Extent of Sinus Surgery, 2000 to 2009: A Population-Based Study

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Objectives/Hypothesis: Sinus surgery is one of the most frequently performed surgical operations. The objective was to determine if rates of surgery have changed over the last 10 years.

Study Design: Secondary data analysis of the State Ambulatory Surgery Database of Florida.

Methods: We calculated population adjusted rates of ambulatory sinus surgery for all adults, 2000 to 2009.

Result: There was a substantial decrease in the proportion of patients who had surgery in a hospital setting and a substantial increase in patients who had surgery with image guidance. Population-adjusted rates of sinus surgery increased over the study period, from a mean of 104 cases per 100,000 population in 2000 to 129 per 100,000 in 2009 ($P < 0.001$). Procedure rates also increased, from a mean of 226 per 100,000 in 2000 to 316 per 100,000 in 2009 ($P < 0.001$). Rates of frontal sinus procedures more than doubled, and rates of cases in which all four sinuses were treated tripled during the same time period. A greater number of sinus procedures was associated with use of image guidance and high annual surgical case volume. The strongest predictor was the individual surgeon.

Conclusion: Rates of sinus surgery increased over the study period, with more patients undergoing surgery and more procedures per surgical case. The strong association of procedural patterns with specific surgeons in sinusitis care highlights the importance of future investigations to examine training, technological, and reimbursement factors that may influence surgeons' clinical decision making for this common condition.

Key Words: State ambulatory surgery database, sinus surgery, multlilevel modeling, population.

Level of Evidence: 2b.

Laryngoscope, 124:820–825, 2014

INTRODUCTION

Sinusitis is one of the most prevalent chronic illnesses in the United States, consistently reported by 13% to 14% of adults annually for the last 20 years.[1,2] Most sinusitis care is provided by primary care physicians, with 17 million ambulatory care visits each year.[3] Patients who fail to improve with medical therapy may undergo sinus surgery.

More than 250,000 sinus operations are performed annually[4]—one of the most frequent surgical procedures after septoplasty (260,000).[4,5] Absolute indications for sinus surgery include orbital or intracranial infection, invasive fungal infection, neoplasm, or spinal fluid leak, but these indications are present in a minority of patients with sinusitis.[6] Most patients have relative indications for surgery—principally sinus disease that is persistent and symptomatic despite medical therapy.

For the typical patient with sinusitis, the clinical question is whether surgery would provide additional benefit over medical treatment. Clinical evidence to inform this decision is based on observational studies in tertiary care practices. These studies are subject to selection bias and we do not know how much we can apply the findings of these studies to less highly selected patient populations. In the absence of robust clinical evidence, nonevidence-based factors may influence sinusitis treatment decisions. In other aspects of medical care with large knowledge deficits, medical treatment may be influenced by factors that otherwise would not influence treatment—e.g., patients' preferences, physicians' experience and training, anecdotal evidence, and medicolegal factors.[7–11]

In the case of sinusitis, the end result of these influential factors may be that surgeons vary widely in the threshold to operate. In this study, we sought to describe the current practice of endoscopic sinus surgery and to identify aspects of surgery with the most variation as a possible indication of clinical uncertainty. We hypothesized that nonclinical factors other than patient demographics contribute to variation in sinus surgery. If true, it may be possible to improve the quality of sinusitis care by identifying nonclinical influential factors and their relative influence in clinical decision making.

MATERIALS AND METHODS

Data Source and Subjects

We used the State Ambulatory Surgery Database (SASD) of Florida. SASD is a product of the Healthcare Cost and

Utilization Project, conducted by the federal Agency for Healthcare Research and Quality.[12] The Florida SASD is one of the largest and most ethnically diverse SASD datasets and, unlike many other states, includes records from hospital-affiliated and freestanding surgery centers. Thus, it contains a 100% sample of ambulatory surgeries each year.

Compilation of the Analytic Dataset

We defined the study cohort from Florida SASD files using Current Procedural and Terminology (CPT) codes for years 2000 to 2009. Endoscopic sinus procedures have supplanted traditional sinus surgery procedures over the last 15 to 20 years[13]; therefore, we limited our analysis to CPT codes for endoscopic sinus surgery (CPT 31256, 31267, 31254, 31255, 31276, 31287, 31288).

We excluded patients <18 years of age because they are not representative of the majority of patients who undergo sinus surgery. We also excluded 2026 patients with missing data for gender, age, zip code, surgeon identifier, race, primary payer, or hospital ambulatory surgery center type, as well as non-Florida residents, leaving 94,152 observations for analysis.

