Impact of Septal Deviation on Recurrent Chronic Rhinosinusitis after Primary Surgery: A Matched Case-Control Study

Terence Fu, MD, MBA1, Daniel Lee, MD1, Jonathan Yip, MD1, Alisha Jamal, MD2, and John M. Lee, MD, MSc1

Abstract

Objective. To evaluate the impact of untreated deviated nasal septum (DNS) on recalcitrant chronic rhinosinusitis (CRS) among patients undergoing revision endoscopic sinus surgery (ESS).

Study Design. Case-control study.

Setting. Tertiary academic center.

Subjects and Methods. We performed a retrospective review of 489 patients undergoing revision ESS for CRS at a tertiary academic center. Patients undergoing septoplasty were matched to nonseptoplasty controls based on age and sex. Preoperative Lund-Mackay score (LMS) was compared between cohorts. Linear regression was used to identify predictors of LMS and ostiomeatal complex (OMC) obstruction.

Results. Thirty-six matched pairs (72 patients) were selected for analysis: 36 undergoing septoplasty and revision ESS and 36 undergoing revision ESS alone. Compared with nonseptoplasty controls, the septoplasty group had a significantly higher average LMS (17.8 vs 14.6, \( P = .02 \)) and a greater rate of OMC obstruction (89% vs 61%, \( P < .01 \)). The septoplasty group also had significantly higher opacification scores in the maxillary (1.5 vs 1.2, \( P = .03 \)) and posterior ethmoid (1.8 vs 1.4, \( P = .02 \)) sinuses. On multivariable analysis, DNS was an independent predictor of LMS (\( P = .02 \)) and OMC obstruction (\( P < .01 \)).

Conclusion. Untreated DNS is associated with radiographic markers of CRS severity among patients undergoing revision ESS and may contribute to the multifactorial pathogenesis of persistent CRS.

Keywords

septal deviation, rhinosinusitis, endoscopic sinus surgery.

Endoscopic sinus surgery (ESS) has become the standard treatment modality for patients with medically refractory chronic rhinosinusitis (CRS). While reported success rates of ESS range from 80% to 98%, a subset of patients requires revision surgery for persistent or recurrent disease. Various host, environmental, and iatrogenic factors are associated with recurrent or persistent CRS, including aspirin-exacerbated respiratory disease, asthma, high inflammatory load (eg, mucosal eosinophilia), and inadequate clearance of sinus disease during primary ESS.

Deviated nasal septum (DNS) has been implicated in CRS by means of mechanical outflow obstruction, impaired mucociliary function, and reduced access for surgical and inadequate postoperative care. DNS is reported for 16% to 54% of patients with CRS and is commonly treated with concurrent septoplasty during primary ESS. Several studies demonstrated a correlation between DNS and CRS among patients undergoing primary surgery, and a recent systematic review found that DNS conferred a significantly increased risk of rhinosinusitis. Additionally, a recent multicenter study of 228 patients found that septoplasty was a significant predictor of postoperative improvement in SNOT-22 scores (Sino nasal Outcome Test). This association, however, remains debated in the literature, with other studies reporting minimal to no correlation between DNS and the incidence or severity of CRS.

Since DNS and CRS can present concurrently, it can be difficult to determine the degree of CRS attributable specifically to concurrent septal deviation. The aforementioned studies were limited by failing to control for confounding local and systemic factors. Furthermore, the role of

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DNS in recurrent, medically recalcitrant CRS has not been elucidated. It is possible that untreated DNS after primary ESS may be particularly susceptible to the resultant mechanical, aerodynamic, and pressure changes that impair paranasal sinus ventilation, subsequently resulting in treatment failure.15

The purpose of this study was to evaluate the impact of untreated DNS on radiographic markers of CRS severity among patients undergoing revision ESS. We hypothesized that inadequate treatment of a septal deviation during ESS may predispose patients to recurrent CRS due to limitations of surgical access and postoperative care.

