Published in final edited form as:

Int Forum Allergy Rhinol. 2014 April ; 4(4): 315–320. doi:10.1002/alr.21269.

The effect of diabetes mellitus on chronic rhinosinusitis and sinus surgery outcome

Zi Zhang, MD, MSCE¹, Nithin D. Adappa, MD³, Ebbing Lautenbach, MD, MPH, MSCE^{1,5}, Alexander G. Chiu, MD², Laurel Doghramji, RN, BSN³, Timothy J. Howland, BS³, Noam A. Cohen, MD, PhD^{3,4}, and James N. Palmer, MD³

¹Department of Biostatistics and Epidemiology, Center for Clinical Epidemiology and Biostatistics, University of Pennsylvania, Perelman School of Medicine, Philadelphia, Pennsylvania

²Department of Surgery, University of Arizona, Tucson, Arizona

³Department of Otorhinolaryngology–Head and Neck Surgery, University of Pennsylvania, Perelman School of Medicine, Philadelphia, Pennsylvania

⁴Philadelphia Veterans Affairs Medical Center, Philadelphia, Pennsylvania

⁵Division of Infectious Diseases, Department of Medicine, University of Pennsylvania, Perelman School of Medicine, Philadelphia, Pennsylvania

Abstract

Objective—Patients with diabetes mellitus (DM) are known to be liable to infection. However, the association between diabetes and chronic rhinosinusitis (CRS) has not been well studied. We sought to determine the effects of DM on CRS culture results and quality of life (QOL) after functional endoscopic sinus surgery (FESS).

Methods—We conducted a retrospective cohort study. Adult CRS patients undergoing FESS were recruited from 10/1/2007 to 12/31/2011. Patient demographics, comorbidities, medication use, Lund-Mackay CT scores were collected prior to FESS. Intraoperative culture was obtained. Preoperative and 1-, 3- and 6-month postoperative QOL was measured by the 22 item Sinonasal Outcome Test (SNOT-22) scores. A mixed effects model was performed for analysis.

Results—Among the 376 CRS patients included, 19 patients (5.05%) had DM. Compared to non-DM patients, DM patients were significantly more likely to have *Pseudomonas aeruginosa* (26.32% versus 7.56%, $p=0.004$) and gram negative rods (26.32% vs. 8.96%, $p=0.013$), but there were no significant difference in the prevalence of *Staphylococcus aureus*; DM patients were also significantly more likely to have nasal polyps and gastroesophageal reflux disease. Additionally, DM patients had significantly less improvement of postoperative SNOT-22 scores from baseline to 6-month follow-up than non-DM patients (adjusted mean=11.14, 95% CI (0.14, 22.15), $p=0.047$) after adjusting for all the other risk factors for CRS.

Conclusion—DM patients may be prone to gram negative bacterial sinus infections, and have significantly worse short-term postoperative QOL. Special postoperative care may need to be considered in CRS patients with DM

Keywords

chronic rhinosinusitis; diabetes mellitus; infection; quality of life; *Pseudomonas aeruginosa*

Correspondence: Zi Zhang, MD, MSCE, Address: 8th Floor, Blockley Hall, 423 Guardian Drive, Philadelphia, PA 19104-6021, Telephone number: 215-573-6625; Fax number: 215-573-5535; zizhang@mail.med.upenn.edu.

All the other authors did not report any conflicts of interest.

Introduction

Chronic rhinosinusitis (CRS) is defined as a group of disorders characterized by inflammation of the mucosa of the nose and paranasal sinuses of at least 12 weeks duration. It is estimated to affect 14–16% of the population in the United States.¹ CRS is a heterogeneous multifactorial disease². Many risk factors for CRS have been identified, such as age³sex^{4,5}smoking status⁶nasal polyps^{3,7}allergic rhinitis⁶asthma^{3,7}aspirin intolerance⁴infection, biofilms, gastroesophageal reflux (GERD)⁸as well as anatomical abnormalities of upper airways and histological appearance of sinus mucosa.^{9–11} However, it is unknown whether diabetes mellitus (DM), the fifth deadliest disease in the United States, affects the pathogenesis and prognosis of CRS.

