Original Article

Modified Lund-Kennedy Score as A Predictor for Significant Symptom Improvement After Endoscopic Sinus Surgery Short Title: MLK Score as A Predictor for SSI After ESS

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Abstract

Background: Currently, there is no pre-operative parameters which can predict operative outcome of endoscopic sinus surgery. In this study, we evaluated the efficacy of the Modified Lund-Kennedy (MLK) endoscopic score as a predictor for significant symptom improvement (SSI) after surgery.

Method: We performed retrospective review of 293 patients who underwent endoscopic sinus surgery for chronic rhinosinusitis at the Stanford Sinus Center from 2015 to 2018. Demographic data, duration of disease, and pre- and post-operative SNOT-22 scores were reviewed. Pre-operative MLK endoscopic score, and Lund-Mackay CT score were also collected. We defined SSI after surgery as a postoperative improvement > 9 in the SNOT-22 score, the MCID.

Result: The median MLK score in the SSI group was 4 versus 2 in the non-SSI group. On average, for every one point increase in the MLK, there was a 2% increase in rate of achieving SSI ($P < 0.05$). The likelihood of achieving SSI varied differentially within subsets of MLK scores. For MLK scores $\leqslant 2$, each one point increase in MLK score was associated with a nonsignificant 0.2% decrease in the SSI rate. The greatest improvement in SSI rate was observed between MLK scores of 2 and 3, with a 14.62% increase in the SSI rate. For every one point increase in the MLK scores $\geqslant 3$, there was a 1.11% increase in SSI rate ($P < 0.05$).

Conclusion: Pre-operative MLK score correlates with SSI after ESS. A MLK score of 3 appears to be an important breakpoint for higher rates of achieving SSI after ESS.

Keywords: Modified Lund-Kennedy score, Endoscopic sinus surgery, Pre-operative evaluation, Surgical outcome, Prediction, Success, Quality of life.

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Introduction

Endoscopic sinus surgery is currently the standard of care surgical option for the management of a variety of inflammatory sinonasal conditions. Validated patient-reported quality of life and outcome measures have reported success rates approximating 70%[1-6] however, predicting successful outcomes remains a challenge. Previous studies have studied the predictive value of pre-operative measurements including Lund-Mackay CT score,[7-10] sinonasal outcome test (SNOT-22),[3, 11-14] visual analog scale (VAS),[12] and demographic data,[15-17] with mixed results.

The Lund-Kennedy endoscopic score is a well-known, validated objective outcomes measure used to stage the inflammatory burden present in sinonasal disease. Psaltis et al. recently modified the Lund-Kennedy endoscopic score by removing scarring and crusting subdomains and including only mucosal edema, discharge, and polyp subdomains.[18] This modified version of Lund-Kennedy has been validated and provides improved correlation with patient-reported outcome measures, regardless of their operative status.[18, 19] In this study, we assessed the association of pre-operative modified Lund-Kennedy (MLK) endoscopic score with clinically meaningful subjective improvement in patient-reported outcomes after endoscopic sinus surgery. In this way, we hope to provide parameters for endoscopic evaluation that may guide more precise patient selection for endoscopic sinus surgery.

Methods

We performed a retrospective study that reviewed medical records of patients with chronic rhinosinusitis seen at the Stanford Sinus Center from 2015 to 2018. The Stanford Translational Research Integrated Database Environment (STRIDE) system was used for patient identification and data extraction. This project was approved by the Institutional Review Board of Stanford University.

In the study group, inclusion criteria were age ≥ 18 years old, diagnosis of chronic rhinosinusitis according to International Consensus Statement on Allergy and Rhinology (ICAR) criteria,[20] history of endoscopic sinus surgery by single surgeon, and have at least six months post-operative follow up evaluation by the same surgeon. Patients with missing data or who received any open procedures in the same operation were excluded.

