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10-1-2013

Incidence and management of rhinosinusitis after complex orbitofacial reconstruction.

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Recommended Citation

Parkes, William; Nyquist, Gurston G.; Rizzi, Christopher; Zhang, Sarah; Evans, James J.; Heffelfinger, Ryan N.; Rosen, Marc; and Curry, Joseph, "Incidence and management of rhinosinusitis after complex orbitofacial reconstruction." (2013). *Department of Otolaryngology - Head and Neck Surgery Faculty Papers.* Paper 27.
http://jdc.jefferson.edu/otofp/27

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As submitted to:

Laryngoscope

And later published as:

Incidence and Management of Rhinosinusitis after Complex Orbitofacial Reconstruction

Oct 1, 2013

doi: 10.1002/lary.24423.

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RUNNING TITLE: Rhinosinusitis after Orbital Reconstruction

FINANCIAL SUPPORT OR FUNDING: none

ABSTRACT

OBJECTIVE: To examine the sinus-related sequelae of free flap reconstruction for complex orbitofacial defects.

STUDY DESIGN: Retrospective chart review

METHODS: Demographic, clinical, and radiographic data on a series of 55 patients who had undergone free tissue transfer for orbitofacial reconstruction was retrospectively reviewed. Follow-up of ≥ 3 months was available for 49 patients. Outcome measures studied included clinical or radiographic evidence of sinusitis and the need for sinus surgery.

RESULTS: The most commonly involved sinuses were the ethmoid (n=40) and maxillary (n=38) sinuses, and the anterolateral thigh was the most common flap used (n=41). Clinical and/or radiographic sinusitis was evident in 21 patients (43%), and 10 patients (20%) required sinus surgery at some point during follow-up. Involvement of multiple sinuses in the initial orbitofacial surgery was associated with a significantly increased need for subsequent sinus surgery (p=0.009). Adjuvant radiotherapy and adjuvant chemo-radiotherapy were associated with a significantly increased risk for the development of rhinosinusitis (p=0.045 and 0.016 respectively).

CONCLUSION: Rhinosinusitis and the need for operative management of sinus obstruction are common in patients having undergone complex orbitofacial reconstruction. Careful management of the paranasal sinuses is an important component of the multidisciplinary treatment of such patients.

KEY WORDS: rhinosinusitis, orbitofacial, skullbase, free tissue transfer

LEVEL OF EVIDENCE: 4

INTRODUCTION

The surgical management of advanced malignancy, trauma, or even locally destructive benign lesions in the orbitofacial region can result in complex defects. Subsequent reconstructive efforts typically focus on protection of the central nervous system (CNS), separation of the orbital, sinonasal, and oral cavities, and aesthetic considerations.[1, 2] As a means to these ends, free tissue transfer is frequently employed. The resultant impact upon the paranasal sinuses has been largely overlooked in the literature. Whether the sinuses have actually been violated or are simply adjacent to the defect, their outflow tracts are susceptible to obstruction secondary to the soft tissue bulk of a free flap. The purpose of this retrospective review is to evaluate our experience with short and long term sinus sequelae of free tissue transfer for orbitofacial defects.

MATERIALS AND METHODS

After obtaining institutional review board approval, the electronic medical records for 55 consecutive patients who underwent free tissue transfer for complex orbitofacial defects at a tertiary medical center between September 2006 and July 2012 were reviewed. Follow-up of ≥ 3 months was available for 49 patients. When examining the incidence and management of post-operative rhinosinusitis, the remaining 6 patients with < 3 months of follow-up were excluded given the potentially delayed nature of this complication. None of these 6 patients required an acute intervention for rhinosinusitis.

Patient demographics, as well as all pertinent operative, clinical, and radiographic findings were compiled into a database. Outcome measures included the rate of clinical or radiographic evidence of sinusitis and the need for subsequent sinus surgery. "Clinical rhinosinusitis" was defined in accordance with the Rhinosinusitis Task Force description from 2003, which requires both a history and physical exam findings compatible with rhinosinusitis.[3] "Radiographic rhinosinusitis" was defined by the presence of moderate to severe mucosal thickening, sinus opacification, or mucocele on a dedicated sinus CT or MRI obtained at least 1 month after the initial surgery and free flap. The indication for the majority of imaging studies reviewed was tumor surveillance. An attending rhinologist (G.G.N) independently assessed all scans reported to be positive to confirm the clinical significance of the findings. Scans revealing "mild mucosal thickening" or expected post-operative changes were considered to be negative. "Operative sinus interventions" in the post-operative period included maxillary antrostomy, ethmoidectomy, sphenoidotomy, frontal sinusotomy, frontal stent placement, frontal drillout and mucocele drainage. Standard, in-office sinonasal debridements for crusting were not considered to be "operative sinus interventions."