Candidate Covariate Factors

We obtained patient demographic information including age, gender, race, primary expected payer, and location of surgery at either a hospital or an ambulatory surgery facility. In addition, we created a covariate, "nasal surgery" to describe whether or not septum or inferior turbinate operations were performed (CPT 30520, 30130, 30140, 30200, 30210, 30801, 30802, 30930), and a covariate "image guidance" to describe whether image guidance technology (navigational assistance for surgical dissection) was used (CPT 61795).

We used hospital service areas to perform population analyses. Each hospital service area is geographically defined by the residents located near the hospital who receive a high percentage of care at the local facility.[14] Residents in a community with only one hospital tend to be uniform in that most patients seek care at the local facility. Residents in a community located between two hospital facilities may be divided in their hospital use, which would be reflected by two different hospital service areas. In contrast, hospital referral regions are defined by the presence of cardiovascular surgery and neurosurgery and are tertiary care facilities.[7] Endoscopic sinus surgery is largely performed in community hospitals, not tertiary care facilities, notwithstanding the fact that some patients are referred to specialists. For this reason, we felt that hospital service area was the appropriate level of analysis. We assigned each patient to the respective hospital service area by using the zip code variable from the SASD file and the crosswalk file from the Dartmouth Atlas project (2006).[15] The crosswalk file is a spreadsheet that assigns each zip code to a hospital service area according to where a plurality of patients residing in that zip code receive their medical care. This enabled the subsequent calculation of rates of surgery to be standardized to local population sizes. In addition, we obtained unique surgeon identifiers from the SASD file and created a continuous variable to describe each surgeon's annual sinus surgery case volume by summing the total number of discharges for endoscopic sinus surgery.

Statistical Analyses

To describe use of sinus surgery over time, we described population-adjusted rates for each procedure (e.g., maxillary, ethmoid, frontal, and sphenoid procedures) of interest by year. For these rates, the numerator was the number of specific operations each year and the denominator was the number of patients residing in each hospital service area by age and gender, using United States population data for the state of Florida.[16]

In order to further explore changes in population-adjusted rates of surgery over time, we defined the primary outcome for each patient discharge ("cases") as the count of sinus procedures performed ("procedures"). Sinus surgery entails a surgical procedure to enlarge the natural opening of one or more of the four pairs of sinuses. Each sinus procedure is coded individually: maxillary (31256 or 31267), ethmoid (31254 or 31255), frontal (31276), and sphenoid (31287 or 31288). We defined the outcome (number of sinus procedures/cases) as the count of sinuses operated upon (range 1–4). This dataset do not distinguish between unilateral versus bilateral sinus procedures. For this reason, paired procedures, e.g., bilateral maxillary procedures, were only counted as a single procedure, "maxillary." Likewise, an anterior ethmoidectomy on one side, and a complete ethmoidectomy on the contralateral side, was counted as a single procedure—"ethmoid." A case with both maxillary and ethmoid procedures was counted as two sinus procedures. We used the χ^2 test to compare patient factors and surgeon case volume across patients undergoing sinus surgery.

We used a multilevel Poisson model for the primary outcome: extent of sinus surgery, expressed as a count of the number of sinus procedures per case.[17,18] We first fit an empty model with no explanatory variables and three nested levels: patient as level 1, surgeon as level 2, and hospital service area as level 3 (stata command *xtmepoisson*). For level 1 models, we included patient demographic, nasal surgery and image guidance variables as predictors of sinus surgery extent. For level 2 models accounting for clustering of variance at the level of individual surgeons, we specified the model with random effects to account for variable effects of unobserved surgeon-level factors. Of note, level 3 models did not explain additional variance in the outcome beyond levels 1 and 2; therefore, only findings from level 1 and level 2 models are presented below.

We performed all analyses with Stata (version 12.0, Stata Corp, College Station, TX). We used two-tailed tests with *P* <0.05 as the level of statistical significance. The University of Michigan Institutional Review Board deemed this study of publicly available de-identified information exempt from human subjects review.

RESULTS

Characteristics of the patients at the beginning versus at end of this 10-year period (Table I) differed significantly in many respects. Between 2000 and 2009 there was a substantial decrease in the unadjusted proportion of patients who had surgery in a hospital setting versus a free-standing ambulatory surgery facility, and a substantial increase in the proportion of patients who had surgery with image guidance. Time trends in age, race/ethnicity, primary expected payer, and the proportion of patients receiving concomitant nasal surgery were comparatively modest but were statistically significant.

