Computed Tomographic Staging and the Fate of the Dependent Sinuses in Revision Endoscopic Sinus Surgery

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Objectives: To determine the patterns of disease recurrence in chronic sinusitis and to examine the influence of surgical intervention on the presence or absence of disease among sinuses at the time of revision.

Design: Retrospective review of case series in a 56-month period. Preoperative computed tomography (CT) scans at the initial surgery and at revision were staged using the Lund and Mackay system. Patterns of disease and CT stage were analyzed with respect to operative intervention, and statistical analysis was conducted to determine the influence of the initial surgical intervention on the patterns of disease at revision.

Setting: An academic general otolaryngology practice.

Results: A total of 42 paired cases of primary and revision endoscopic sinus surgery were identified with complete data. The average interval between procedures was 11.8 months, with a mean follow-up of 31.7 months. The average total Lund scores for the CT scan before the primary procedure and at revision were not significantly different at 10.5 and 9.7, respectively (P = .38). Analysis of 84 sides revealed that performance of a sinusotomy on an initially undiseased sinus resulted in a higher percentage of disease in that sinus at revision, although this was not significant (P = .15). A sinusotomy performed on an initially diseased sinus was associated with a higher likelihood of disease in that sinus at revision (P = .02). Similar data were found for the subset analysis of the sphenoid and frontal sinuses.

Conclusions: The Lund and Mackay system can be applied in the setting of revision endoscopic sinus surgery. Sinusotomies should be performed only in sinuses with radiographic disease, and not prophylactically to prevent disease. The standard functional approach may allow disease initially present in the sphenoid or frontal sinuses to normalize without formal sphenoidotomy or frontal sinusotomy.
MATERIALS AND METHODS

The study protocol was approved by the institutional review board of our institution. The procedural database for an academic otolaryngology practice was searched for all cases of ESS. Cases in which the primary and revision procedures were performed at our institution were identified. Cases with an associated diagnosis of cystic fibrosis were excluded. The medical records, operative notes, pathologic results, and results of radiography were reviewed. Data for the design variables, including patient demographics, diagnostic procedures, and surgical procedures, were collected and tabulated. The types of primary and revision procedures were recorded, with special attention to the tabulation of which sinuses were specifically surgically addressed. The preoperative sinus CT scans for both procedures were reviewed in blinded fashion and staged using the Lund system. Cases with incomplete data for the major design variables were discarded.

The remaining data were then analyzed using the SPSS statistical system (SPSS Inc, Chicago, Ill). First, the Lund staging data for each paired case were analyzed. The Lund score for the initial ESS procedure was compared with the Lund score for the secondary (revision) procedure using the Wilcoxon matched-pairs signed rank test. The aggregate data for all of the sinuses were then subdivided into 2 data sets. First, the data set containing all sinuses that were normal (Lund score of 0) was examined. These cases were stratified according to whether they underwent operation and whether the secondary scan (at the time of revision) showed evidence of disease. These groups were then compared using the Fisher exact test for proportions. Similarly, the sinuses that showed abnormal findings on initial CT scan (Lund score of 1 or 2) were stratified according to surgical procedure and status on secondary CT scan, and again analysis was conducted using the Fisher exact test. Finally, analysis of proportions with the Fisher exact test was performed on the sphenoid and frontal sinus data separately to address the influence of specific sinusotomy on the likelihood of recurrent disease in these dependent sinuses.

Since the introduction of the functional concept, ESS has supplanted the more radical surgical procedures previously used for the treatment of chronic sinusitis. The functional concept in ESS emphasizes the patency of the ostiomeatal complex as the key to a successful surgical outcome. However, the 2 dependent sinuses, the frontal and sphenoid sinuses, do not typically receive consistent surgical address in the basic functional concept. For example, it is not uncommon for frontal sinus disease to be present preoperatively. In the functional concept, correction of disease involving the anterior ethmoid complex should also treat the frontal sinus disease. Therefore, a formal frontal sinusotomy is often not routinely performed at the primary procedure. Similarly, sphenoidotomy usually is performed only in the setting of disease on preoperative CT scan, but may also be deferred if the surgeon adheres to the functional concept. This leads to 2 questions. First, since subsequent disease in the sphenoid or frontal sinus may be a cause for revision, should the initially nondiseased sphenoid or frontal sinus be routinely specifically addressed at the first surgery? Second, can true functional ESS normalize the diseased sphenoid or frontal sinus without a formal frontal or sphenoid sinusotomy? The second portion of this study addresses these questions.