8.3% of the U.S. population has DM¹². The percentage of people with diagnosed diabetes is increasing over the past decades. Elevated blood sugar levels in patients with DM inhibit the immune system.¹³ In addition, some diabetes-related health issues, such as nerve damage and reduced blood flow also increase the body's vulnerability to infection. Previous study has shown that patients with DM are at increased risk for lower respiratory tract infection, urinary tract infection, and skin and mucous membrane infection.¹⁴ *Pseudomonas aeruginosa* and *Staphylococcus aureus* are two of the most common bacterial isolates in patients with CRS.^{15,16} It is of considerable interest to assess if CRS patients with DM are more susceptible to certain types of infection and whether DM affects the prognosis of CRS after functional endoscopic sinus surgery (FESS). The specific aims of our study were to determine whether DM was associated with certain types of sinus culture results, especially *Staphylococcus aureus* or *Pseudomonas aeruginosa*, as well as the short-term quality of life (QOL) improvement after FESS for CRS.

Methods

Study design and study population

Institutional review board approval was obtained from the University of Pennsylvania. We conducted a retrospective cohort study. Adult CRS patients (≥ 18 years old) who were scheduled to have FESS at the Department of Otorhinolaryngology–Head and Neck Surgery, the Hospital of the University of Pennsylvania were recruited between 10/1/2007 to 12/31/2011. The inclusion criteria were patients who met the objective and subjective guidelines for the diagnosis of CRS¹⁷. CRS diagnosis is set forth by the Rhinosinusitis Initiative: patients with CRS experienced at least 2 of the typical symptoms, such as headache, nasal obstruction, and nasal drainage, that persisted for 12 weeks or longer and showed edema or erythema of the middle meatus, as identified by means of nasal endoscopy¹⁷. Furthermore, a computed tomographic (CT) scan showed diffuse mucosal thickening, opacification, or swelling of the ethmoidal and maxillary mucosa with bilateral obstruction of the osteomeatal complex.¹⁸ According to the recommendation of guidelines for the studies of CRS,^{19,20} patients with the following diseases were excluded: cystic fibrosis, congenital or acquired immunodeficiency, congenital mucociliary, non-invasive fungal balls and invasive fungal disease, systemic vasculitis and granulomatous diseases, cocaine abuse, or neoplasia.

Diabetes and other covariates

Patients' medical records were reviewed to determine whether the patients had diagnosis of DM. Type I or Type II diabetes diagnosis was listed in the preoperative medical records. Preoperative fasting glucose level, hemoglobin A1c (HbA1c) and diabetic medications were also collected. In addition, basic demographic data and comorbidities including age, sex,

race, asthma, nasal polyps, allergic rhinitis, obstructive sleep apnea, smoking status, GERD, prior FESS history, and Samter's triad were collected from patients' medical records at baseline. The preoperative Lund-Mackay CT scores were assessed by a research nurse and a medical assistant. The use of oral antibiotics, oral steroids, nasal steroid spray, and nasal irrigations in the month before surgery was also recorded.

Outcomes

There were two outcomes of our study. One was to identify any bacterial isolates from sinus culture at the time of FESS, especially *S. aureus* or *P. aeruginosa*. The other was to evaluate the improvement of QOL from the latest preoperative visit to 1-, 3- and 6-month postoperative follow up visits. Each patient had endoscopically guided sinus culture taken from one of the diseased sinuses during FESS using standard method^{21–23}. The samples were immediately sent to the hospital microbiology laboratory for standard microbiological speciation. QOL was measured by the 22 item Sinonasal Outcome Test (SNOT-22) scores. The SNOT-22 contains 22 symptoms related items on sinonasal symptoms, sleep, emotional and psychosocial functioning, where each item is scored on a range of 0 to 5 depending on severity, thus giving a total score of 0 to 110.²⁴ Higher scores represent worse QOL. Clinically significant change of SNOT-22 score was defined as difference of at least ½ SD of the baseline SNOT-22 score in the reference group.^{25,26}