Statistical analysis of risk factors for the development of post-operative rhinosinusitis was performed using SPSS statistics software. Risk factors analyzed included specific sinus involvement, number of sinuses involved, orbital exenteration, free flap selection, prior radiotherapy and adjuvant therapy. Fisher's exact test was employed, and a p value <0.05 was considered statistically significant.

RESULTS

Patient demographics and pathology are reviewed in Tables 1 and 2 respectively. All of the patients in the series underwent resection involving the orbitofacial complex, as well as paranasal sinuses. Eighteen patients had undergone prior external beam radiation, and 4 patients had previously been treated with chemotherapy. Only 4 patients had a history of prior sinus surgery. The mean length of follow-up was 21 months (range 0-66 months). Patients were predominantly male (n=40), and the majority underwent resection with free flap reconstruction for malignancy (n=47). Other indications for surgery included 5 meningiomas and 3 instances of frontal bone osteomyelitis.

The anatomic subsites involved in the initial resections are detailed in Table 3. Forty-two patients (76%) required orbital exenteration, and 28 patients (51%) underwent anterior cranial base resection. The most commonly involved sinus was the ethmoid (n=40, 73%). Notably, the bordering medial orbital wall was resected in 32 patients. The maxillary sinus was surgically violated or resected in 38 patients (69%). A number of defects also involved subsites adjacent to the maxillary sinus, including the inferior orbital rim (n=30) and the orbital floor (n=29). Frontal sinus involvement was not uncommon either, occurring in 29 patients (53%). Sphenoid involvement, on the other hand, was only seen in 11 patients (20%).

Free flap selection from the series is outlined in Table 4. Sixty total flaps were used in 55 patients. An additional flap was required in two patients for subsequent resection of recurrent disease, two patients for management of flap loss, and one patient for radiation-related wound breakdown. The anterolateral thigh (ALT, n=41) was the most commonly used flap (68%), and the soft tissue radial forearm (RF, n=13) was the only other flap used more than 3 times. Bony flaps were employed sparingly, including 1 fibula and 1 osteocutaneous RF.

Complications are reviewed in Table 5. Myocardial infarction occurred in 2 patients, and there were 2 instances of hemorrhagic stroke. One of the cases complicated by stroke required extensive craniofacial extirpation, and the patient ultimately expired. One additional peri-operative mortality occurred 4 weeks after surgery (2 weeks after discharge), and the cause of death remains unknown. Post-operative cerebrospinal fluid (CSF) leak was documented in 3 (11%) out of 28 cases involving anterior cranial base resection. In each instance, there was a large dural defect, and an ALT was used to reinforce a synthetic primary dural repair. There were 3 instances of flap loss (95% flap success rate). Of the 3 losses, 2 were recognized and managed intra-operatively while the other was found to have necrosed at the first follow-up visit on post-operative day 18.

The most common complication throughout the whole series was post-operative rhinosinusitis, evident clinically and/or radiographically in 43% of patients with at least 3 months of follow-up. Five patients were found to have clinical evidence only, 7 were found to have radiographic evidence only and 9 were found to have both clinical and radiographic evidence of rhinosinusitis (total n=21). The mean time interval before the development of post-operative clinical rhinosinusitis (14 patients) was 188 days (range 8-471 days). Out of these 14 patients, 57% had 2 or more episodes documented, the latest of which occurred 1011 days (34 months) after the initial surgery. Post-operative radiographic rhinosinusitis was found in 16 patients. Diagnosis was confirmed by CT alone in 8 patients, MRI alone in 3 patients, and both CT and MRI in 5 patients. The mean time interval before the development of radiographic rhinosinusitis was 231 days (range 36-1084 days). Six patients had evidence of radiographic rhinosinusitis at more than 1 time-point, with a mean interval between positive findings of 355 days (range 34-1137 days).