RESULTS

DEMOGRAPHICS

A total of 51 paired cases of primary and revision ESS performed at our institution were identified during a 56-month period. These constituted 6.6% of 768 ESS procedures performed during the same period. Four cases had a concurrent diagnosis of cystic fibrosis and were excluded. In addition, 5 cases had incomplete imaging studies or incomplete documentation of the operative procedure and were excluded. The remaining 42 paired primary and revision procedures in 37 patients (5 patients underwent a second revision) were then reviewed. The mean age of the patients was 41.2 years (range, 17-71 years), with a male-female ratio of 1.6:1. Twelve unilateral and 30 bilateral procedures were performed; a concurrent septoplasty was performed in 13 (31.0%) of the primary procedures. The surgical elements performed at the first ESS are depicted graphically in Figure 1. The average number of sinuses per patient was 5.7 at the initial surgery. The average interval between surgical procedures was 11.8 months (range, 0.7-31.0 months), and the mean follow-up from the initial surgical procedure was 31.7 months (range, 8.7-57.4 months).

TOTAL LUND SCORES

The average total Lund scores for the first (before the primary procedure) and second scan were 10.5 and 9.7, respectively. This was not a significant difference, as determined by the Wilcoxon matched-pairs signed ranks test (P = .38). Primary procedures that used an image-guided surgical tracking system (n = 12 [28.6%]) did not have a significant difference between Lund scores.
when compared with procedures that did not use the tracking system (13.00 vs 9.43, respectively; $P = .14$, Mann-Whitney $U$ test). A total of 84 sides were analyzed. The sites of disease at the time of revision and their corresponding Lund scores are listed in the Table and Figure 2. The maxillary sinus, anterior ethmoids, and ostiomeatal complex were each diseased in more than two thirds of the revisions.

**ALL SINUSES**

Analysis of all 84 sides yielded a total of 420 individual sinuses (the ostiomeatal complex was not analyzed, as its corresponding surgical procedure is encompassed by the anterior ethmoidectomy and middle meatal antrostomy). One hundred fifty-seven sinuses had no disease (Lund score, 0) before the initial ESS. Among these, 59 (37.6%) underwent sinusotomies, resulting in 43 normal sinuses (72.9%) on the CT scan before revision ESS and 16 diseased sinuses. Ninety-eight (62.4%) of the initially undiseased sinuses did not undergo sinusotomy. Of these, 82 sinuses (83.7%) were disease free at the time of revision ESS, whereas 16 (16.3%) were found to have new disease on follow-up CT scan before revision ESS. These data are summarized in Figure 3. The proportion of diseased sinuses at the time of revision ESS was independent of whether the sinus originally underwent sinusotomy. In fact, sinusotomy on an undiseased sinus resulted in a higher proportion of disease at revision than if the sinus were left alone, although these results were not statistically significant (Fisher exact test, $P = .15$).

**SPHENOID SINUS**

Forty-four sphenoid sinuses were initially free of disease. Further analysis revealed that a sphenoidotomy was performed in 9 cases (20.5%), and sphenoid disease subsequently developed in 3 (33.3%) of these sides. Of the 35 sphenoid sinuses not surgically addressed at the initial procedure, sphenoid sinusitis subsequently developed in 4 (11.4%). This distribution is demonstrated in Figure 5. The likelihood of disease at secondary scan was not associated with whether a sphenoidotomy was performed (Fisher exact test, $P = .14$). Among all initially normal sphenoid sinuses, in only 1 side (2.9%) was the nonsurgically treated sphenoid the sole site of disease at the time of revision.

