fluid

CT – Computed tomography

ERTC – Endoscopic resection with transnasal craniectomy

TRITT – Three-layer reconstruction with the iliotibial tract