Statistical Analysis

First, we summarized all the patients' characteristics and tested whether the continuous variables were normally distributed. If the distribution was not normal, the variable was log transformed. In the univariate analyses, χ^2 tests were used for categorical variables and t tests were used for continuous variables. We compared the isolation rates of different bacteria between patients with and without DM using χ^2 tests. To determine whether DM was independently associated with the improvement of SNOT-22 scores from baseline to 1-, 3- and 6-month postoperative follow up visits, we conducted the analysis using the linear mixed-effects regression model, with fixed effects for time modeled as a categorical variable, diagnosis of diabetes, and the interaction between the two in order to allow the effects of diabetes on postoperative QOL to vary over time. The model also included random effects for patient to account for the correlation between repeated measures per patient. If a SNOT-22 score was missing at a certain time point, the rest of the scores from that same patient were still included in the mixed effects model. Potential confounding variables listed above were considered, and these with $p < 0.2$ in the univariate analyses were entered into the final multiple regression model. The adjusted β coefficients and 95% confidence intervals (95% CI) were calculated from the linear mixed effects regression model to assess the magnitudes of the associations. The adjusted β coefficient can be interpreted as the adjusted mean difference of postoperative improvement of SNOT-22 scores in CRS patients with and without the condition while holding the other variables in the model constant. Significance was based on $\alpha < 0.05$ and all hypothesis tests were 2-sided. The analyses were performed using Stata version 11.0 (Stata Corp, College Station, Texas).

Results

376 CRS patients were included in the analysis. Table 1 shows the patients' characteristics in our study. The mean $\pm$ SD age was 48 ± 13 years. 42.55% of the patients were female ($n=160$) and 88.8% were white ($n=333$). 5.05% patients ($n=19$) had DM. Among them, 90% type II diabetes and 10% were type I; the range of fasting glucose level was 65–367 mg/dL, the mean was 162.5 mg/dL; the range of HbA1c was 5.9–8.8%, the mean was 7.12%; for diabetic medications, 25% had metformin only, and 40% had insulin from the preoperative records. However, approximately 10% of the patients only have the diagnosis of diabetes in

the medical records without any of the detailed information. Compared to non-DM patients, CRS patients with DM were significantly more likely to have nasal polyps (89.47% versus 58.54%, $p=0.007$) and GERD (47.37% versus 24.37%, $p=0.025$). 27.66% patients ($n=104$) had isolate of *S. aureus* and 8.51% ($n=32$) had *P. aeruginosa*. The culture results are listed in Table 2. Compared to CRS patients without DM, CRS patients with DM were significantly more likely to have *P. aeruginosa* (26.32% versus 7.56%, $p=0.004$) and other gram-negative rods (26.32% versus 8.96%, $p=0.013$), but not *S. aureus* (21.05% versus 28.01%, $p=0.509$), *S. pneumonia* (0 versus 5.30%, $p=0.302$), Coagulase-negative *staphylococcus* (73.68% versus 56.86%, $p=0.148$) and anaerobes (45.45% versus 55.40%, $p=0.518$).

We further evaluated whether the preoperative severity of CRS was different between patients with and without DM. The preoperative Lund-Mackay CT scores were not significantly different between patients with and without DM (13 ± 7 versus 13 ± 6 , $p=0.732$), and neither were the preoperative SNOT-22 scores (41 ± 18 versus 40 ± 23 , $p=0.926$). However, compared to non-DM patients, CRS patients with DM had less improvement of QOL from baseline to 1-, 3- and 6-month postoperative visits as shown in Figure 1.

After adjusting for all the covariates in the linear mixed-effects regression model, compared to patients without DM, the improvement of SNOT-22 scores in CRS patients with DM were marginally significantly less from baseline to 1-month postoperative follow-up (adjusted β -coefficient=9.74, 95% CI (-0.18, 19.66), $p=0.054$), and significantly less from baseline to 6-month postoperative follow-up (adjusted β -coefficient=11.14, 95% CI (0.14, 22.15), $p=0.047$). The results are shown in Table 3. This adjusted mean SNOT-22 score difference from baseline to 6 month postoperative follow-up, 11.14, was greater than the $\frac{1}{2}$ SD of baseline SNOT-22 scores of CRS patients without DM, 11, and thus, CRS patients with DM had clinically significantly less QOL improvement from baseline to 6-month postoperative visits.

In our sub-analysis, we further explored whether patients with Type I versus Type II diabetes had different culture results and postoperative QOL improvements, but did not find any statistically significant results.