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### Sites of Disease and Lund Scores for 84 Revision Endoscopic Sinus Surgery Cases

<table>
<thead>
<tr>
<th>Disease Site</th>
<th>Lund Score</th>
<th>% Diseased</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Maxillary sinus</td>
<td>18</td>
<td>54</td>
</tr>
<tr>
<td>Anterior ethmoids</td>
<td>27</td>
<td>46</td>
</tr>
<tr>
<td>Posterior ethmoids</td>
<td>33</td>
<td>41</td>
</tr>
<tr>
<td>Sphenoid</td>
<td>44</td>
<td>31</td>
</tr>
<tr>
<td>Frontal</td>
<td>35</td>
<td>29</td>
</tr>
<tr>
<td>Ostiomeatal complex</td>
<td>27</td>
<td>0</td>
</tr>
</tbody>
</table>

**Figure 2. Lund score distribution at revision.**

Two hundred sixty-three sinuses presented with disease before the first ESS (Lund score 1 or 2). Of these, 182 sinuses underwent sinusotomy. Twenty-seven sinuses (14.8%) were normal at the time of revision ESS, and 155 (85.2%) demonstrated disease at the time of CT scan before revision ESS. Of the 81 initially diseased sinuses that did not undergo sinusotomy at the initial ESS, 22 (27.2%) became normal, and 59 (72.8%) were diseased. The distribution of outcomes is displayed in Figure 4. Sinuses that underwent formal sinusotomy when initially diseased had a higher proportion of disease at revision than those that did not (Fisher exact test, $P = .02$).

**Figure 3. Outcome for initially normal sinuses (aggregate).**

**Figure 4. Outcome for initially diseased sinuses (aggregate).**

**Figure 5. Outcome for initially nondiseased sphenoid sinuses.**
Forty sphenoid sinuses initially harbored disease. Of these, 12 sides (30.0%) did not have a sphenoidotomy at the initial procedure. Eight (66.7%) of these 12 showed normal findings on the second CT scan, whereas 4 (33.3%) remained diseased. The remaining 28 sides underwent sphenoidotomy, with 6 sphenoids (21.4%) showing normal findings on secondary scan and 22 sphenoids (78.6%) remaining diseased. This distribution is demonstrated in Figure 6. There was a significant association between performance of a sphenoidotomy at the initial procedure and the presence of disease on secondary scan (Fisher exact test, $P = .009$). The proportion of Lund scores of 1 or 2 was not appreciably different between those cases that underwent sphenoidotomy and those that did not. Among all sides, in only 1 side (1.2%) was the sphenoid the sole site of disease at revision.

FRONTAL SINUS

Thirty-five frontal sinuses initially had no disease. Of these, 34 did not undergo a frontal sinusotomy. In 7 cases (20.6%), subsequent disease developed in the frontal sinus at the time of revision. The 1 case in which a frontal sinusotomy was performed in the absence of frontal disease remained free of disease at the time of revision. There was no association between frontal sinus surgery and development of disease (Fisher exact test, $P > .99$).

Forty-nine frontal sinuses presented with disease at the time of initial surgery. Of these, 28 did not undergo a frontal sinusotomy. Twenty-three (82.1%) of these were found to have disease at the time of revision. Twenty-one of the frontal sinuses underwent sinusotomy, and 19 (90.5%) returned with persistent frontal sinus disease. The frequency of frontal sinus disease at the time of revision was not different among those sinuses that received an initial sinusotomy compared with those that did not (Fisher exact test, $P = .68$). Among all sides, in only 1 side (1.2%) was the frontal sinus the sole site of disease at revision. The frontal sinus results are summarized in Figure 7 and Figure 8. Frontal sinusotomy in an initially diseased sinus resulted in a higher proportion of frontal sinus disease at revision, but this was not statistically significant ($P = .68$).