Materials and Methods
Research ethics approval was obtained from St Michael’s Hospital (Toronto, Canada). The electronic medical records were reviewed for all adult patients with CRS, as defined by the clinical practice guideline of the American Academy of Otolaryngology–Head and Neck Surgery Foundation,16 who were undergoing revision ESS by the senior author (J.M.L.) between January 2010 and December 2017. Patients were eligible for revision ESS if they failed a trial of appropriate medical therapy and had radiographic evidence of persistent disease (ie, thickening mucosa within the ostiomeatal complex [OMC] and/or paranasal sinuses on computed tomography [CT] scans). Appropriate medical therapy generally consisted of saline irrigations, intranasal corticosteroids, a 2- to 4-week course of broad-spectrum or culture-directed antibiotics (particularly for CRS without nasal polyposis [NP]), and a short course of oral corticosteroids. Exclusion criteria included patients with fungal sinusitis, rhinosinusitis due to sinonasal malignancy or systemic disease (ie, cystic fibrosis, primary ciliary dyskinesia, immune deficiency), and missing preoperative CT imaging. Surgical extent was determined by physician discretion and based on the Messerklinger technique. Patients were assessed preoperatively for concurrent septoplasty, which was offered for severe DNS limiting endoscopic access and/or significant complaint of nasal obstruction. All septoplasties were performed with an endoscopic approach.

Data Extraction
All clinical and operative notes were reviewed, and data were recorded on patient demographics, comorbidities, and surgical management. Preoperative CT sinus imaging was assigned a Lund-Mackay score (LMS) by 2 independent reviewers (T.F. and D.L.); any disagreements were resolved by the senior author (J.M.L.). The need for septoplasty during revision ESS was considered a surrogate measure of DNS.

Statistical Analysis
Patients undergoing septoplasty and revision ESS (cases) were matched to patients undergoing ESS alone (controls) based on age and sex. Patient, disease, and treatment characteristics were compared between the septoplasty and nonseptoplasty groups with a t test or chi-square test. Average LMS and the proportion of patients with OMC obstruction were compared between case and control groups with t tests. Predictors of LMS and OMC obstruction were identified by entering the following variables into a stepwise multiple regression model: age, sex, asthma, acetylsalicylic acid (ASA) sensitivity, NP, and septoplasty.

Data were aggregated with Microsoft Excel 2016, and statistical analyses were performed with SPSS 24.0 (SPSS Inc, Chicago, Illinois). A P value <.05 was considered statistically significant.

Results
During the 8-year study period, 489 patients underwent revision ESS for CRS at our institution. Of these, 164 (33.5%) were excluded due to missing preoperative imaging and 117 (23.9%) due to incomplete medical records. Fifty-one patients (10.4%) had rhinosinusitis due to cystic fibrosis or another systemic disorder, and 32 (6.5%) had fungal sinusitis and hence were removed from analysis. Of the remaining 125 patients, 72 were included in the final analysis after case-control matching by age and sex: septoplasty (n = 36) and nonseptoplasty (n = 36).

Patient and disease characteristics are shown in Table 1. There were no significant differences in age, sex, asthma, NP, or ASA sensitivity between the septoplasty and nonseptoplasty groups. Patients who underwent revision ESS alone (controls) had a significantly higher number of prior ESS procedures (1.9 vs 1.4, P = .01).