Discussion

To our knowledge, this appears to be the first study to assess the impact of DM on CRS in a large clinical cohort. DM increases patients' susceptibility to various types of infections due to the metabolic derangements.^{14,27,28} The most common affected sites in DM are the skin and urinary tract,^{29,30} such as staphylococcal follicular skin infections, fungal infections, cellulitis, erysipelas, lower urinary tract infections and acute pyelonephritis. However, it is unclear how DM would affect bacteria isolated from CRS and FESS outcome. Our study showed that CRS patients with DM were significant more likely to have *P. aeruginosa* and other gram negative rods isolated from the infected sinus, as well as clinically significantly less improvement of postoperative SNOT-22 scores from baseline to 6-month postoperative follow up. Interestingly, CRS patients with DM were also significantly more likely to have nasal polyps and GERD as compared to patients without DM.

Our study found that CRS patients with DM had 3.5 times higher isolation rate of *P. aeruginosa* and other gram negative rods than CRS patients without DM, however, the isolation rate of *S. aureus*, *S. pneumonia*, Coagulase-negative *staphylococcus* and anaerobes were similar between patients with and without DM. DM infection is usually polymicrobial in nature³¹. *S. aureus* is common in skin and soft tissue infections in patients with diabetes,

but *P. aeruginosa* and other gram negative rods have been associated with worse outcomes in hospitalized patients.³² Additionally, *P. aeruginosa* has been associated with malignant external otitis in diabetic patients decades ago³³. Our study appears to be the first one to demonstrate a high prevalence of *P. aeruginosa* and other gram negative rods from sinus culture in CRS patients with DM. *P. aeruginosa* and other gram negative rods are important causes of infection, especially in patients with compromised host defense mechanisms. The common bacterial isolates from CRS patients include *P. aeruginosa*, other gram negative rods and *S. aureus*^{16,34–36}. The bacterial isolation rates in our study consist with previous studies^{34,37}. Further study is needed to better understand the biological mechanism regarding how DM makes the sinus mucosa susceptible for *P. aeruginosa* and other gram negative rods in CRS.

Another novel finding of our study is that we found CRS patients with DM were significantly more likely to have nasal polyps compared to non-DM patients. As patients with asthma, frequent sinus infections and allergies are more likely to develop nasal polyps,^{38–40} further studies are needed to assess whether diabetes affects the inflammatory status of the nasal cavity and sinuses to facilitate the development of nasal polyps. In addition, our finding agrees with previous studies that patients with DM had higher prevalence of GERD.^{41,42} Recent studies have shown that GERD was more common in diabetic patients with neuropathy or nerve damage, which are common complications of diabetes.^{42,43}

After adjusting for the confounding effects of nasal polyps and GERD on postoperative QOL improvement in the linear mixed effects regression model, only DM was a significant independent risk factor for less postoperative improvement of SNOT-22 scores from baseline to 6 month follow up visit; nasal polyps, GERD, *P. aeruginosa*, other gram-negative rods and prior FESS were not significantly associated with postoperative QOL improvement. Previous studies have shown that prior FESS was independently associated with poor postoperative QOL outcomes.^{4,44} However, prior FESS was not significant in our final model. This may be because we included diabetes, *P. aeruginosa* and other gram negative rods in the final regression model, which were not adjusted in previous studies. Thus, our findings added evidence to the literature that DM was a clinically significant independent risk factor for short-time QOL improvement after FESS for CRS. Future studies with long-term follow up can help to better evaluate the effect of DM on long-term QOL outcome after FESS for CRS.

There are several limitations in our study. First, we did not have objective measures of the postoperative outcomes, such as nasal endoscopy score. However, the use of patient-reported outcome measures is rapidly growing in studies of clinical effectiveness and quality of care. Second, not every CRS patient in our institute completed the SNOT-22 scores. We compared patients with and without SNOT-22 scores and there were no statistically significant differences between them. Third, due to the fact that many patients followed up with specialist outside of Penn for diabetes control, we did not have objective measures of diabetes across different time points to determine whether diabetes control and compliance of diabetes treatment affect the outcome of CRS. Fourth, the prevalence of DM was 5% in our population, which is lower than the reported 8.3% in the US population. However, no prior studies have shown whether the prevalence of diabetes in the CRS population should be higher or lower than the general US population. Our results may be due to the fact that CRS patients tend to be younger in age than those with many chronic medical conditions with a lower number of patients having yet to develop type II DM. In addition, we cannot rule out the possibility that some diabetic patients were not captured in this retrospective cohort study, but if undiagnosed diabetic patients were misclassified as non-diabetic, the effects would be biased towards the null, so the real effects would be strengthened. Finally,

there may be other unknown or uncollected factors associated with postoperative QOL outcome, which were not evaluated in our study.

