The Impact of Sinus Computed Tomography on Treatment Decisions for Chronic Sinusitis

Yoshimi Anzai, MD; Ernest A. Weymuller, Jr, MD; Bevan Yueh, MD, MPH; Nicole Maronian, MD; Jeffrey G. Jarvik, MD, MPH

Objectives: To determine the impact of sinus computed tomography (CT) on treatment decisions by otolaryngologists and to explore the factors leading to choice of surgical treatment for patients suspected of having chronic sinusitis.

Design: Prospective cohort study.

Setting: A tertiary academic medical center.

Patients: Questionnaires were administered to 3 otolaryngologists in a tertiary academic institution regarding diagnosis and treatment decisions in 27 patients suspected of having chronic sinusitis, before and after they reviewed sinus CT scans.

Main Outcome Measures: The dichotomous decisions regarding surgical or nonsurgical treatment and the agreement of treatment decisions among surgeons were evaluated. The factors strongly influencing surgeons’ treatment decisions regarding patients selected for surgery were also determined.

Results: The dichotomous treatment decisions were changed in one third of patients (9 of 27) after the sinus CT scans were reviewed. The agreement of treatment decisions among the 3 surgeons was markedly improved after they reviewed sinus CT scans. The factors favorably influencing surgical treatment were obstruction of the ostiomeatal complex on CT and concordance of CT abnormality with a patient’s symptoms. Lund-Mackay stage, symptoms, and corticosteroid or antibiotic use were not significant predictors.

Conclusions: Despite the common belief that treatment decisions for chronic sinusitis should be solely based on clinical grounds, with sinus CT providing only anatomic detail before surgery, our study indicates that the decision to perform surgery was altered by CT in a substantial portion of the patients. In our preliminary study, CT increased the tendency to elect surgical treatment by all 3 surgeons.

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CHRONIC SINUSITIS IS A widespread condition, affecting 33 million Americans, according to the National Center for Health Statistics. The Centers for Disease Control and Prevention reported that sinusitis is the most common chronic condition in people younger than 45 years and the second most common, following hypertension, in people between 45 and 65 years of age. Chronic sinusitis is more common in the Midwest and the South than in the coastal areas.

Chronic sinusitis has a significant economic impact. In 1992, more than $200 million was spent for prescription medication and $2 billion was spent for over-the-counter medication. Overall direct cost of chronic rhinosinusitis was recently estimated to be more than $4.3 billion. The Agency for Health Care Policy and Research estimated that $5.8 billion is spent annually for medication. Approximately 200,000 sinus surgeries are performed each year. The Medical Expenditure Panel Survey reported that 11 million physician visits and 1.3 million outpatient hospital visits in 1999 were for chronic sinusitis.

Even though chronic sinusitis is a self-limiting disease with a low incidence of serious complication, it negatively affects a patient’s quality of life. There were 73 million restricted-activity days related to chronic sinusitis in the period 1990 through 1992, which was a 50% increase compared with 1986 through 1988. Indirect costs due to lost workdays are substantial. Gliklich and Metson evaluated the health burden of chronic sinusitis relative to the general population. Their study showed significantly worse scores in measures of bodily pain and social function-
ing for patients with chronic sinusitis than for patients with congestive heart failure, angina, chronic obstructive pulmonary disease, and back pain.

Sinus computed tomography (CT) is widely performed in the imaging workup of sinusitis, but is criticized for lack of specificity. Mucosal thickening of the paranasal sinus can be seen in up to 30% of the asymptomatic population. In addition, mucosal thickening of sinuses has been reported in patients with nonspecific upper respiratory viral infection, such as the common cold. Several reports in surgical journals found that sinus CT findings did not correlate well with a patient's clinical symptoms, since results of sinus CT can be normal for severely symptomatic patients and abnormal for patients with minimal symptoms.