Table 1. Descriptive Statistics.a

<table>
<thead>
<tr>
<th></th>
<th>No Septoplasty (n = 36)</th>
<th>Septoplasty (n = 36)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y, mean ± SE</td>
<td>55 ± 2</td>
<td>52 ± 2</td>
<td>.36</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>15 (42)</td>
<td>15 (42)</td>
<td>&gt;.99</td>
</tr>
<tr>
<td>Female</td>
<td>21 (58)</td>
<td>21 (58)</td>
<td></td>
</tr>
<tr>
<td>Asthma</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>20 (56)</td>
<td>16 (44)</td>
<td>.48</td>
</tr>
<tr>
<td>No</td>
<td>16 (44)</td>
<td>20 (56)</td>
<td></td>
</tr>
<tr>
<td>ASA sensitivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>29 (81)</td>
<td>30 (83)</td>
<td>.76</td>
</tr>
<tr>
<td>No</td>
<td>7 (19)</td>
<td>6 (17)</td>
<td></td>
</tr>
<tr>
<td>Polyps</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>28 (78)</td>
<td>29 (81)</td>
<td>.77</td>
</tr>
<tr>
<td>No</td>
<td>8 (22)</td>
<td>7 (19)</td>
<td></td>
</tr>
<tr>
<td>Previous ESS, mean ± SE</td>
<td>1.9 ± 0.3</td>
<td>1.4 ± 0.1</td>
<td>.01</td>
</tr>
</tbody>
</table>

Abbreviations: ASA, acetylsalicylic acid; ESS, endoscopic sinus surgery. Values are presented as n (%) unless otherwise specified.

As compared with nonseptoplasty controls, the septoplasty group had a significantly higher preoperative LMS (17.8 vs 14.6, P = .02; Figure 1) and a greater rate of OMC obstruction (89% vs 61%, P < .01; Figure 2). Average opacification scores were significantly greater in the septoplasty group within the maxillary (1.5 vs 1.2, P = .03) and posterior ethmoid (1.8 vs 1.4, P = .02; Figure 3)
There were no significant differences in average opacification scores within the other paranasal sinuses between the septoplasty and nonseptoplasty groups (anterior ethmoid, 1.8 vs 1.6, \( P = .17 \); sphenoid, 1.4 vs 1.1, \( P = .19 \); frontal, 1.5 vs 1.4, \( P = .65 \)).

On univariable analysis, asthma, ASA insensitivity, NP, and septoplasty were associated with significantly higher LMS (Table 2). However, only NP and septoplasty were independent predictors of LMS after controlling for relevant factors on multivariable analysis (\( P = .001 \) and \( P = .02 \), respectively). Septoplasty was the only variable significantly associated with OMC obstruction on both univariable and multivariable analysis (\( P < .01 \) and \( P < .01 \), respectively; Table 3).

### Discussion

Failure of primary ESS is often associated with reobstruction of the OMC, which can be due to local or systemic factors. Local factors include anatomic abnormalities such as DNS, which represent a common cause of revision ESS. In this study, we demonstrated that patients with recurrent CRS and untreated DNS had greater radiographic disease severity as compared with their counterparts without DNS. Specifically, patients with DNS had significantly worse preoperative LMS and higher rates of OMC obstruction as compared with those without DNS. Furthermore, multivariate analysis identified DNS as an independent predictor of disease severity after controlling for known risk factors, including NP, asthma, and ASA sensitivity.

Several mechanisms may explain how DNS may contribute to failure of primary ESS in CRS. First, DNS may cause mechanical obstruction or stenosis of the OMC, leading to stagnation of mucus and causing subsequent infection or perpetuation of infection. Second, mechanical obstruction can diminish surgical access at the time of primary ESS, predispose to the formation of synechiae of the middle meatus, and reduce the ease of postoperative care. The third potential mechanism is due to alterations in maxillary sinus pressure and ventilation at the level of the OMC. Finally, DNS may alter the aerodynamics, specifically by increasing

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**Table 2. Predictors of Lund-Mackay Score.**