Three hundred and thirty-two patients were initially identified as meeting the inclusion criteria. Thirty-nine patients were excluded using the above-mentioned exclusion criteria. We then reviewed the medical records of the remaining 293 patients. Demographic data such as age, race, gender, and co-morbidities were reviewed. Diagnosis, operation, revision, duration of disease, and pre-operative SNOT 22 were also reviewed. Pre-operative Modified Lund-Kennedy (MLK) endoscopic score, and Lund-Mackay CT score were reviewed by rhinology staffs on pre-operative admission. Post-operative SNOT-22 score was collected at six months. We defined significant symptom improvement (SSI) as a post-operative improvement > 9 in the SNOT-22 score, the minimal clinically important difference.[21]

Statistical analysis

Statistical analysis was performed using SAS statistical software version 9.4 (SAS Institute, Inc, Cary, NC). Comparison between success and failure groups was made using Wilcoxon testing. Bivariate and multivariable Poisson regression model were performed to evaluate the prevalence ratio of successful outcomes.

Results

Demographic Data

The demographic characteristics of patients are summarized in Table 1. There were no differences in age, sex, ethnicity, or duration of disease between the two groups. The pre-operative SNOT22, Lund-Mackay CT score, and MLK score were all significantly different between the two groups (all $P < 0.05$). The SSI group presented with nasal polyp more than the non-SSI group ($P = 0.023$). Surgery performed included: 15 (5.12%) unilateral endoscopic sinus surgery; 98 (33.45%) bilateral endoscopic sinus surgery; 6 (2.05%) unilateral endoscopic sinus surgery with septoplasty; 140 (47.78%) bilateral endoscopic sinus surgery with septoplasty; 34 (11.6%) limited endoscopic sinus surgery (≤ 2 out of 4 sinuses opened on each side). There was no difference in the frequency of revision cases between the two groups ($P = 0.205$).

Table 1 Demographic data for patients in success and failure group

Parameters	Median(IQR)		*P*
	SSI	Non-SSI	
Age	55	57.5	0.160
Duration (Mo)	36	36	0.660
Pre-operative MLKS	4	2	0.001
Pre-operative SNOT 22	50	24.5	< 0.001
Pre-operative LMS	11	9	0.007
Post-operative MLKS	1	1	0.716
Post-operative SNOT 22	16	28.5	< 0.001
Sex			0.849
- Male	113 (46.9%)	25 (48.1%)	
- Female	128 (53.1%)	27 (51.9%)	
Race			0.091
- Caucasian	168 (69.7%)	35 (67.3%)	
- Asian	20 (8.3%)	9 (17.3%)	
- African American	7 (2.9%)	1 (1.9%)	
- Unknown or other	46 (19.1%)	7 (13.5%)	
Smoking			0.179
- Never smoke	164 (68.1%)	41 (78.8%)	
- Current smoker	9 (3.7%)	0 (0%)	
- Past smoker	68 (28.2%)	11 (21.2%)	
Co-morbidities			
- AERD	22 (9.1%)	2 (3.8%)	0.208
- Asthma	97 (40.2%)	14 (26.9%)	0.072
- Depression	27 (11.2%)	8 (15.4%)	0.399
- Nasal polyp	101 (41.9%)	13 (25%)	0.023
- AFRS	5 (2.1%)	1 (1.9%)	0.944
- CF	3 (1.2%)	1 (1.9%)	0.702
Operation			
- Unilateral ESS	11 (4.6%)	4 (7.7%)	0.353
- Bilateral ESS	83 (34.4%)	15 (28.8%)	0.438
- Unilateral ESS with septoplasty	3 (1.2%)	3 (5.8%)	0.037
- Bilateral ESS with septoplasty	119 (49.4%)	21 (40.4%)	0.239
- Limited ESS	25 (10.4%)	9 (17.3%)	0.157
Revision case	116 (48.1%)	20 (30.5%)	0.205

Data expressed as median or as number (%).
Calculated using the Wilcoxon test.
Values are significant at $P \leq 0.05$
Pre-op: pre-operative
SNOT: Sinonasal outcome test
MLKS: Modified Lund-Kennedy endoscopic score
LMS: Lund-Mackay CT score
ESS: endoscopic sinus surgery
AERD: aspirin-exacerbated respiratory disease
AFRS: allergic fungal rhinosinusitis
CF: cystic fibrosis

Outcomes after endoscopic sinus surgery

The median pre-operative and post-operative SNOT 22 scores of the overall cohort were 47 and 18 respectively, with an SSI rate of 82.25%. The median MLK endoscopic score in the SSI group was 4 versus 2 in the non-SSI group (Table 1). The SSI rates for each pre-operative MLK endoscopic score are shown in Figure 1, ranging from a score of 72.55% for MLK = 0 to a score of 100% for MLK = 12 (maximum score). Using a bivariable Poisson regression analysis, there was an average 3% increase in the SSI rate for each point increase in the MLK score above 0 ($P = 0.001$) (Table 2). After controlling for demographic data, duration of disease, and pre-operative SNOT-22, the multivariable analysis resulted in an adjusted average of 2% increase in SSI rate for each point increase in the MLK score above 0 ($P = 0.03$) (Table 3).