Ten patients (20%) required operative sinus intervention after their initial free flaps. All ten developed rhinosinusitis as a delayed complication and required operative intervention at least 2 months after the initial extirpation and flap. The clinical characteristics of these 10 patients are detailed in Table 6. The mean time interval between the initial surgery and endoscopic sinus surgery was 278 days (range 56-808 days). Half of these sinonasal surgeries were performed in conjunction with another procedure. Concurrent procedures included a tracheostomy, removal of hardware, parotidectomy for recurrence, and flap debulking (n = 2). The most common sinus intervention was a maxillary antrostomy (n = 7), followed by ethmoidectomy (n = 4). Frontal sinusotomy was performed in 1 patient, and 2 additional patients required Draf II procedures for frontal mucoceles. The mucoceles were noted on imaging at 182 and 588 days post-operatively. One of the 2 patients who had a Draf II procedure developed recurrent stenosis of the frontal outflow tract and subsequently required a Draf III procedure approximately 10 months later. Two patients underwent sphenoidotomy for post-operative sinusitis.

Statistically significant findings from the Fisher's exact test are highlighted in Table 7. With respect to the incidence of post-operative rhinosinusitis, patients undergoing adjuvant external beam radiation alone and patients undergoing adjuvant chemo-radiotherapy were both found to have developed the complication at significantly higher rates (p=0.045 and 0.016 respectively). Regarding the need for subsequent sinus surgery, only the inclusion of multiple sinuses in the initial defect seemed to have an effect. Ten out of 21 patients with multiple sinuses resected eventually developed rhinosinusitis that mandated an operative sinus intervention, whereas 0/18 patients with single sinus involvement needed subsequent sinus surgery (48% vs 0%, p=0.009). Prior radiotherapy, orbital exenteration, which specific sinus was involved at time of the initial surgery, and free flap selection did not significantly impact either outcome measure in this series.

DISCUSSION

Advanced lesions of the periorbital area pose complex cosmetic and functional reconstructive challenges that are commonly addressed with free tissue transfer.[4] Unfortunately, the prognosis for aggressive malignancy of this region is poor, and large, multi-institutional reviews of craniofacial resection for skullbase, sinonasal and cutaneous malignancies have reported 5-year overall survival rates of 48-64%.[5-7] Consequently, the longer term sequelae of ablative and reconstructive surgery in this anatomic region are rarely reported.

One important outcome measure that has not been studied in patients undergoing orbitofacial resection and free tissue transfer is the incidence of post-operative rhinosinusitis. The paranasal sinuses drain into the nose via a highly coordinated pathway of mucociliary transport toward natural ostia. Rhinosinusits is more likely in the setting of mucocilliary dysfunction or outflow tract obstruction. As many patients undergoing orbitofacial surgery receive external beam radiation, mucociliary dysfunction is common.[8] Moreover, there is substantial risk for obstruction of their sinonasal outflow tracts during both extirpation and reconstruction. Given these considerations, we hypothesized that sinus complications in this patient population would be substantial.

This retrospective review of a 6-year experience with orbitofacial resection and free flap reconstruction at our institution revealed the rates of post-operative rhinosinusitis and subsequent sinus surgery to be 43% and 20% respectively. The importance of these findings is multifactorial. Most significantly, the occurrence of rhinosinusitis in these patients can be devastating. When extirpation involves the anterior cranial base (51% of patients in this series), the risk of intracranial extension of infection must be considered. Reported rates of CSF leak after free flap reconstruction for cranial base defects range from 4-9%[9-12]. In the presence of an anterior skull base CSF leak, fronto-ethmoidal infection can track intracranially and lead to meningitis or even abscess formation. Moreover, in patients who require potentially immunosuppressive chemotherapy, indolent sinus disease has the potential to progress to a fulminant state.[13] Even in the absence of life-threatening complications, the morbidity of chronic rhinosinusitis (CRS) and the recovery from any necessary surgery negatively impact quality of life, which is especially significant in a patient population with a guarded prognosis. Lastly, the medical and surgical management of CRS in these patients contributes to the cost of their care, which has increasingly become a focal point of much scrutiny. According to a claims-based cost analysis by Bhattacharyya et al, the average annual non-surgical and surgical treatment costs per CRS patient can exceed $2,000 and $7,000 respectively.[14]