Conclusion

We have demonstrated in a large clinical cohort study that DM appears to have a significant impact on CRS. Compared to CRS patients without DM, patients with DM were significantly more likely to have nasal polyps, GERD, positive *P. aeruginosa* and other gram negative rods isolated from sinus cultures, and clinically significantly less improvement of postoperative SNOT-22 scores from baseline to 6 month follow up visits. Thus, CRS patients with DM may require special postoperative care, such as using oral steroids with caution, and clinicians treating CRS in diabetic patients may consider antibiotics with improved pseudomonal coverage. Future studies with long-term postoperative follow up and objective measures of postoperative outcomes and diabetes controls, such as nasal endoscopy scores and HbA1c, are needed to further evaluate the impact of DM on long-term CRS prognosis after FESS, as well as to determine whether DM control improves the prognosis of CRS after FESS.

Acknowledgments

This work was supported by the National Institutes of Health (K24 AI080942 to E.L.). E.L. received research grant support from Merck, AstraZeneca, and 3M.

References

1. Bloom B, Cohen RA, Freeman G. Summary health statistics for U.S. children: National Health Interview Survey, 2008. *Vital Health Stat.* 2009 Dec; 10(244):1–81.
2. Hamilos DL. Chronic rhinosinusitis patterns of illness. *Clin Allergy Immunol.* 2007; 20:1–13. [PubMed: 17534042]
3. Staikuniene J, Vaitkus S, Japertiene LM, Ryskiene S. Association of chronic rhinosinusitis with nasal polyps and asthma: clinical and radiological features, allergy and inflammation markers. *Medicina (Kaunas).* 2008; 44(4):257–265. [PubMed: 18469501]
4. Smith TL, Mendolia-Loffredo S, Loehrl TA, Sparapani R, Laud PW, Nattinger AB. Predictive factors and outcomes in endoscopic sinus surgery for chronic rhinosinusitis. *Laryngoscope.* 2005 Dec; 115(12):2199–2205. [PubMed: 16369166]
5. Baumann I, Blumenstock G, Zalaman IM, et al. Impact of gender, age, and comorbidities on quality of life in patients with chronic rhinosinusitis. *Rhinology.* 2007 Dec; 45(4):268–272. [PubMed: 18085019]
6. Houser SM, Keen KJ. The role of allergy and smoking in chronic rhinosinusitis and polyposis. *Laryngoscope.* 2008 Sep; 118(9):1521–1527. [PubMed: 18758323]
7. Pearlman AN, Chandra RK, Chang D, et al. Relationships between severity of chronic rhinosinusitis and nasal polyposis, asthma, and atopy. *Am J Rhinol Allergy.* 2009 Mar-Apr; 23(2):145–148. [PubMed: 19401038]
8. DelGaudio JM. Direct nasopharyngeal reflux of gastric acid is a contributing factor in refractory chronic rhinosinusitis. *Laryngoscope.* 2005 Jun 17; 115(6):946–957. [PubMed: 15933499]
9. Richtsmeier WJ. Top 10 reasons for endoscopic maxillary sinus surgery failure. *Laryngoscope.* 2001 Nov; 111(11 Pt 1):1952–1956. [PubMed: 11801976]
10. Musy PY, Kountakis SE. Anatomic findings in patients undergoing revision endoscopic sinus surgery. *Am J Otolaryngol.* 2004 Nov-Dec; 25(6):418–422. [PubMed: 15547811]
11. Kennedy DW. Prognostic factors, outcomes and staging in ethmoid sinus surgery. *Laryngoscope.* 1992 Dec; 102(12 Pt 2 Suppl 57):1–18. [PubMed: 1453856]
12. Boronat M, Saavedra P, Lopez-Rios L, Riano M, Wagner AM, Novoa FJ. Differences in cardiovascular risk profile of diabetic subjects discordantly classified by diagnostic criteria based