Population-adjusted rates of sinus surgery cases increased over the study period, from an annual mean of 104 cases per 100,000 population in 2000 to 129 per 100,000 in 2009 (*P* < 0.001). Procedure rates also increased, from a mean of 226 per 100,000 in 2000 to

	2000	2009	P
Case Count	**8138**	**10242**	
Mean age (SD)	48.6 (15.5)	50.2 (16.1)	<0.001
Female (%)	50.8	50.8	0.9
Race/ethnicity (%)			<0.001
White	84.6	80.9	
Hispanic	7.0	8.6	
Black	5.0	6.0	
Other	3.4	4.6	
Expected primary payer (%)			<0.001
Private insurance	75.2	69.8	
Medicare	19.2	22.4	
Medicaid	1.7	2.35	
Other	3.9	5.5	
Hospital (%)	62.7	50.0	<0.001
Nasal surgery (%)	53.2	55.5	<0.001
Image guidance (%)	3.1	17.3	<0.001

CI = confidence interval; SD = standard deviation.

Fig. 1. Trends in population-adjusted rates (per 100,000 population) of sinus surgery cases and procedures: Florida, 2000 to 2009.

316 per 100,000 in 2009 (P <0.001), consistent with trends over the entire study period (Table II and Fig. 1).

Between 2000 and 2009, population-adjusted rates of all types of sinus procedures increased, with two trends that were particularly salient. Rates of frontal sinus procedures more than doubled, and during the same time period rates of cases in which all four sinuses were treated tripled (Table III and Fig. 2).

Multilevel Analyses

In the adjusted model at level 1 (patients only), we found that image guidance was the variable most strongly associated with the number of sinus procedures (Table IV, column 2). Adjusted for time trends, use of image guidance was associated with 18% more sinus procedures per case (95% CI: 16.75%, 19.91%).

With respect to patient gender and age, male gender was significantly associated with more procedures per case compared with female gender, with a 5% difference in the average number of procedures per case. Increased age (>65 years vs. <35 years) was associated with additional procedures per case (data not shown).

Next we considered the surgeons. The number of surgeons in the dataset was fairly consistent over time:

annual mean 431 (410–451). The annual case volume per surgeon varied substantially (annual median 15 cases; range 1–235).

In the adjusted level 2 model (patients + surgeons) we found that race and expected primary payer were no longer significant, gender remained significant, and hospital location became a significant predictor of the number of sinus procedures performed per case. The variable, sinus case volume, which describes the surgeon's annual number of sinus cases, was also a statistically significant predictor. The effect of surgeon case volume for a surgeon with 200 sinus cases annually versus 20 cases annually was a 48% higher association with an additional sinus procedure per case.

However, most notably, the level 2 model found that approximately 17% of the observed variance in sinus procedures performed during the study period was attributable to variation at the level of the surgeon, independent of his annual case volume (Table IV, column 3). This amount of variance was substantially more than the share explained by patient demographics, nasal surgery, image guidance, and the surgeon case volume combined (1%).

DISCUSSION

This study demonstrates that the total number of sinus procedures has increased over the last 10 years at

	2000 Annual Mean (SD)	2009 Annual Mean (SD)	Increase	95% CI for Increase	P Value
Cases	104.0 (74.6)	128.9 (80.0)	24.8	22.6, 27.1	P <0.001
Procedures	225.8 (167.4)	316.3 (208.2)	90.5	85.0, 96.1	P <0.001

Rates per 100,000 population, standardized for age and gender by hospital service area.
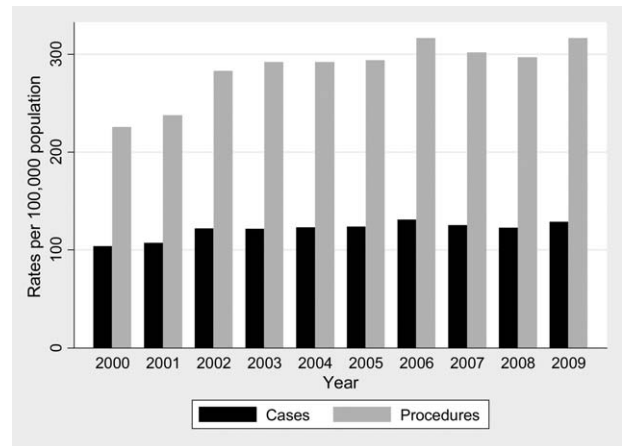CI = confidence interval; SD = standard deviation.

