



# Complications and donor site morbidity of 3-layer reconstruction with iliotibial tract of the anterior skull base: Retrospective analysis of 186 patients

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## Abstract

**Background:** Anterior skull base reconstruction after resection of sinonasal cancers may be challenging when pedicled flaps are unavailable. The purpose of the present study was to analyze the complication rate and donor site morbidity of 3-layer reconstruction with the iliotibial tract (ITT).

**Methods:** We retrospectively reviewed all anterior skull base reconstructions with ITT performed from 2007 to 2015. Donor site morbidity was investigated by a dedicated questionnaire. Factors impacting on cerebrospinal fluid (CSF) leak were assessed using the Fisher's exact test.

**Results:** One hundred eighty-six patients were included. The overall complication rate was 9.7%. A CSF leak occurred in 11 patients (5.8%). Twenty patients (10.8%) and 130 patients (69.9%) underwent previous or adjuvant radiotherapy, respectively. Neither radio(chemo)therapy nor age impacted the risk of CSF leak. Six patients (3.2%) experienced complications at the donor site. The questionnaire demonstrated minimal functional and aesthetic morbidity.

**Conclusion:** Three-layer reconstruction with the ITT is a safe procedure with acceptable complication rate and donor site morbidity.

## KEYWORDS

complications, graft, iliotibial tract, multilayer reconstruction, sinonasal tumors

## 1 | INTRODUCTION

In recent years, endoscopic resection with transnasal craniectomy has been shown to be a safe and effective procedure for treatment of sinonasal tumors involving the ethmoid roof and dura mater.<sup>1–3</sup> The resulting bony and dural defect of the anterior skull base is usually large (approximately  $2 \times 4$  cm). Reconstruction may present different pitfalls. Vascularized flaps represent the best option, but may be unavailable due to direct tumor invasion of the mucosa or pedicle. Moreover, in this setting, their use is arguable for oncologic

reasons. In fact, the extent of surgical resection should be always dictated by the extension of the tumor, and in no case should it be limited by the need of preserving a flap.

Among the different extranasal pedicled flaps proposed in the literature,<sup>4</sup> only the pericranial flap displays geometrical and dimensional features that are suitable to reconstruct the anterior skull base.<sup>5,6</sup> However, the morbidity associated with this procedure (skin incision, glabellar or frontal sinus bone hole, risk for V1 paresthesia, etc) limits its routine application.

The 3-layer reconstruction with the iliotibial tract (ITT) can represent an optimal option in this setting; in fact, the

graft is always available whatever the extent of the resection. This technique was proposed by our groups in 2008 and seemed to be reliable in preliminary analyses.<sup>1,2</sup> However, some controversial issues continue to be a matter of debate, namely the effectiveness of the technique in large defects, the rate of complications associated with adjuvant treatments, and long-term morbidity of the donor site.

The present retrospective study analyzed a large cohort of patients who underwent anterior skull base reconstruction with a 3-layer graft of the ITT after endoscopic resection with transnasal craniectomy. It was designed to investigate acute and late complications, factors impacting their occurrence, and long-term morbidity of the donor site.

## 2 | MATERIALS AND METHODS

The study was performed in compliance with the Declaration of Helsinki and with the approval of the local ethical board.

The clinical records of all patients who received 3-layer duraplasty with the ITT after endoscopic resection with transnasal craniectomy at the Units of Otorhinolaryngology-Head and Neck Surgery of the Universities of Brescia and Insubria (Varese) from 2007 to March 2015 were retrospectively reviewed. The exclusion criteria included: (1) anterior skull base defect less than bilateral craniectomy (ie, removal of the entire ethmoid roof, from lamina papyracea to lamina papyracea and from posterior frontal sinus to planum sphenoidale); (2) use of vascularized flaps, heterologous material, or autologous graft other than the ITT for duraplasty; and (3) <12 months' follow-up.

Our surgical technique (ITT harvesting, 3-layer reconstruction, and postoperative care) has already been described in detail in a technical report.<sup>7</sup> In case of evidence of cerebrospinal fluid (CSF) leak during the postoperative course, the complication was managed either by revision surgery (with the patient under local or general anesthesia) or by conservative therapy (lumbar drain and bedrest), depending on the entity of the leak and patient comorbidities.