While the deleterious mucosal and immunosuppressive effects of adjuvant therapy appeared to be significant in this review, they are unfortunately often unavoidable. Iatrogenic obstruction at the time of resection and reconstruction, on the other hand, may be preventable. This is a critical notion because, if left unaddressed, iatrogenic obstruction tends to result in medically refractory sinusitis and will commonly require additional surgical intervention.[15] At our institution, we now uniformly obtain Rhinologic input pre-operatively and commonly perform functional sinus surgery upfront for patients undergoing complex orbitofacial surgery.

The most common post-operative sinus intervention required in this review was maxillary antrostomy (14% of patients with >3 months of follow-up), which is not surprising considering that 70% of the resections included at least part of the maxillary sinus. If the floor of the orbit is involved in the resection, especially more medially toward the ostiomeatal complex, then a wide maxillary antrostomy with removal of the uncinate process is recommended during the initial surgery. Additionally, one must recognize that soft tissue from a free flap may obstruct a maxillary antrostomy centered on the natural ostium (Figure 1). In this case, an inferior window to the maxillary sinus can be created in addition to a standard maxillary antrostomy. Alternatively, a "mega-antrostomy" could be performed.[16] If a large portion of the maxilla is resected and preservation of a functional sinus is unlikely, then we typically strip residual mucosa and use a diamond drill to remove any mucosal remnants.

The second most common delayed sinus procedure noted in this series was ethmoidectomy (8% of patients with >3 months of follow-up). The management of the ethmoid sinuses is the most straightforward of all the paranasal sinuses in this setting. Namely, if there is tumor involvement within the ethmoid cavity, or the lamina papyracea requires resection, then a complete anterior and posterior ethmiodectomy is recommended. This is optimal for tumor removal, and also promotes a wide pathway to facilitate mucus drainage and endoscopic surveillance post-operatively.

The frontal sinus is the most precarious as the incidence of synechia formation and resultant obstruction from frontal sinus surgery is significant.[17] With this in mind, the patency of the frontal sinus outflow tract should be established during the initial surgery if resection of this region occurs. When frontal sinus resection is excessive and function cannot be preserved, cranialization or obliteration with a portion of the free flap may be necessary.[18] In these instances, care must be taken to ensure that all of the mucosa is removed, and the bone should be polished with a diamond drill. With more limited frontal sinus involvement and a naturally wide anterior-posterior diameter of the frontal recess, a simple frontal sinusotomy may prove satisfactory. To limit post-op re-stenosis, the introduction of a stent or spacer may be considered as an adjunct in these patients, but the literature regarding long-term results with these techniques remains inconclusive.[19] Patients with an inherently narrow frontal recess or in whom the frontal recess has been significantly narrowed iatrogenically, might need more aggressive management. In our series, two such patients required post-operative frontal sinus drillout procedures for flap-related obstruction and mucocele formation. The first patient developed a right-sided frontal mucocele after undergoing a left orbital exenteration, frontal sinus resection and ALT free flap obliteration of the left frontal sinus. Representative CT images are presented in Figure 2. If a Draf III procedure had been performed at the time of the initial resection, impingement of the contralateral frontal outflow tract could possibly have been prevented. Instead, a Draf IIa procedure was performed in a delayed fashion. The second patient required a Draf IIa and then later a Draf III procedure for a recurrent left frontal sinus mucocele after initially undergoing a left orbital exenteration, partial ethmoidectomy, and maxillectomy. Had a prophylactic frontal sinus procedure been performed upfront, one or both of these additional interventions may have been unnecessary.

The same principles apply to the sphenoid sinus as the other paranasal sinuses. Namely, the size of any sphenoidotomy required is dictated by the level of sinus resection and bulk of the free flap obstructing its outflow. Although the sphenoid sinuses were less commonly involved in the resections from this series, free flap reconstruction filling the ethmoid vault was noted to block the sphenoethmoidal recess (Figure 3). A large bilateral sphenoidotomy with removal of the intersinus septum and a limited posterior septectomy should be considered in these circumstances or when the sphenoid is entered as part of the extirpation.