Functional endoscopic sinus surgery has been widely performed since its introduction in 1985. This surgery is intended to preserve mucociliary function of the paranasal sinuses and improve drainage of the sinuses. It has revolutionized sinus surgery and has been reported to improve clinical outcome for patients with chronic and recurrent sinusitis. Endoscopic sinus surgery is generally indicated when maximal medical treatment fails to resolve the patient's symptoms. However, maximal medical treatment is not clearly defined, and the basis for selection of medical vs surgical treatment in patients with chronic sinusitis is not universally accepted. It is an open question whether treatment decisions should be based purely on physical examination and clinical history, or if sinus CT alters the treatment decision by ear, nose, and throat surgeons. Moreover, the degree of agreement among otolaryngologists regarding their treatment decisions has not been previously addressed, to our knowledge.

The objectives of this study were (1) to determine the impact of sinus CT on treatment decisions by surgeons, (2) to evaluate the agreement of treatment decisions among ear, nose, and throat surgeons, and (3) to identify the factors strongly influencing surgical treatment decisions for patients suspected of having chronic sinusitis.

METHODS

STUDY DESIGN

We identified a prospective series of 27 new patients presenting to an experienced otolaryngologist (surgeon A [E.A.W.]) in his sinus clinic. The history of disease and physical findings were recorded and summarized. We administered a questionnaire to the surgeon immediately after he saw a new patient with suspected chronic sinusitis. Patients with a history of cancer, organ transplant, or immunocompromise were also excluded, since the treatment decisions for these subjects may be significantly different from those in patients without such medical histories. All patients had had sinus CT before the visit. The surgeon's treatment decisions were first recorded without viewing the sinus CT scan, and then repeated after he reviewed the scan. We also asked the surgeon to express his level of confidence in the effectiveness of the treatment decision by means of a 10-point scale, with 1 being least confident and 10 being most confident (this is referred to as the "clinical decision-making model").

The abstracted clinical information for these 27 patients was presented to 2 other otolaryngologists (surgeons B [B.Y.] and C [N.M.]), and the same questionnaires were administered before and after the surgeons reviewed the sinus CT scans. Their treatment decisions, as well as their levels of confidence, were recorded. Since these 2 surgeons did not examine the patients, this is referred to as the "theoretical decision-making model." The abstracted clinical information was presented to surgeon A more than 6 months after he had examined these 27 patients to address the intraobserver reliability of his treatment decisions. These surgeons were selected because they were experienced in endoscopic sinus surgery and in treating patients with chronic sinusitis. The study was approved by the institutional review board at our institution.

QUESTIONNAIRE

The questionnaire asked the surgeon for the best treatment plan, given clinical history and physical examination findings with and without sinus CT results. The choices of treatment plans included the following: (1) medical management such as antibiotics, antihistamine, systemic corticosteroid, nasal decongestant, nasal spray, and nasal irrigation; (2) surgical treatment such as limited functional endoscopic sinus surgery, complete functional endoscopic sinus surgery, nasofrontal duct opening, frontal sinus obliteration, sphenoidecomy, Caldwell-Luc procedure, and antrostomy; (3) consultation with other specialists (eg, allergy specialists, psychiatrist); (4) none; and (5) other.

CLINICAL HISTORY AND PHYSICAL EXAMINATION

The pertinent clinical history and physical examination findings were obtained by surgeon A. Medical history, such as asthma, allergy, aspirin sensitivity, smoking, past medication use and its response, and sinus-related symptoms, was recorded. The surgeon performed nasal endoscopy during the clinic visit when clinically indicated. Information regarding nasal endoscopy or anterior nasal examination, such as the presence of a mass, polyp, or stenosis of the middle meatus, as well as nasal secretion, was recorded. This clinical information was provided to the surgeons who participated in the theoretical decision-making model.