Demographics, clinical data, treatment details, and possible complications were retrieved by medical chart review and telephone interviews with the patients.

Donor site morbidity was investigated by a dedicated questionnaire adapted from a study<sup>8</sup> analyzing donor site morbidity in the lateral thigh free flap (Table 1).<sup>8</sup> It was administered to all living patients not lost to follow-up.

The association between CSF leak and other variables was assessed by the Fisher's exact test. The correlation between complication rate and time over the study period was investigated by the Cochran-Armitage test and linear regression test. The power of the statistical analysis was calculated considering the sample size (186 patients) and effect size (0.15). Significance was set at 0.05.

## 3 | RESULTS

### 3.1 | Demographics and treatment details

One hundred eighty-six patients were identified. Median age was 65 years (range 22-85 years). The majority of patients ( $n = 147$ ; 79%) were men. Overall, 47 patients (25.3%) were previously treated: 19 (10.2%) had received a surgical procedure with curative intent; 18 patients (9.7%), 11 patients (5.9%), and 9 patients (4.8%) were treated with neo-adjuvant chemotherapy, radiotherapy, and chemoradiotherapy, respectively.

After surgical treatment (tumor resection and duraplasty), 131 patients (70.4%) received adjuvant treatment: radiotherapy in 107 patients (57.5%), chemoradiation in 23 patients (12.4%), and chemotherapy in the remainder (0.5%).

Mean hospitalization time was 11 days (range 2-36 days). Median follow-up was 45 months (range 12-106 months).

### 3.2 | Complications of the duraplasty

Complications are detailed in Table 2. The overall complication rate was 9.7%. A CSF leak occurred in 11 patients (5.8%). In all cases, CSF leak had an early onset (on average, 4 days after surgery; range 1-9 days); no case of late onset CSF leak was observed.

In 7 patients (63.6%), revision surgery was required. In 3 cases (27.3%), a minor revision with the patient under local anesthesia was adequate to fix the leak. Among the 4 remaining patients, 3 patients (27.3%; including 1 patient with brain herniation and 2 patients with hypertensive pneumocephalus) had the leak repaired by a single endoscopic procedure while they were under general anesthesia, whereas 1 patient (9.1%; the patient was experiencing hypertensive pneumocephalus) required a double revision with a pericranial flap (see Figure 1). Conversely, in the remaining 4 patients (36.4%) with CSF leak, a conservative management with lumbar drain was successfully used.

Other complications had a lower prevalence. Delirium occurred in patients with a high mean age (76.3 years) and was successfully controlled with antipsychotics. Only 1 occurrence of stenosis of the frontal sinusotomy required surgical revision, the other being completely asymptomatic. The only case of epistaxis originated from a branch of the sphenopalatine artery was effectively controlled by bipolar cauterization with the patient under general anesthesia. Finally, a pulmonary embolism was successfully treated with anticoagulants without any further morbidity.

Except for frontal sinusotomy stenosis, all complications occurred early: 14 (77.8%) within the first week, and 10 (55.6%) during the first 3 postoperative days.

The correlation between complication rate, CSF leak rate, and time is depicted in Figure 2. The variation of prevalence over the study period was not statistically significant (overall

**TABLE 1** Questionnaire on morbidity of the donor site of iliotibial tract administered to 129 patients

Pain		No. of patients	Percentage
Score 0	No pain	94	72.9
Score 1	Mild (occasional and not intense)	26	20.2
Score 2	Intermediate (occasional and slightly intense)	9	6.9
Score 3	Moderate (frequent and intense)	0	0
Score 4	Severe (continue and very intense)	0	0
Paresthesia and numbness			
Score 0	None	111	86.1
Score 1	Minimal (able to feel but slightly altered)	11	8.5
Score 2	Intermediate (some feeling to touch, altered sensation)	7	5.4
Score 3	Moderate (able to feel pain only but not to touch)	0	0
Score 4	Severe (no feeling at all times)	0	0
Walking ability			
Score 0	Unlimited, same as preoperative	121	93.8
Score 1	Intermediate (restriction in running)	7	5.4
Score 2	Minor limitation (restriction on uneven terrain/stairs/uphill)	1	0.8
Score 3	Major limitation (limited walking distance at <300 m)	0	0
Score 4	Need support	0	0
Restriction in activity			
Score 0	No disability	125	96.9
Score 2	Minor disability (need occasional assistance)	4	3.1
Score 4	Major disability (restriction in daily activities)	0	0
Gait alteration			
Score 0	None	122	94.6
Score 2	Minor limping	7	5.4
Score 4	Major limping	0	0
Cosmetic appearance			
Score 0	Excellent	94	72.9
Score 1	Good appearance	30	23.2
Score 2	Acceptable	4	3.1
Score 3	Major problem in appearance	1	0.8
Score 4	Unacceptable	0	0