CONCLUSION

In conclusion, we identified the post-operative rate of rhinosinusitis and incidence of endoscopic sinus surgery to be 43% with 20% respectively in patients undergoing resection of advanced orbitofacial lesions and reconstruction with free tissue transfer. Patients who had multiple sinuses resected at the time of initial surgery along with adjuvant radiotherapy and chemotherapy were at increased risk. Prophylactic surgical treatment strategies to optimize sinus drainage pathways at the initial surgery may decrease the incidence of rhinosinusitis in this patient population.

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LEGENDS

Figure 1. Coronal CT of the paranasal sinuses 70 days after left orbital exenteration, partial maxillectomy and anterolateral thigh free flap depicting left osteomeatal obstruction from the flap soft tissue.

Figure 2. Coronal (A) and axial (B) CT imaging of the paranasal sinuses 116 days after left orbital exenteration, frontal sinus resection and anterolateral free flap obliteration of the left frontal sinus. Opacification of the right frontal sinus is evident secondary to impingement of the frontal recess by the contralateral soft tissue flap.

Figure 3. Axial CT of the paranasal sinuses 2 weeks after left orbital exenteration, anterior cranial base resection and anterolateral thigh reconstruction demonstrating flap-related obstruction of the left sphenoethmoidal recess and post-obstructive frothy secretions in the left sphenoid.

Table 1. Patient Demographics	n
Male	40
Female	15
Prior sinus surgery	4
Prior radiation	18
Prior chemotherapy	3
Adjuvant radiation	28
Adjuvant chemotherapy	19
Mean age (yrs)	65
Mean follow-up (mos)	21

Table 2. Pathology	n=55 patients
Squamous cell carcinoma	
Cutaneous Sinonasal Mucosal	12 7 3
Basal cell carcinoma	5
Melanoma	
Cutaneous Mucosal	1 3
Recurrent meningioma	5
Sinonasal adenocarcinoma	3
Basosquamous carcinoma	3
Frontal bone osteomyelitis	3
Lacrimal sac carcinoma	2
Adenoid cystic, esthesioneuroblastoma, hemangiopericytoma, lacrimal gland carcinoma, malignant peripheral nerve sheath tumor, osteosarcoma, poorly differentiated sinonasal carcinoma, SNUC	8 (1 each)

Table 3. Defect Subsites			
Skin/soft tissue:	**n**	**Bone:**	**n**
Lid	41	Skullbase	29
Brow	32	Frontal bar	22
Frontal	27	Lateral orbital rim	17
Temporal	20	Orbital floor	29
Malar	29	Inferior orbital rim	30
Nasal	23	Medial orbital wall	32
Lower cheek	7	Zygoma	7
Orbit	42	Maxilla	31
		Nasal	26
Sinuses:			
Ethmoid	40	Single sinus	17
Maxillary	38	Multiple sinuses	38
Frontal	29		
Sphenoid	11		

Table 4. Free Flap Selection (60 flaps in 55 patients)	
	n (%)
Anterolateral thigh	41 (68)
Soft tissue radial forearm (RF)	13 (22)
Fibula	1 (2)
Latissimus	2 (3)
Osteocutaneous RF	1 (2)
Lateral arm	1 (2)
Rectus	1 (2)

Table 5. Complications	n	%
Peri-operative Mortality (within 1 mo)	2	4
Stroke	2	4
MI	2	4
CSF leak*	3	11
Intraoperative flap loss	2	4
Delayed flap loss	1	2
Hematoma	4	7
Wound infection	3	5
Epidermolysis or partial flap loss	3	5
Breakdown during XRT†	2	6
Rhinosinusitis‡	21	43

* Incidence proportion (%) calculated using only patients who had undergone anterior cranial base resection (n=28) as the denominator

† Incidence proportion (%) calculated using only patients who went on to receive adjuvant XRT (n=32) as the denominator

‡ Incidence proportion (%) calculated using only patients with follow-up of ≥ 3 months (n=49) as the denominator

MS = maxillary sinus, OMC = osteomeatal complex, PE = posterior ethmoids, R = right, RF = radial forearm, SS = sphenoid sinus

† Sinonasal interventions for cases 4, 5, 6, 7, & 10 were performed in conjunction with another procedure