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Patients, n</th>
<th>Mean Lund-Mackay Score</th>
<th>( T ) Test</th>
<th>Multiple Linear Regression</th>
</tr>
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<tbody>
<tr>
<td>Age</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>.59</td>
</tr>
<tr>
<td>Sex</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Male</td>
<td>30</td>
<td>16.9</td>
<td>.52</td>
<td>.47</td>
</tr>
<tr>
<td>Female</td>
<td>42</td>
<td>15.7</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Asthma</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Yes</td>
<td>36</td>
<td>18.7</td>
<td>&lt;.001</td>
<td>.06</td>
</tr>
<tr>
<td>No</td>
<td>36</td>
<td>13.7</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>ASA sensitivity</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Yes</td>
<td>59</td>
<td>19.6</td>
<td>.02</td>
<td>.36</td>
</tr>
<tr>
<td>No</td>
<td>13</td>
<td>15.4</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Polyps</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Yes</td>
<td>15</td>
<td>17.7</td>
<td>&lt;.001</td>
<td>.001</td>
</tr>
<tr>
<td>No</td>
<td>57</td>
<td>10.3</td>
<td>—</td>
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<tr>
<td>Septoplasty</td>
<td>—</td>
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<tr>
<td>Yes</td>
<td>36</td>
<td>17.8</td>
<td>.02</td>
<td>.02</td>
</tr>
<tr>
<td>No</td>
<td>36</td>
<td>14.6</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Abbreviation: ASA, acetylsalicylic acid.
nasal airflow velocity, thereby resulting in mucosal desiccation and diminished mucociliary clearance. Li et al\(^8\) compared aerodynamic differences around the OMC between the convex and concave sides of 56 patients with CRS and concurrent DNS with computational fluid dynamics. This study detected significant differences between sides in various aerodynamic indices, including maximal velocity, maximal turbulence kinetic energy, maximal wall shear stress, and minimal temperature around the OMC.

Our findings are supported by studies that demonstrated a significant association between DNS and the development of CRS on radiography.\(^{10-14}\) Yousem et al\(^{11}\) examined the CT scans of 100 patients with rhinosinusitis symptoms and found a significant correlation between DNS and radiologic signs of rhinosinusitis (\(P < .05\) for ethmoid and maxillary sinusitis). Calhou et al\(^{12}\) reproduced this finding by demonstrating a correlation between DNS and both OMC obstruction (\(P < .01\)) and ethmoid sinusitis (\(P < .05\)).

Moreover, Elahi and Frenkel showed that the severity of DNS is correlated with worse bilateral sinus disease.\(^{18}\)

In the context of revision ESS, Chang et al\(^{19}\) utilized a retrospective claims-based study to show that patients with CRS who underwent a concurrent septoplasty during primary ESS had a lower revision rate than those who had ESS alone. There are, however, no studies that examined the impact of DNS on objective or patient-reported outcome measures among those undergoing revision surgery for CRS. The paucity of research in this area may be due to the multitude of other variables that affect revision rates in CRS and the difficulty in adjusting for them. Prior studies showed the following factors to influence the need for and rate of revision ESS: sex, young age, ethnicity, smoking, occupational exposure, presence of NP, asthma, aspirin-exacerbated respiratory disease, allergic rhinitis, radiologic signs of frontal sinusitis, previous ESS, and preoperative oral corticosteroid use.\(^{20-25}\) Although our study was able to adjust for some of these factors in the matched case-control analysis, we did not control for certain variables, including allergies, corticosteroid treatment, and smoking status. Our control group also had a statistically greater number of prior ESS procedures than the treatment group, suggesting that there may be some differences in the etiologic and/or disease factors driving recurrence.

Studies also demonstrated a correlation between the degree of septal deviation and CRS severity. In a systematic review by Orlandi,\(^{14}\) a septal deviation angle (SDA) >10° was found to be the breakpoint that increased the risk of developing rhinosinusitis, but the clinical effect of DNS was modest with an odds ratio of 1.47 (95% CI, 1.19-1.81). Furthermore, the difference in SDA between subjects with and without rhinosinusitis was 2°. A power calculation by Yousem et al\(^{11}\) indicated that >600 patients would be necessary to detect a 2° difference in SDA with 80% power and a threshold \(P\) value of .05. While our study did not measure SDA, our ability to detect a statistical difference with a smaller sample size suggests that DNS may play a more clinically significant role in recurrent CRS after primary ESS.