SINUS CT SCANS

The hard copy of the sinus CT scan was provided to each surgeon after completion of the pre-CT questionnaire. Sinus CT results were analyzed by a board-certified radiologist specializing in neuroradiology—head and neck radiology (Y.A.). The CT scans were also scored by means of the Lund-Mackay staging system, which is a widely used CT staging method for chronic sinusitis. It classifies mucosal abnormalities as normal, partial opacification, or total opacification. The severity of mucosal thickening was further evaluated by means of a 5-grade system: 0, normal; 1, minimal; 2, less than 25% of mucosal thickening of each sinus; 3, less than 50%; and 4, less than 75%. A score was assigned to 5 areas—frontal, maxillary, anterior, and posterior ethmoid, and sphenoid sinuses—for both sides. Thus, the possible CT score ranged from a minimum of 0 to a maximum of 40. Obstruction of the ostiomeatal complex was also recorded bilaterally.

The disease distribution was assessed as diffuse if mucosal thickening was seen in multiple sinuses bilaterally and as localized if localized to sinuses or unilateral disease. The concordance of CT findings with a patient's clinical symptoms (facial pain, pressure, or tenderness) was addressed. For example, a patient with left maxillary pain and left maxillary sinus abnormality on CT was considered to have concordant radiographic findings. A patient with a localized symptom but diffuse CT abnormality was considered to have discordant findings. The ostium of the sinus of interest was also addressed on
CT. For example, in a patient with left maxillary pain and pressure, the left ostiomeatal complex was evaluated for its patency on sinus CT. If any of the ostia appeared blocked, this was recorded as mechanical obstruction on CT.

**BINARY LOGISTIC REGRESSION ANALYSIS**

There were a total of 21 independent variables for logistic regression analysis (including 16 variables for pre-CT analysis). The variables included patient demographics (age and sex), medical history (allergy and asthma), clinical symptoms (pain, nasal congestion, nasal discharge, postnasal drip, headache, and fatigue), previous treatment (antibiotic, corticosteroid, and number of previous sinus surgeries), and findings on physical examination (presence of polyp, nasal secretion, middle meatal stenosis). The variables related to CT were Lund-Mackay staging, CT score, presence of mechanical obstruction, disease pattern (localized vs diffuse), and concordance of CT abnormality and clinical symptoms. Several items were collected but excluded from the analysis because only a few patients had such history or symptoms. The excluded items were smoking (no patients had a smoking history); pain in the temporomandibular joint, dizziness, and lightheadedness (2 patients each); and cough (3 patients).

**STATISTICAL ANALYSIS**

Changes in dichotomous treatment decisions (surgical vs nonsurgical) were analyzed with a paired McNemar test. The agreement among surgeons regarding treatment decisions was analyzed with Cohen κ. The confidence level for diagnosis and treatment decisions was analyzed with a paired t test. For the prediction of surgical treatment, multivariate forward logistic regression analysis with a probability of entry of .05 was applied after controlling for antibiotic use. In addition, univariate regression analysis was performed for each variable to address the strength of association. These regression analyses were performed for each surgeon separately.

**RESULTS**

**PATIENT DEMOGRAPHICS AND CLINICAL SYMPTOMS**

Twenty-seven patients (12 male and 15 female) were included in the study. The patients’ ages ranged from 20 to 83 years, with a mean age of 50 years. Six patients had a history of asthma, 12 patients had allergies, and 3 had aspirin sensitivity. Twenty of 27 patients had had previous sinus surgery at the time of the initial clinic visit. The average number of previous sinus surgeries was 1.41. Recent antibiotic treatment had been given in 24 patients, and 16 had received systemic corticosteroids. Clinical symptoms for these 27 subjects were facial pressure or pain (21 patients), nasal discharge (19), nasal congestion (14), fatigue (11), headache (10), postnasal drip (10), and loss of sense of smell (4).

**NASAL EXAMINATION AND/OR ENDOSCOPIC EXAMINATION**

Ten patients had fiberoptic nasal endoscopic examination at the clinic, and the remaining 17 patients had the anterior nasal examination alone. Surgeon A decided which patients needed the endoscopic examination on the basis of clinical grounds. The nasal and endoscopic examinations disclosed a polyp or mass in 4 patients, nasal secretion in 8, and obstruction of the sinus ostium in 8.