- on glycosylated hemoglobin and oral glucose tolerance test. *Diabetes care*. 2010 Dec; 33(12):2671–2673. [PubMed: 20807875]
13. Delamaire M, Maugeudre D, Moreno M, Le Goff MC, Allannic H, Genetet B. Impaired leucocyte functions in diabetic patients. *Diabetic medicine : a journal of the British Diabetic Association*. 1997 Jan; 14(1):29–34. [PubMed: 9017350]
 14. Muller LM, Gorter KJ, Hak E, et al. Increased risk of common infections in patients with type 1 and type 2 diabetes mellitus. *Clin Infect Dis*. 2005 Aug 1; 41(3):281–288. [PubMed: 16007521]
 15. Hsu J, Lanza DC, Kennedy DW. Antimicrobial resistance in bacterial chronic sinusitis. *Am J Rhinol*. 1998 Jul-Aug; 12(4):243–248. [PubMed: 9740916]
 16. Bhattacharyya N, Kepnes LJ. Assessment of trends in antimicrobial resistance in chronic rhinosinusitis. *Ann Otol Rhinol Laryngol*. 2008 Jun; 117(6):448–452. [PubMed: 18646442]
 17. Meltzer EO, Hamilos DL, Hadley JA, et al. Rhinosinusitis: establishing 18 definitions for clinical research and patient care. *J Allergy Clin Immunol*. 2004 Dec; 114(6 Suppl):155–212. [PubMed: 15577865]
 18. Meltzer EO, Hamilos DL, Hadley JA, et al. Rhinosinusitis: developing guidance for clinical trials. *J Allergy Clin Immunol*. 2006 Nov; 118(5 Suppl):S17–S61. [PubMed: 17084217]
 19. Rosenfeld RM, Andes D, Bhattacharyya N, et al. Clinical practice guideline: adult sinusitis. *Otolaryngol Head Neck Surg*. 2007 Sep; 137(3 Suppl):S1–S31. [PubMed: 17761281]
 20. Fokkens W, Lund V, Mullol J. EP3OS 2007: European position paper on rhinosinusitis and nasal polyps 2007. A summary for otorhinolaryngologists. *Rhinology*. 2007 Jun; 45(2):97–101. [PubMed: 17708455]
 21. Rombaux P, Collet S, Hamoir M, et al. The role of nasal cavity disinfection in the bacteriology of chronic sinusitis. *Rhinology*. 2005 Jun; 43(2):125–129. [PubMed: 16008068]
 22. Zhang Z, Kofonow JM, Finkelman BS, et al. Clinical factors associated with bacterial biofilm formation in chronic rhinosinusitis. *Otolaryngol Head Neck Surg*. 2011 Mar; 144(3):457–462. [PubMed: 21493213]
 23. Zhang Z, Linkin DR, Finkelman BS, et al. Asthma and biofilm-forming bacteria are independently associated with revision sinus surgeries for chronic rhinosinusitis. *J Allergy Clin Immunol*. 2011 Jul; 128(1):221–223. e221. [PubMed: 21439623]
 24. Hopkins C, Gillett S, Slack R, Lund VJ, Browne JP. Psychometric validity of the 22-item Sinonasal Outcome Test. *Clin Otolaryngol*. 2009 Oct; 34(5):447–454. [PubMed: 19793277]
 25. Norman GR, Sloan JA, Wywrich KW. Interpretation of changes in health-related quality of life: the remarkable universality of half a standard deviation. *Med Care*. 2003 May; 41(5):582–592. [PubMed: 12719681]
 26. Norman GR, Sloan JA, Wywrich KW. The truly remarkable universality of half a standard deviation: confirmation through another look. *Expert Rev Pharmacoecon Outcomes Res*. 2004 Oct; 4(5):581–585. [PubMed: 19807551]
 27. Joshi N, Caputo GM, Weitekamp MR, Karchmer AW. Infections in patients with diabetes mellitus. *N Engl J Med*. 1999 Dec 16; 341(25):1906–1912. [PubMed: 10601511]
 28. Bertoni AG, Saydah S, Brancati FL. Diabetes and the risk of infection-related mortality in the U.S. *Diabetes care*. 2001 Jun; 24(6):1044–1049. [PubMed: 11375368]
 29. Ki V, Rotstein C. Bacterial skin and soft tissue infections in adults: A review of their epidemiology, pathogenesis, diagnosis, treatment and site of care. *The Canadian journal of infectious diseases & medical microbiology = Journal canadien des maladies infectieuses et de la microbiologie medicale / AMMI Canada*. 2008 Mar; 19(2):173–184.
 30. Mokabberi R, Ravakhah K. Emphysematous urinary tract infections: diagnosis, treatment and survival (case review series). *The American journal of the medical sciences*. 2007 Feb; 333(2): 111–116. [PubMed: 17301591]
 31. Citron DM, Goldstein EJ, Merriam CV, Lipsky BA, Abramson MA. Bacteriology of moderate-to-severe diabetic foot infections and in vitro activity of antimicrobial agents. *J Clin Microbiol*. 2007 Sep; 45(9):2819–2828. [PubMed: 17609322]
 32. Lipsky BA, Tabak YP, Johannes RS, Vo L, Hyde L, Weigelt JA. Skin and soft tissue infections in hospitalised patients with diabetes: culture isolates and risk factors associated with mortality, length of stay and cost. *Diabetologia*. 2010 May; 53(5):914–923. [PubMed: 20146051]