TABLE III.
Population-Adjusted Rates of Sinus Surgery Procedures: Florida, 2000 Versus 2009. Procedure Types Are Rank-Ordered by Mean Annual Rate of Procedure in 2009.

Procedure Type	2000 Annual Mean (SD)	2009 Annual Mean (SD)	Increase (%)	95% CI for Increase	P Value
Maxillary sinus	84.1 (78.0)	111.4 (86.7)	27.4 (32)	25.0, 29.8	<0.001
Ethmoid sinus	89.8 (78.5)	108.3 (89.4)	18.5 (21)	16.1, 21.0	<0.001
Frontal sinus	10.4 (26.6)	26.3 (49.6)	15.9 (153)	14.7, 17.1	<0.001
Sphenoid sinus	16.4 (41.7)	25.1 (47.3)	8.7 (53)	7.4, 10.0	<0.001
*All 4 sinuses	2.3 (11.2)	6.9 (19.2)	4.6 (200)	4.1, 5.0	<0.001

Rates per 100,000 population, standardized for age and gender by hospital service area.
*Maxillary, ethmoid, sphenoid, and frontal sinus procedures performed.
CI = confidence interval; SD = standard deviation.

the population level in a large state (Florida)—chiefly attributable to a marked increase in the number of sinus procedures performed per patient case, with a comparatively modest increase in the number of patients with sinusitis who undergo surgery. Additionally, we find that frontal sinus procedures increased 153%, and that operations in which all four sinus procedures were performed increased 200% over the study period.

The findings that we report build upon Venkatraman's study,[13] which demonstrated increased rates of endoscopic sinus surgery among Medicare patients, and Psaltis's study,[19] which demonstrated increased numbers endoscopic sinus surgery procedures. Because we analyzed 10 years of data and because we also report growth in sinus surgery as a rate, our findings substantially build upon the Psaltis report, which was limited to 3 years of procedure counts and did not control for the size or changes in the size of the reference population.

Although we do not have a clinical explanation for these changes, this study did not include patient-level covariates that might explain these findings. While the prevalence and severity of sinus disease are not expected to have increased during the study period,[1,2] a limitation of this study is that we do not have information on disease severity such as computed tomography (CT),

endoscopy, or quality of life scores. In addition to clinical factors, there may be nonclinical factors at the patient and provider level that partially explain this finding. It is possible that increased patient acceptance of sinus surgery, technological advances, and a greater numbers of surgeons trained in endoscopic sinus surgery techniques have contributed to the growth in endoscopic sinus procedures. Over the last two decades, traditional sinus surgery techniques have been replaced with endoscopic techniques because of the improved visualization and shorter patient recovery times[20]; consequently, more surgeons have been trained in endoscopic techniques during this time, and they are now a routine part of residency training and surgical practice.

Surgical instrumentation has also evolved during this time and two specific innovations, image guidance and balloon dilation, may have contributed to perceived ease and safety of endoscopic sinus surgery. Image guidance was introduced in the 1990s and was initially used primarily in academic and tertiary care rhinology settings because of the cost of the device. Over time, image guidance has become more widespread, and now a majority of practitioners surveyed report access to the technology.[21] Balloon dilation technology is a more recent development, introduced in 2006.[22–25] The sinus balloon may be threaded through natural sinus opening using a guide wire. Inflation of the balloon dilates the sinus opening, and neither bone nor mucosa is resected. The extent to which sinus balloon devices contributed to the observed increase in sinus procedures per case cannot be determined with this dataset. However, in 2011 new CPT codes specific for balloon sinus surgery were introduced. Future research using these new CPT codes may be able to discern the proportion of growth of frontal sinus surgery attributable to this new technology.

Our initial hypothesis that variations in sinus surgery are driven by nonclinical factors appears strongly supported by this analysis. The multilevel model demonstrated that the individual surgeon accounts for the majority of variance in the number of sinus procedures performed during each case. In fact, even patient-level factors (gender, nasal surgery, and image guidance) of statistical significance that are associated with sinus procedure patterns were comparatively weak determinants of the procedures performed when surgeon
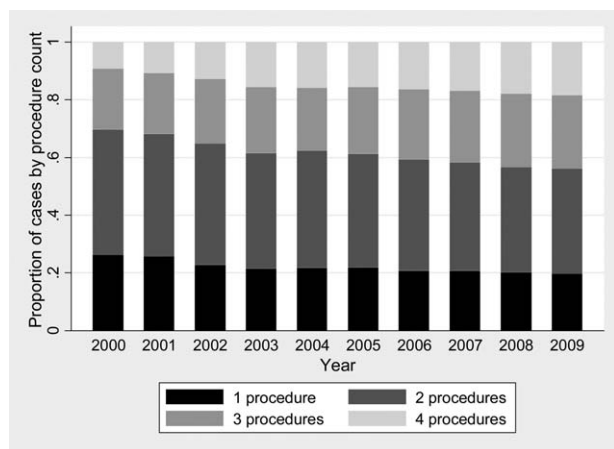

Fig. 2. Comparative proportions of sinus surgery cases by procedure count: Florida, 2000 to 2009.