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complication rate: Cochran-Armitage test  $P = .999$ ; linear regression test:  $r^2$  0.002,  $P = .922$ ; CSF leak rate: Cochran-Armitage test  $P = .791$ ; and linear regression test:  $r^2$  0.012,  $P = .797$ ). The power of the analysis was very high (1.00; beta = 0.000433).

Of note, all treatments used to manage complications were successful and all patients recovered well. No permanent disability or related deaths were recorded.

### 3.3 | Risk factors for failure of the duraplasty

A CSF leak was considered as evidence of reconstruction failure. Demographic and treatment-related variables were analyzed as possible risk factors (Table 3). Adjuvant

treatments were not included in the analysis because no event occurred after their completion.

None of the variables analyzed was significantly associated with a higher risk of CSF leak. In particular, older age or previous radiotherapy and/or chemotherapy were not related to an increased risk of failure.

### 3.4 | Complications and long-term morbidity of donor site

Only 6 patients experienced complications at the donor site, accounting for an overall complication rate of 3.2%. Seroma occurred in 4 patients (2.1%), and hematoma and wound dehiscence in 1 patient (0.55%) each. Seroma was diagnosed

**TABLE 2** Complications of 3-layer reconstruction with iliotibial tract

Complication	No. of patients	Percentage	Time from surgery (mean and range)
CSF leak	7	3.7	3 d (1-6)
With hypertensive pneumocephalus	3	1.6	6 d (3-9)
With brain herniation	1	0.5	3 d
Delirium	3	1.6	5 d (1-12)
Draf type III sinusotomy stenosis	2	1.1	7.5 mo (6-9)
Major epistaxis	1	0.5	6 d
Pulmonary embolism	1	0.5	2 d

Abbreviations: CSF, cerebrospinal fluid.

within a range of 5-8 days from surgery (mean 7 days); treatment included drainage with a syringe followed by application of compressive dressing. Hematoma occurred the same day of the surgical procedure: after evacuation, a bleeding point was controlled by bipolar coagulation with the patient under general anesthesia. Of note, nasal epistaxis and hemorrhage in the thigh were experienced by the same patient who had a very high hemorrhagic risk (because of double antiplatelet therapy that could not be stopped because of a recent coronary stenting).

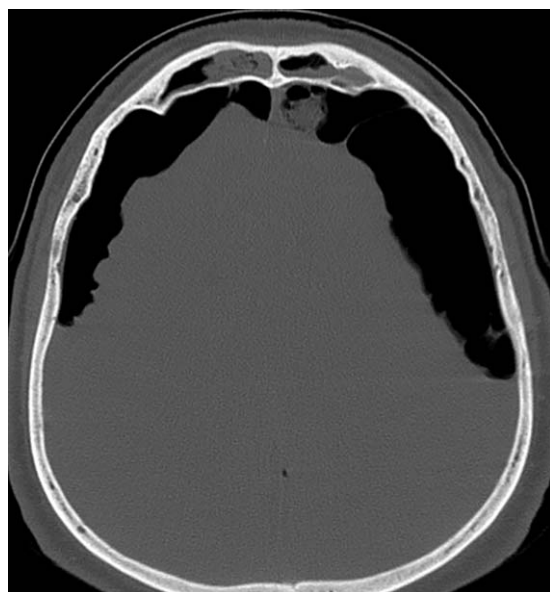
Finally, wound dehiscence occurred about 10 days after surgery in a patient with diabetes and who was immunodeficient. It was addressed by curettage of the necrotic tissue and local rotational flap.