33. Zaky DA, Bentley DW, Lowy K, Betts RF, Douglas RG Jr. Malignant external otitis: a severe form of otitis in diabetic patients. *Am J Med.* 1976 Aug; 61(2):298–302. [PubMed: 821345]
34. Kingdom TT, Swain RE Jr. The microbiology and antimicrobial resistance patterns in chronic rhinosinusitis. *Am J Otolaryngol.* 2004 Sep-Oct;25(5):323–328. [PubMed: 15334396]
35. Coffey CS, Sonnenburg RE, Melroy CT, Dubin MG, Senior BA. Endoscopically guided aerobic cultures in postsurgical patients with chronic rhinosinusitis. *Am J Rhinol.* 2006 Jan-Feb;20(1):72–76. [PubMed: 16539298]
36. Nadel DM, Lanza DC, Kennedy DW. Endoscopically guided cultures in chronic sinusitis. *Am J Rhinol.* 1998 Jul-Aug;12(4):233–241. [PubMed: 9740915]
37. Bhattacharyya N. Bacterial infection in chronic rhinosinusitis: a controlled paired analysis. *Am J Rhinol.* 2005 Nov-Dec;19(6):544–548. [PubMed: 16402638]
38. Larsen K. The clinical relationship of nasal polyps to asthma. *Allergy Asthma Proc.* 1996 Sep-Oct; 17(5):243–249. [PubMed: 8922143]
39. Norlander T, Bronnegard M, Stierna P. The relationship of nasal polyps, infection, and inflammation. *Am J Rhinol.* 1999 Sep-Oct;13(5):349–355. [PubMed: 10582112]
40. Kirtsreesakul V. Nasal polyps: the relationship to allergy, sinonasal infection and histopathological type. *J Med Assoc Thai.* 2004 Mar; 87(3):277–282. [PubMed: 15117044]
41. Wang X, Pitchumoni CS, Chandrarana K, Shah N. Increased prevalence of symptoms of gastroesophageal reflux diseases in type 2 diabetics with neuropathy. *World J Gastroenterol.* 2008 Feb 7; 14(5):709–712. [PubMed: 18205259]
42. Lee SD, Keum B, Chun HJ, Bak YT. Gastroesophageal Reflux Disease in Type II Diabetes Mellitus With or Without Peripheral Neuropathy. *J Neurogastroenterol Motil.* 2011 Jul; 17(3): 274–278. [PubMed: 21860819]
43. Promberger R, Lenglinger J, Riedl O, et al. Gastro-oesophageal reflux disease in type 2 diabetics: symptom load and pathophysiologic aspects - a retro-pro study. *BMC Gastroenterol.* 2013 Aug 23;13(1):132. [PubMed: 23972125]
44. Smith TL, Litvack JR, Hwang PH, et al. Determinants of outcomes of sinus surgery: a multi-institutional prospective cohort study. *Otolaryngol Head Neck Surg.* 2010 Jan; 142(1):55–63. [PubMed: 20096224]