Although ESS has proved to be a valuable and effective modality for the treatment of chronic sinusitis in which medical management has failed, those cases that eventually surface as surgical failures remain a challenging problem. The goal of this study was to provide some insights into the patterns of disease recurrence and the relationship between specific surgical interventions and objective postoperative outcomes.

Endoscopic sinus surgery is directed at the following 3 goals: (1) relief from the symptoms of chronic sinusitis, (2) restoration of the normal sinus physiology, and (3) prevention of disease recurrence. A number of studies have documented the success of ESS for the first 2 components. Recurrent disease (as determined by symptoms, endoscopic findings, or radiographic evidence) presents a challenging problem. Several authors have reported their experience with revision ESS. These studies have included cases of revision ESS performed after non-ESS as well as those in which the primary surgery was performed elsewhere. In this series, the primary and revision ESS were performed at the same institution, and all of the primary procedures were endoscopic in nature. This allows a more specific analysis of disease recurrence after true ESS, in a cohort of patients in whom consistency in operative technique for the primary procedure is highly likely.

In our patients, disease recurrence was defined by radiographic evidence of sinus abnormalities. All of these patients had symptoms of chronic sinusitis and were therefore considered candidates for revision ESS. Objective findings on office endoscopy were far too variable among physicians to be used for rigorous analysis. Although some studies have questioned the value of the CT scan and CT scan staging for chronic sinusitis, it remains the most objective tool for the evaluation of disease and disease recurrence. The analysis used herein was predicated on the Lund system, but the statistical analysis was based on the dichotomous outcomes: whether the sinus was normal (Lund score, 0) or abnormal (Lund score, 1 or 2). This simpler analysis was chosen because it was evident in the analysis of the surgical procedures that surgeons chose in general to operate on abnormal sinuses inde-
ependent of whether their Lund score was 1 or 2. In addition, there is no strong evidence that a Lund score of 2 implies more symptomatic disease for any given sinus. In general, our goal with ESS and revision ESS is to render the diseased sinuses in a symptomatic patient to a Lund score of 0.

Application of the Lund scoring system to revision cases illuminated some difficulties. First of all, with respect to the evaluation of the ostiomeatal complex, potential causes for variation were identified. In previously nonsurgically treated cases, the ostiomeatal complex is readily identified by the presence of the uncinate process. In revision cases, though the uncinate process may be retained (a potential surgical error and cause for failure), it may not be identified easily on CT scan. Although the patient may have a patent posterior antrostomy, the true region of the ostiomeatal complex may be diseased. In addition, in revision cases, it is not uncommon to find synechiae. Although these are suboptimal, they are often asymptomatic. However, on CT scan, they may appear as areas of mucosal thickening, especially in the anterior ethmoid complex. Despite these problems, CT scan offers a reasonable way of analyzing revision cases for patterns of failure when it is acknowledged that all of these patients had symptomatic disease. Therefore, the Lund system appears to be readily adaptable to staging revision cases. Further study will be required to determine whether the Lund system is consistent and offers prognostic value in revision cases.

The total Lund score for the primary procedure did not differ significantly from that for the revision procedure. This implies that patients who require revision will present with a similar level of disease as they did initially. The distribution of actual sites of disease at the time of revision was similar to that reported in the literature.4 With respect to anatomic location of disease at revision, the aggregate data suggest that normal sinuses remain normal, regardless of whether a specific sinusotomy is performed. This supports the notion that normal sinuses should be left in their native state; a prophylactic sinusotomy does not seem prevent disease in that sinus at revision. The aggregate data also imply that the sinuses with disease at primary surgery are the same sinuses that will present with disease at the time of revision. Somewhat surprisingly, performance of a sinusotomy on an initially diseased sinus was associated with an increased likelihood of disease in that sinus at revision. Although at first glance this suggests that all sinuses should be left alone, it must be interpreted in the correct context in that all of these cases came to revision; those that responded to the initial sinusotomy were not included in the analysis. The conclusions drawn regarding the initially normal sinuses are the most compelling, since the surgeon’s first goal should be to avoid creating disease where none previously existed.