TABLE IV.
Patient-level Factors and Surgeon Case Volume Associated with Number of Procedures per Case.

	Unadjusted Patient Level IRR (SE) 95% CI	Adjusted Patient Level IRR (SE) 95% CI	Adjusted Patient and Surgeon Levels IRR (SE) 95% CI
Female	*.95 (.004)	*.95 (.004)	*.95 (.004)
	.95–.96	.95–.96	.94–.96
Race/ethnicity			
White	Reference	†Reference	Reference
Black	1.00 (.010)	1.01 (.010)	1.02 (.010)
	.99–1.02	.99–1.03	1.00–1.04
Hispanic	.99 (.008)	.98 (.008)	.99 (.009)
	.98–1.01	.96–1.0	.97–1.01
Other	1.02 (.011)	.99 (.011)	1.00 (.012)
	1.00–1.03	.97–1.02	.98–1.03
Expected primary payer			
Medicare	†Reference	†Reference	Reference
Medicaid	.93 (.017)	.99 (.019)	1.00 (.020)
	.90–.97	.95–1.02	.96–1.04
Private insurance	1.00 (.005)	1.03 (.008)	1.01 (.008)
	1.00–1.01	1.01–1.04	1.00–1.03
Other	.97 (.011)	1.00 (.013)	1.01 (.013)
	.95–.99	.97–1.02	.98–1.03
Hospital	1.00 (.004)	1.01 (.004)	*1.02 (.006)
	.99–1.01	1.00–1.01	1.0–1.03
Nasal surgery	*.98 (.004)	*.97 (.004)	*.96 (.005)
	.97–.98	.96–.98	.96–.97
Image guidance	*1.21 (.008)	*1.18 (.008)	*1.21 (.010)
	1.19–1.22	1.17–1.20	1.19–1.23
Surgeon case volume			*1.002 (.0001)
			1.00–1.00
Surgeon-specific random effects variance			0.17 (0.0034)
			.16–.18

Models were adjusted for study year.
*P <0.05 for comparison.
†P < 0.05 for comparison across entire group.
CI = confidence interval; IRR = incidence rate ratio; SE = standard error.

identity was taken into account. This point highlights two important limitations of this study, which must be understood so that the findings are not taken out of context: First, our analysis was restricted to the procedures performed, and we could not analyze clinical presentations and outcomes. It is possible that changes in patients' presentation or desires for different clinical outcomes over the study duration led surgeons to modify their practice patterns over time. From these data, we cannot know whether the changes in procedural patterns led to positive, negative, or negligible changes in patients' outcomes. A second important limitation is that we lack information about referral patterns and surgeon case mix that may impact surgeon case volume. This study design did not differentiate a rhinology specialist

with a complex case mix from a general otolaryngologist with a less complex case mix.

Our inability to distinguish unilateral from bilateral procedures may be perceived as a limitation. We recognize this perspective, but we believe the salient perspective is the location of the sinuses—i.e., the extent of surgical dissection. Other limitations of this study include those common to analyses based on administrative data—i.e., that procedures and diagnoses may have been miscoded and therefore are subject to errors of omission and commission. Furthermore, we chose Florida because the ambulatory surgical data for this state are particularly robust and have been used in other studies indicative of broader patterns of care,[26–29] but it is possible that patterns in other states may have differed and the results of this single state are not necessarily representative of the broader U.S. population.

CONCLUSION

In conclusion, we find that during 2000 to 2009 rates of sinus surgery in Florida increased at the population level, as measured by the number of operations and the number of procedures performed during each operation. Patients with a greater number of procedures performed during surgery were more likely to have had concomitant use of image guidance and to have had surgery performed by a surgeon with a high annual case volume. However, the strongest predictor was the individual surgeon. The strong association of procedural patterns with specific surgeons in sinusitis care highlights the importance of future investigations to examine training, technological, and reimbursement factors that may influence surgeons' clinical decision making for this common condition.

Acknowledgement

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