~~Table 6. Clinical Characteristics of Patients Requiring Delayed Operative Sinonasal Intervention~~

~~Case~~	~~Sinuses Involved in Initial Defect~~	~~Prophylactic Sinus Intervention~~	~~Free Flap Used~~	~~Interval from Flap to Pertinent Imaging (days)~~	~~Radiographic Findings~~	~~Interval from Flap to Sino-nasal Surgery (days)~~	~~Sinonasal Operative Intervention~~
~~1~~	~~Anterior table L FS, L AE~~	~~Obliteration of L FS~~	~~ALT~~	~~116~~	~~R FS mucocele (CT & MRI)~~	~~182~~	~~R total ethmoidectomy, MS antrostomy, frontal drillout (Draf II)~~
~~2~~	~~R MS, b/l FS (including R outflow tract)~~	~~FS cranialization, obliteration of L outflow tract~~	~~ALT~~	~~70~~	~~B/L MS thickening, R SS thickening complete L SS opacification (CT & MRI)~~	~~73~~	~~B/L sphenoidotomy & posterior septectomy, B/L inferior windows~~
~~3~~	~~L FS, MS~~	~~None~~	~~RF~~	~~52~~	~~Soft tissue obstruction L OMC (CT)~~	~~56~~	~~L total ethmoidectomy, MS antrostomy~~
~~4~~	~~R AE, PE, MS~~	~~None~~	~~ALT~~	~~196~~	~~Frothy secretions R MS, opacification of all sinuses & OMC on L w/ septal spur (CT)~~	~~199~~	~~Extensive sinonasal debridement, resection L septal spur*~~
~~5~~	~~R AE, MS~~	~~None~~	~~RF~~	~~150~~	~~Air-fluid level R MS, opacification R AE, PE (CT)~~	~~241~~	~~R MS antrostomy*~~
~~6~~	~~L AE, PE, MS~~	~~L MS antrostomy~~	~~RF~~	~~770~~	~~Opacification L MS, AE, FS, & frontal recess (CT)~~	~~808~~	~~Revision L MS antrostomy*~~
~~7**~~	~~L AE, PE, MS~~	~~None~~	~~ALT~~	~~1) 588 2) 862~~	~~1) L FS mucocele 2) Thickening L FS, AE (CT)~~	~~1) 588 2) 875~~	~~1) L frontal drillout (Draf II), septoplasty* 2) Frontal drillout (Draf III)~~
~~8~~	~~L FS, AE, PE, MS~~	~~L frontal sinusotomy (external)~~	~~ALT~~	~~70~~	~~B/L OMC obstruction (CT)~~	~~70~~	~~L MS antrostomy, partial ethmoidectomy, frontal sinusotomy~~
~~9~~	~~B/L FS~~	~~L frontal obliteration~~	~~ALT~~	~~99~~	~~B/L ethmoid sinusitis (CT)~~	~~266~~	~~B/L total ethmoidectomy, MS antrostomy~~
~~10~~	~~L FS, AE, PE, MS~~	~~L frontal obliteration, L MS antrostomy~~	~~ALT~~	~~281~~	~~Opacity L SS, MS (CT)~~	~~294~~	~~L sphenoidotomy*~~

Table 6. Clinical Characteristics of Patients Requiring Delayed Operative Sinonasal Intervention*

Case	Sinuses Involved in Initial Defect	Prophylactic Sinus Intervention	Free Flap Used	Interval from Flap to Pertinent Imaging	Radiographic Findings	Interval from Flap to Sino-nasal	Sinonasal Operative Intervention†