The data and analysis for the sphenoid sinus reflected the aggregate data. Specifically for undiseased sphenoid sinuses, the lack of statistical association between performance of sphenoidotomy and the presence or absence of disease at the time of revision, along with the trend toward an increased proportion of sphenoid disease at revision in sinuses undergoing operation, imply that the undiseased sphenoid sinus should be left in its native state. Again, a prophylactic sphenoidotomy does not seem warranted. In fact, performance of a sphenoidotomy in a normal preoperative sinus was associated with a higher likelihood of sphenoid disease at revision. This negative association, however, was not statistically significant. For sphenoid sinuses that initially had disease, performing a sphenoidotomy resulted in a higher likelihood of disease being present in the surgically treated sphenoid at the time of revision, and this association was statistically significant. In other words, the outcome was potentially better if the sphenoid sinuses were left alone and the true functional concept was used. This conclusion must be taken in the correct context. There are many ESS cases with initial sphenoid sinus disease in which a sphenoidotomy was performed that did not require revision. It has been shown that most patients who undergo ESS with sphenoidotomy do not have an adverse result due to sphenoidotomy and have marked improvement in sinusitis symptom scores.10 The potential bias toward an initially more diseased sphenoid sinus (Lund score, 2) being more likely to receive a sphenoidotomy was not evident, as the likelihood of sphenoidotomy was not related to the Lund score.

The frontal sinus retains its reputation as an enigma for the sinus surgeon. Despite recent reports of successful ESS on the frontal sinus using “drill-out” procedures, most sinus surgeons prefer not to remove mucosa from the frontal recess or to drill out the nasofrontal duct region unless more conservative measures have been tried already. In our practice, it is uncommon to perform a formal frontal sinusotomy at the first ESS procedure. The frontal sinus manifests disease at the time of revision in approximately 48% to 63% of cases.4,7,11 These data confirm that frontal sinusitis is a frequent cause of and finding at revision surgery. The questions then arise as to what percentage of revision cases are due to persistent frontal sinus disease that failed to respond to the functional procedure, and what percentage of frontal sinus disease was caused by the basic functional ESS procedure. These data suggest that a normal frontal sinus will remain normal with or without a formal frontal sinusotomy. In other words, revision ESS for new frontal disease is not common. In addition, performing a frontal sinusotomy at the initial procedure, even in the setting of initial frontal disease, did not result in less frequent disease in the frontal sinus at revision. Although the diseased frontal sinus may not always normalize with the simple functional anterior ethmoidectomy and middle meatal antrostomy, performing an “up-front” sinusotomy does not improve the odds for normalization. Thus, the frontal sinus probably should be left alone initially. Again, a bias does exist, since there are likely cases of initial frontal sinusitis with good results that did not come to revision. However, it is uncommon in our practice to perform a prophylactic frontal sinusotomy, so that bias is likely limited.
These data tend to support the functional concept, even for the sphenoid and frontal sinuses. The ostiomeatal complex region should be addressed at first, since even a diseased sphenoid (or frontal) sinus may normalize without sphenoidotomy (or frontal sinusotomy). These results must be interpreted with some caution, since the denominator here is revision cases, not all patients who underwent ESS. There are many patients with disease in these sinuses who respond completely to ESS and never return for a second CT scan. A prospective study to examine these cases is currently under way.

CONCLUSIONS

1. The Lund system of staging for chronic sinusitis can be applied to revision cases with some limitations.
2. The average total Lund score at revision ESS is not significantly different from that at the primary procedure.
3. In revision cases, the most common sites for radiographic disease are the originally involved sinuses.
4. A sphenoidotomy should be performed at the time of ESS only if disease is present in the sphenoid on the CT scan. However, even the diseased sphenoid sinus may normalize with a functional ESS approach without formal sphenoidotomy.
5. Frontal sinusotomy at the time of primary ESS, even in the setting of initial frontal disease, does not prevent recurrent disease at the time of revision.

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REFERENCES