Our study did not examine the impact of untreated DNS and subjective outcomes—namely, patient-reported, CRS disease-specific, health-related quality-of-life (HRQoL) outcomes. Prior reports examined the association between DNS and HRQoL in the setting of primary ESS. Rudmik et al\(^{6}\) compared 221 patients undergoing concurrent septoplasty against those who did not receive a septoplasty during primary ESS. Outcomes included the Rhinosinusitis Disability Index and Chronic Sinusitis Survey, as well as standardized visual analog scale symptom scores. Their study found no significant differences in postoperative improvement between the septoplasty and nonseptoplasty groups, suggesting that septoplasty does not confound QOL outcomes after primary ESS.

More recently, a multicenter study of 228 patients undergoing ESS for CRS examined postoperative HRQoL improvement in SNOT-22 and Rhinosinusitis Disability Index scores.\(^{10}\) On multivariate regression, septoplasty was a significant predictor of postoperative improvement in SNOT-22 scores (\(P = .004\)), which were predominantly driven by nonrhinologic subdomains of the SNOT-22. The authors hypothesized that improvement in postoperative access and drug delivery could explain the impact of septoplasty on QOL outcomes following ESS. Additionally, in their study, approximately half of patients underwent revision ESS; however, subgroup analysis was not performed on this subset of patients, and revision surgery was not included as a factor in multivariate analysis. Further study will be needed to examine HRQoL outcomes among patients with untreated DNS undergoing revision ESS.
The findings of this study must be interpreted with caution, particularly given the major limitation that we examined only radiologic markers of CRS severity in the form of LMS. The LMS has widely been used in the assessment of CRS due to its simplicity and high interobserver reliability, and studies demonstrated a correlation between LMS and nasal polyph grade, complication rate, revision rate, and symptomatic improvement following ESS.26 However, studies found that LMS is poorly correlated to symptom scores such as the SNOT-22 and may measure a different aspect of CRS as compared with subjective markers of disease severity.26,27 Furthermore, to our knowledge, no studies have examined the minimal clinically important difference of changes in LMS; therefore, the observed difference between the septoplasty and nonseptoplasty groups in our study (3.2) may not be of clinical significance. Another potential limitation is the inherent intersurgeon variability between the primary surgeon and revision surgeon in judging the degree of septal deviation and deciding to perform septoplasty. Our study also assumes that the status of the DNS did not change between assessments by the primary and revision surgeons.

Other study limitations include the retrospective design and small sample size in the matched cohorts. Due to insufficient data, we did not examine time to revision surgery or the number of courses of oral corticosteroids or antibiotics between index and revision surgery, and we did not control for all potential factors. Our results are also confounded by the difference in number of previous ESS procedures between the septoplasty and nonseptoplasty groups (1.4 vs 1.9, respectively; \( P = .01 \)), although it is difficult to ascertain the bias of this difference.

Future prospective studies are also needed to examine postoperative changes in objective and subjective HRQoL outcomes within this specific patient population undergoing revision surgery, and the sample size could be increased with a multicenter study design. Finally, additional physiologic studies are needed to elucidate mechanisms by which DNS may predispose patients to persistent or recurrent CRS.

Conclusion

This is the first study, to our knowledge, that examines the association between DNS and CRS severity among patients undergoing revision ESS, and it is the first to identify predictors of disease severity in this population. Our findings demonstrate that untreated DNS is associated with radiographic markers of CRS disease severity and likely represents one of many local factors that contribute to the multifactorial pathogenesis of CRS. Our study suggests that treatment of clinically significant DNS during primary ESS may reduce the risk of persistent or recurrent CRS.

Author Contributions

Terence Fu, design/conception, data analysis and interpretation, drafting/revising work, final approval, accountable for all aspects of work; Daniel Lee, data interpretation, drafting/revising work, final approval, accountable for all aspects of work; Jonathan Yip, data interpretation, drafting/revising work, final approval, accountable for all aspects of work; Alisha Jamal, data interpretation, drafting/revising work, final approval, accountable for all aspects of work; John M. Lee, design/conception, data interpretation, drafting/revising work, final approval, accountable for all aspects of work.

Disclosures

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References