**IMPACT OF SINUS CT ON TREATMENT DECISIONS**

Sinus CT changed the dichotomous treatment decision (surgical vs nonsurgical) in 9 (33%) of 27 patients by surgeon A in the clinical decision model. Because of the small sample size, this did not reach statistical significance (Table 1). Similarly, CT changed the treatment decision in 7 (26%) of 27 patients by surgeon B in the theoretical decision-making model. In 10 (37%) of 27 patients treatment was altered from nonsurgery to surgery after a CT review by surgeon C. This reached statistical significance by the 2-sided McNemar test (P=.002). The levels of confidence in effectiveness of treatment were statistically higher with CT for all 3 surgeons (P<.001, P=.02, and P<.001 for surgeons A, B, and C, respectively) (Table 2). All 3 surgeons offered surgical treatment more frequently after reviewing sinus CT than before viewing the CT.
AGREEMENT OF SURGEONS REGARDING TREATMENT DECISIONS

The agreement between the clinical decision model (surgeon A) and the theoretical decision model (surgeons B and C) before sinus CT scans were reviewed was poor ($\kappa$ = 0.14), but improved significantly after the CT scans were seen ($\kappa$ = 0.46). Agreement among the 3 surgeons on scenario-based treatment decisions was similarly poor before CT (average $\kappa$ = 0.13) and substantially improved after the CT scans were reviewed ($\kappa$ = 0.43). The intraobserver variability for surgeon A was also substantially higher after sinus CT scans were reviewed ($\kappa$ = 0.44 before CT to 0.71 after CT).

PREDICTION OF SURGICAL TREATMENT BEFORE AND AFTER SINUS CT

The significant predictors of surgical treatment for each surgeon before and after CT are summarized in Table 3. Although antibiotic use was not a significant predictor for any of surgeons, this was placed in the model because of our a priori hypothesis (patients should have antibiotic treatment before surgery is considered).

Surgeon A (in the clinical decision-making model) had offered surgical treatment for patients who had no allergy history and for younger patients. For surgeon B (in the theoretical decision-making model), the presence of middle meatal stenosis on physical examination was a significant predictor of pre-CT surgical treatment. Male sex was a marginally significant predictor. For surgeon C, younger age and middle meatal stenosis were significant predictors of pre-CT surgical treatment.

Post-CT analysis showed that concordance of CT with the patient’s symptoms was the single significant predictor for surgeon A. For surgeon B, the presence of middle meatal stenosis on physical examination remained a significant predictor, and CT score was a marginally significant predictor. The presence of ostiomeatal complex obstruction on CT was a significant predictor and younger age remained a marginally significant predictor for surgeon C.

EFFECT OF EACH PREDICTIVE VARIABLE ON SURGICAL TREATMENT

A univariate regression analysis was performed for all 21 variables by the 3 surgeons, to extract the impact of each variable on treatment decisions. The summary of significant predictors is shown in Table 4. The 3 surgeons made treatment decisions on the basis of slightly different factors. Lack of allergy history favored surgical treatment for surgeons A and B, but not surgeon C. Presence of middle meatal stenosis favored surgical treatment for surgeons B and C, but not for surgeon A. A larger number of previous sinus surgeries favored additional surgical treatment for surgeons A and C, but not surgeon B. Male sex was a significant predictor for surgeon B only.

All surgeons had a tendency to offer surgical treatment for younger patients, patients who did not have nasal secretion on physical examination, patients with ostiomeatal complex obstruction on CT, and patients whose clinical symptoms matched a location of abnormality on CT scan (CT concordance).