The questionnaire was administered to 129 patients (42 patients were dead and 15 were lost during follow-up). The

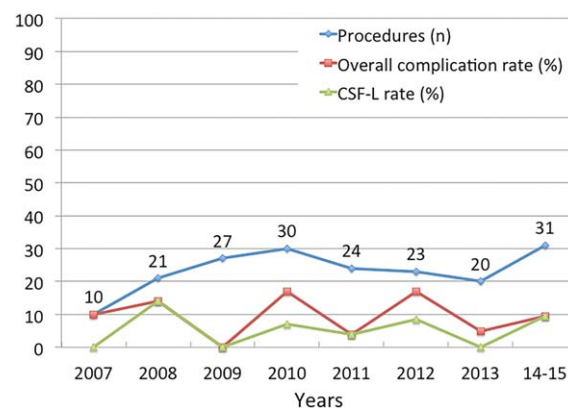
results are summarized in Table 1. The vast majority of the patients reported no or mild pain (72.9% and 20.2%, respectively), no paresthesia or numbness (86.1%), no restriction in activity (96.9%), and no gait alteration (94.6%). Likewise, walking ability was unaltered in 121 patients (93.8%), and cosmetic outcome was reported as excellent or good in 94 patients (72.9%) and 30 patients (23.2%), respectively.

## 4 | DISCUSSION

This retrospective study analyzed the complication rate and long-term donor site morbidity of 3-layer reconstruction of the anterior skull base with the ITT. The points of strength are the size and homogeneity of the sample. In fact, the anterior skull base defect was regular and uniform in all patients. Likewise, the reconstructive technique has been standardized in detail by our 2 groups<sup>7</sup> and is highly reproducible. This



**FIGURE 1** Brain CT on day 2 of a patient complaining worsening headache and hallucination. Urgent revision with pericranial flap was required to fix the pneumocephalus



**FIGURE 2** Incidence per year of complication and cerebrospinal fluid leak (CSF-L) rates over the study period. The blue line = absolute number of procedures per year; the red line = overall complication rate per year expressed in percentage; and the green line = CSF leak rate per year expressed in percentage [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

**TABLE 3** Analysis of risk factors for cerebrospinal fluid leak (Fisher's exact test)

Variables	No. of patients	CSF leak, no. of patients	<i>P</i> value
Sex			.13
Male	147	11	
Female	39	0	
Age, years			.35
<65	84	3	
≥65	102	8	
Previous RT alone			.99
Yes	11	0	
No	175	11	
Neoadjuvant chemotherapy			.60
Yes	18	0	
No	168	11	
Previous chemotherapy/RT			.09
Yes	9	2	
No	177	9	
Previous surgery			.31
Yes	19	2	
No	167	9	

Abbreviations: CSF, cerebrospinal fluid; RT, radiotherapy.

statement is corroborated by the absence of an association between complication rate and time (see Figure 2), despite the entry of novice surgeons in our teams over the study period.

Evaluation of complications was very strict. The difficulty in separating those related to tumor resection from those associated with duraplasty might have resulted in an overestimation of the latter. In fact, some complications (ie, delirium and epistaxis) are hardly attributable to duraplasty alone, but more likely due to endoscopic craniectomy or patient-related factors (ie, age and double antiplatelet therapy).

A CSF leak is the most important parameter to evaluate the efficacy of a skull base reconstruction procedure. Overall, its rate was 5.8%. If we consider the size of the defect and the exclusive use of autologous grafts (ITT and fat), this percentage is surprisingly low. In fact, historically, multilayer free graft reconstruction was deemed reliable only for small defects (<1 cm) in which it could ensure rates of success >90%.<sup>9,10</sup> Conversely, with the increase in size of the defect, the success rate significantly decreased (<70%).<sup>11,12</sup> In a recent systematic review analyzing the outcomes of endoscopic reconstructions of large dural defects,<sup>13</sup> the CSF leak rate in the free graft group was 15.6%. However, this review includes different types of defects in terms of site and size, so that comparison with our data, which focuses on a group of patients with similar dura defects, is of little value.

The few cases of fistula we observed were mostly minimal leaks that could be repaired with conservative measures or minor revision with the patient under local anesthesia. In the latter case, sealing of the leaking point with fibrin glue with or without heterologous material (ie, Surgicel Original Absorbable Hemostat; Ethicon US) is effective and can be even performed in the ward. In our experience, urgent revision with the patient under general anesthesia was required only in case of concomitant neurological complications (such as hypertensive pneumocephalus and brain herniation).