				(days)		Surgery (days)	
1	Anterior table L FS, L AE	Obliteration of L FS	ALT	116	R FS mucocele (CT & MRI)	182	R total ethmoidectomy, MS antrostomy, frontal drillout (Draf II)
2	R MS, b/l FS (including R outflow tract)	FS cranialization, obliteration of L outflow tract	ALT	70	B/L MS thickening, R SS thickening complete L SS opacification (CT & MRI)	73	B/L sphenoidotomy & posterior septectomy, B/L inferior windows
3	L FS, MS	None	RF	52	Soft tissue obstruction L OMC (CT)	56	L total ethmoidectomy, MS antrostomy
4	R AE, PE, MS	None	ALT	196	Frothy secretions R MS, opacification of all sinuses & OMC on L w/ septal spur (CT)	199	Extensive sinonasal debridement, resection L septal spur
5	R AE, MS	None	RF	150	Air-fluid level R MS, opacification R AE, PE (CT)	241	R MS antrostomy
6	L AE, PE, MS	L MS antrostomy	RF	770	Opacification L MS, AE, FS, & frontal recess (CT)	808	Revision L MS antrostomy
7*	L AE, PE, MS	None	ALT	1) 588 2) 862	1) L FS mucocele 2) Thickening L FS, AE (CT)	1) 588 2) 875	1) L frontal drillout (Draf II), septoplasty 2) Frontal drillout (Draf III)
8	L FS, AE, PE, MS	L frontal sinusotomy (external)	ALT	70	B/L OMC obstruction (CT)	70	L MS antrostomy, partial ethmoidectomy, frontal sinusotomy
9	B/L FS	L frontal obliteration	ALT	99	B/L ethmoid sinusitis (CT)	266	B/L total ethmoidectomy, MS antrostomy
10	L FS, AE, PE, MS	L frontal obliteration, L MS antrostomy	ALT	281	Opacity L SS, MS (CT)	294	L sphenoidotomy

Table 7. Risk Factor Analysis		
	Clinical &/or Radiographic Rhinosinusitis	
Adjuvant Radiotherapy	Yes	No
Yes	16	13
No	5	15
	p=0.045	
Adjuvant Chemo-Radiotherapy	Yes	No
Yes	12	6

* Patient underwent 2 separate sinus procedures post-operatively

No	9	22
	p=0.016	
	Need for Subsequent Sinus Surgery	
Sinus Involvement in Initial Orbitofacial Defect	Yes	No
Single sinus	0	17
Multiple sinuses	10	22
	p=0.009	

Figure 1.

Figure 2.

A B

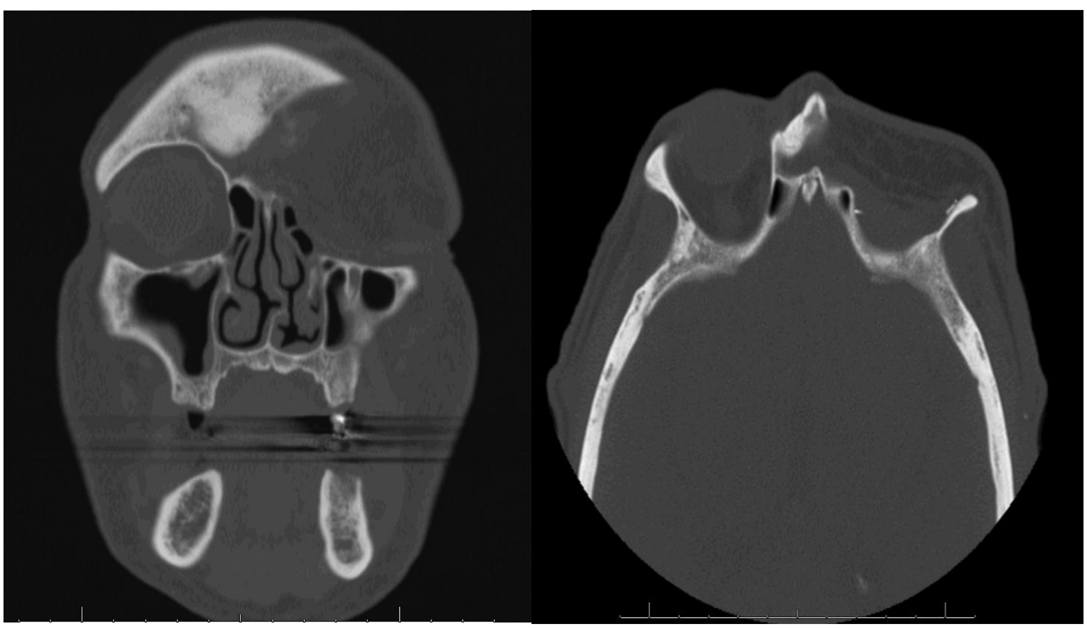

Figure 3.