COMMENT

Sinus CT has been criticized for its lack of correlation with symptom severity in a setting of chronic sinusitis.10,11 Stewart et al10 and Bhattacharyya et al11 concluded that CT should be reserved for delineating anatomy and pattern of inflammation before surgery. It is not known whether the symptom-based diagnosis of chronic sinusitis is accurate or reliable, since there is no gold standard for diagnosis of chronic sinusitis. It has been reported that 47% of patients with a diagnosis of chronic sinusitis based on symptoms had abnormalities on CT scans, and there was no difference in symptom severity between a CT-positive group and a CT-negative group.25
The discrepancy between CT findings and patients’ symptoms is well known but not clearly understood. The surgical literature suggests that treatment decisions should be based on clinical grounds, rather than imaging findings, since patients’ symptoms drive medical attention and health care utilization. It remains controversial whether symptomatic patients with a completely normal sinus CT scan result who fail to respond to medical treatment should undergo surgery.25-27 Many reports indicate that CT understimates the degree of mucosal inflammation. Therefore, a normal sinus CT scan result does not necessarily indicate normal sinuses. Patients with chronic sinusitis are often heavily treated with anti-inflammatory medications, antibiotics, and even systemic corticosteroids. Therefore, absent or minimal mucosal thickening may reflect a temporary response to therapy.

Despite a general belief that treatment decisions should be based on clinical grounds, in this exploratory study CT had a substantial impact on treatment decisions in patients suspected of having chronic sinusitis. All surgeons offered surgery more frequently after reviewing sinus CT results. These results suggest that CT has an important role in surgeons’ treatment decisions and provides objective information regarding disease status. It is possible that surgeons are unwilling to offer surgery before reviewing sinus CT results, since they are used to having such information before seeing a patient. There were also a few patients for whom surgical treatment was offered before a CT scan, but the scan failed to demonstrate corresponding abnormality. These patients were offered medical management.

Multivariate regression analyses indicated that variables predicting surgical treatment were slightly different among surgeons. Significant predictors related to CT were concordance of CT abnormality and mechanical ostiomeatal complex obstruction on CT. Neither Lund-Mackay staging nor our CT scores, which further subclassified the severity of mucosal thickening, was a significant predictor of surgical treatment. A disease pattern on CT scan was a significant predictor for one surgeon; localized disease on CT resulted in a higher likelihood of surgical treatment than diffuse disease did. This seems logical, since functional endoscopic sinus surgery aims to improve mechanical drainage impairment, whereas diffuse mucosal inflammation might be better managed by medical therapy.

In terms of variables not related to CT, a history of allergy was a negative predictor of surgery for all surgeons (odds ratio less than 1 in Table 4). This is likely owing to the availability of medical management for patients with allergy as well as a tendency for allergic patients to remain symptomatic after surgery. The presence of secretion on physical examination was also a negative predictor of surgery, since surgeons consider continuous medical management in the setting of active infection, regardless of what sinus CT shows. The number of previous surgeries had a positive effect on surgical treatment for 2 of 3 surgeons in the study. A study by Marks and Shamsa28 also reported that a previous sinus surgery was strongly associated with the need for subsequent surgery.

A weakness of this exploratory study is the small number of cases used for evaluation of treatment deci-

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Table 4. Significant Predictors of Surgical Treatment by Each Surgeon: Univariate Analysis