Figure 1.
Pre- and post-FESS SNOT-22 scores by diabetes

Table 1

Patients' characteristics by diabetes

	Total	Diabetes, n (%)		p-value
		No	Yes	
Age (mean, SD)	48 ± 13	50 ± 14	48 ± 13	0.671
Sex (female)	160(42.55)	153(42.86)	7(36.84)	0.605
Race				
<i>Black</i>	31(8.27)	30(8.43)	1(5.26)	0.131
<i>Other</i>	11(2.93)	10(2.81)	1(5.26)	
Preoperative antibiotics	67(17.82)	63(17.65)	4(21.05)	0.705
Nasal rinse				0.341
<i>Saline</i>	123(32.98)	114(32.20)	9(47.37)	0.523
<i>With Medications</i>	8(2.15)	8(2.26)	0(0)	
Steroid use				
<i>Nasal</i>	65(17.29)	63(17.65)	2(10.53)	0.098
<i>Oral</i>	119(31.65)	112(31.37)	7(36.84)	
<i>Both</i>	31(8.25)	28(7.84)	3(15.79)	
Prior FESS	229(60.9)	214(59.94)	15(78.95)	0.438
Asthma	205(54.52)	193(54.06)	12(63.16)	0.007
Nasal polyps	226(60.11)	209(58.54)	17(89.47)	0.466
Allergic rhinitis	248(65.96)	234(65.55)	14(73.68)	0.330
Sleep apnea	17(4.52)	17(4.76)	0(0)	0.923
Smoking				
<i>Former</i>	75(19.95)	71(19.89)	4(21.05)	0.025
<i>Current</i>	51(13.56)	49(13.73)	2(10.53)	
Gastroesophageal reflux disease	96(25.53)	87(24.37)	9(47.37)	0.654
Samter's triad	30(7.98)	29(8.12)	1(5.26)	0.732
Preoperative Lund-Mackay CT scores (mean ± SD)	13 ± 6	12.63	13.19	0.926
Preoperative SNOT-22 scores (mean ± SD)	40 ± 22	40.35	40.84	

Table 2

Culture results by diabetes

Positive Culture	Total N=376	Diabetes, n (%)		p-value
		Yes n=19	No n=357	
<i>S. aureus</i>	104	4 (21.05)	100 (28.01)	0.509
<i>P. aeruginosa</i>	32	5 (26.32)	27 (7.56)	0.004
Other gram-negative rods	37	5 (26.32)	32 (8.96)	0.013
<i>S. pneumonia</i>	17	0	17 (5.30)	0.302
Coagulase-negative <i>staphylococcus</i>	217	14 (73.68)	203 (56.86)	0.148
Anaerobes (n=224) *	123	5 (45.45)	118 (55.40)	0.518

* 224 patients had anaerobic culture results.

Table 3

Adjusted QOL improvement after FESS at 1-, 3- and 6-month follow up

	Unadjusted means	Adjusted Coef.	95% Conf. Interval	p-value
Difference of SNOT-22 scores between patients with and without diabetes				
<i>From baseline to 1-month follow-up</i>	10	9.74	(−0.18, 19.66)	0.054
<i>From baseline to 3-month follow-up</i>	3	7.34	(−3.66, 18.33)	0.191
<i>From baseline to 6-month follow-up</i>	11	11.14	(0.14, 22.15)	0.047
Difference of SNOT-22 scores between patients with and without variable below*				
<i>Nasal polyps</i>	NA	−0.16	(−3.87, 3.55)	0.932
<i>Gastroesophageal reflux disease</i>	NA	0.72	(−3.30, 4.74)	0.726
<i>P. aeruginosa</i>	NA	2.47	(−3.76, 8.70)	0.438
<i>Other gram-negative rods</i>	NA	−2.89	(−8.84, 3.05)	0.340
<i>Prior FESS</i>	NA	3.24	(−0.53, 7.00)	0.092

* Their effects on QOL improvement were averaged across all postoperative follow-up time points.