We acknowledge that vascularized flaps can provide a higher success rate and promote faster healing. Nevertheless, the failure rate of vascularized flaps (such as pericranium) when used to repair a large anterior skull base defect is about 3.7%-4.8%, a percentage that compares fairly well with ours.<sup>3,14</sup>

Moreover, the frequently reported concern about the use of graft in case of previous or adjuvant (chemo)radiotherapy is not justified by our analysis. In fact, all CSF leaks in our series occurred at very early onset. Despite a large use of adjuvant treatments (70.4%), no event was recorded after their completion. This evidence strongly supports our technique as a possible option for anterior skull base reconstruction even when postoperative treatments are predictable.

Similarly, no risk factor for CSF leak was identified, demonstrating that the technique can be performed in any patient. In particular, differences between patients older than



65 years or those with previous treatments did not reach statistical significance. Previous chemoradiation showed only a trend ( $P = .09$ ) toward increased risk. Obviously, the surgical scenario after chemoradiation is more challenging both in resection of the tumor and in reconstruction of anterior skull base. In fact, radiation-induced damage of tissues can hinder the engraftment of the ITT and cause a slight increase in the risk of CSF leak. However, this is true whatever the type of reconstruction. The limited number of patients prevents us from drawing any definitive conclusion, but, in our opinion, previous chemoradiation should not be considered a contraindication for 3-layer reconstruction with the ITT.

The safety profile of this procedure is very satisfactory. In fact, no infectious event, such as meningitis or brain abscess, was recorded. Almost all complications (94.4%) occurred very early, before the patient was discharged. Consequently, they could be rapidly addressed and resolved. Accordingly, no permanent disability or death was recorded.

These data, coupled with the absence of an adverse event after adjuvant treatments, can be probably interpreted as the evidence that, after consolidation, the duraplasty with the ITT is very strong and able to resist mechanical stress and biological insults in a way similar to the normal anterior skull base.

In addition to being an effective and safe technique, another advantage of this technique is its availability regardless of the extent of the resection. In view of its relevant reliability, we are against minimizing tumor resection with the aim to preserve a pedicled flap. For instance, we usually remove the entire nasal septum when involvement of its osteocartilaginous part is detected.

In our series, the donor site complication rate was negligible. Only minor complications were recorded and did not result in any permanent disability. Of note, in the few reports published in literature, the incidence of complications is remarkably higher (hematoma 4.5%; wound discharge 9%–14%).<sup>15,16</sup>

Concerning long-term donor site morbidity, we deliberately chose to use a patient-centered questionnaire, rather than objective parameters (such as the measurement of possible muscle prolapse), in order to have a reliable estimate of the impact on the patient's quality of life. The results are thoroughly satisfactory, in terms of both functional and cosmetic outcomes. We believe these data support our ITT harvesting procedure<sup>7</sup> as a safe, simple, and reliable technique, allowing excellent long-term quality of life.

Comparison of our data with the literature is difficult because of the paucity of reports and the variability of techniques adopted. Moreover, the few reports published focused mostly on short-term outcomes.<sup>15–18</sup> Nevertheless, some speculations can be made to explain our favorable outcomes. First, the ITT is harvested in the middle third of the thigh. This location is an optimal compromise between the

pliability and thickness of the graft (getting thicker toward the knee) and morbidity of the harvesting. In fact, this site is far enough from the knee to avoid any restriction in joint mobility; this is supported by the excellent functional results in terms of pain, walking ability, gait alteration, and restriction in activity.

The second technical aspect is the double layer of subcutaneous stitches used to counterbalance muscle pulsation. Muscle prolapse is often reported as a frequent sequela.<sup>17</sup> Recently, a preliminary experience with an allograft used to close the fascial defect with the aim to avoid muscle adherence and prolapse, has been published.<sup>18</sup> Based on our series, the reconstruction of the fascial defect is not necessary and muscle prolapse is effectively counterpoised by a tighter subcutaneous suture. Even if this issue is not directly addressed in our analysis, the excellent cosmetic outcomes demonstrate the effectiveness of our technique.

## 5 | CONCLUSIONS

Three-layer reconstruction with the ITT is a safe, effective, and always available reconstructive option for large defects of the anterior skull base. Elderly age, previous treatments, and adjuvant (chemo)radiation are not risk factors for a higher CSF leak rate. Long-term morbidity of the donor site and the impact of the ITT harvesting on quality of life are negligible.

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