<table>
<thead>
<tr>
<th>Variables</th>
<th>Surgeon A</th>
<th>Surgeon B</th>
<th>Surgeon C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR (95% CI)</td>
<td>P Value</td>
<td>OR (95% CI)</td>
</tr>
<tr>
<td>Before CT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allergy</td>
<td>0.14 (0.022-0.86)</td>
<td>.03*</td>
<td>0.18 (0.03-1.14)</td>
</tr>
<tr>
<td>Age</td>
<td>0.97 (0.92-1.03)</td>
<td>.35</td>
<td>0.97 (0.92-1.03)</td>
</tr>
<tr>
<td>Sex</td>
<td>1.43 (0.30-6.88)</td>
<td>.66</td>
<td>9.1 (1.39-59.00)</td>
</tr>
<tr>
<td>Polyp</td>
<td>0.26† (N/A)</td>
<td>.10</td>
<td>8.5 (0.74-98.00)</td>
</tr>
<tr>
<td>MM stenosis‡</td>
<td>1.03 (0.19-5.67)</td>
<td>.97</td>
<td>16 (2.12-120.00)</td>
</tr>
<tr>
<td>After CT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allergy</td>
<td>0.25 (0.05-1.25)</td>
<td>.09</td>
<td>0.18 (0.03-0.93)</td>
</tr>
<tr>
<td>No. of previous sinus surgeries</td>
<td>4.95 (1.25-19.60)</td>
<td>.02*</td>
<td>0.94 (0.53-1.68)</td>
</tr>
<tr>
<td>Secretion on physical examination</td>
<td>0.35 (0.06-1.93)</td>
<td>.23</td>
<td>0.19 (0.03-1.24)</td>
</tr>
<tr>
<td>MM stenosis§</td>
<td>3.33 (0.53-21.00)</td>
<td>.20</td>
<td>5.63 (1.21-30.00)</td>
</tr>
<tr>
<td>Total CT score</td>
<td>1.02 (0.95-1.09)</td>
<td>.63</td>
<td>1.09 (1.004-1.15)</td>
</tr>
<tr>
<td>Concordance§</td>
<td>32.5 (3.38-272.00)</td>
<td>.001*</td>
<td>4 (0.80-20.00)</td>
</tr>
<tr>
<td>CT pattern†</td>
<td>6 (1.11-33.00)</td>
<td>.04*</td>
<td>1.17 (0.26-5.30)</td>
</tr>
<tr>
<td>OMC-CT</td>
<td>4.64 (0.71-30.00)</td>
<td>.11</td>
<td>3.75 (0.58-24.30)</td>
</tr>
<tr>
<td>LM staging on CT</td>
<td>1.034 (0.92-1.16)</td>
<td>.57</td>
<td>1.15 (0.99-1.33)</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; CT, computed tomography; LM, Lund-Mackay; MM, middle meatus; N/A, not applicable; OMC-CT, obstruction of ostiomeatal complex on CT. OR, odds ratio.

*Indicates P<.05.
†Result of Fisher exact test; no 95% CI is available because one of the values in the 2 × 2 table for this variable was 0.
‡By physical examination and/or endoscopy.
§CT abnormality matched the patient’s symptoms.
| Localized vs diffuse disease pattern.
sions and the tertiary care academic setting, which resulted in highly skewed populations of patients with chronic sinusitis. Our patients were primarily referred from general otolaryngologists or primary care physicians. Many of the patients had persistent or recurrent symptoms despite previous sinus surgery. The validity of the theoretical decision-making model is also uncertain. When surgeons are asked to make treatment decisions on the basis of scenarios, their decisions may not be as realistic as when they do so by examining patients. Another limitation of our study is the absence of data about subsequent clinical outcomes. Therefore, although it appears that CT impacts decision making, it is beyond the scope of this article to determine whether sinus CT leads to right or wrong treatment decisions.

Finally, sinus CT scanning in patients with chronic sinusitis is generally performed 4 to 6 weeks after medical management to visualize the detailed anatomy. We did not control for the timing of CT study with respect to previous medical management. Our intention was to use CT as an intervention, rather than to stage chronic sinusitis by means of CT. In this study, we purposely provided a hard-copy sinus CT scan rather than radiology reports to participating surgeons. In this way, a surgeon could extract any information from a CT scan, such as anatomy or extent of mucosal disease, which may not be accurately reflected in radiology reports.

In summary, our study confirms that the treatment decisions of surgery vs no surgery were altered in one third of patients after sinus CT, increasing the probability of surgical treatment. The surgeons’ agreement regarding the treatment decisions was also improved after they reviewed the sinus CT. Surgeons tended to offer surgical management when disease detected by CT was localized and matched with a patient’s symptoms, or associated with mechanical obstruction of the ostiomeatal complex. The CT stage or the severity of mucosal disease on the CT was not a significant predictor of surgery.

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Corresponding author and reprints: Yoshimi Anzai, MD, Department of Radiology, University of Washington, Box 357115, RR-215, 1939 NE Pacific St, Seattle, WA 98195-7115 (e-mail: anzai@u.washington.edu).

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