Table 2 Association between pre-operative variables and prevalence ratio of achieving SSI

Independent variables	Prevalence ratio	*P*
Age	0.866 (0.766, 0.979)	0.021
Male	0.965 (0.864, 1.077)	0.525
African American	1.058 (0.808, 1.385)	0.682
Asian	0.834 (0.648, 1.073)	0.157
Other race	1.051 (0.930, 1.187)	0.424
Duration	0.866 (0.766, 0.979)	0.011
Pre-op SNOT22	1.008 (1.005, 1.011)	< 0.001
Pre-op MLKS	1.028 (1.012, 1.045)	0.001
Pre-op LMS	1.013 (1.004, 1.022)	0.003
Low pre-op MLKS	0.813 (0.719, 0.919)	0.001
Higher pre-op MLKS	1.230 (1.088, 1.392)	0.001
Unilateral ESS	0.886 (0.650, 1.208)	0.445
Bilateral ESS	1.060 (0.950, 1.182)	0.295
Unilateral ESS with septoplasty	0.603 (0.270, 1.344)	0.216
Bilateral ESS with septoplasty	1.062 (0.955, 1.181)	0.264
Limited ESS	0.882 (0.715, 1.087)	0.238
Revision case	1.068 (0.960, 1.188)	0.224
Current or past smoker	1.089 (0.980, 1.210)	0.112
AERD	1.154 (1.028, 1.297)	0.016
Asthma	1.105 (0.998, 1.224)	0.054
Depression	0.938 (0.778, 1.131)	0.502
Nasal polyp	1.147 (1.031, 1.277)	0.011
AFRS	1.013 (0.705, 1.455)	0.944
CF	0.910 (0.516, 1.607)	0.746

Analysis using bivariable Poisson regression model.
Each variables were analyzed in separate model.
Values are significant at $P \leq 0.05$
Pre-op: pre-operative
SNOT: Sinonasal outcome test
MLKS: Modified Lund-Kennedy endoscopic score
LMS: Lund-Mackay CT score
ESS: endoscopic sinus surgery
Low pre-op MLKS: pre-operative Modified Lund-Kennedy endoscopic score of 0-2.
Higher pre-op MLKS: pre-operative Modified Lund-Kennedy endoscopic score of 3-12.
AERD: aspirin-exacerbated respiratory disease
AFRS: allergic fungal rhinosinusitis
CF: cystic fibrosis

Table 3 Association between pre-operative variables and SSI rate, adjusted

Independent variables	Prevalence ratio	*P*
Age	0.998 (0.994, 1.001)	0.220
Male	1.028 (0.927, 1.141)	0.599
African American	1.062 (0.859, 1.312)	0.579
Asian	0.866 (0.684, 1.097)	0.233
Other race	0.983 (0.872, 1.108)	0.779
Duration	1.001 (1.000, 1.001)	0.024
Pre-op SNOT22	1.007 (1.004, 1.010)	< 0.001
Pre-op LMS	1.006 (0.999, 1.014)	0.108
Pre-op MLKS	1.018 (1.002, 1.034)	0.030
Low pre-op MLKS	0.998 (0.892, 1.067)	0.407
Higher pre-op MLKS	1.011 (1.001, 1.026)	0.003

Analysis using multivariable Poisson regression model, controlling for demographics, duration, pre-op SNOT 22, pre-op LMCT score, when not use as independent variable.
Each variables were analyzed in separate model.
Values are significant if $P \leq 0.05$
Pre-op: pre-operative
SNOT: Sinonasal outcome test
MLKS: Modified Lund-Kennedy endoscopic score
LMS: Lund-Mackay CT score
ESS: endoscopic sinus surgery
Low pre-op MLKS: pre-operative Modified Lund-Kennedy endoscopic score of 0 - 2.
Higher pre-op MLKS: pre-operative Modified Lund-Kennedy endoscopic score of 3 - 12.

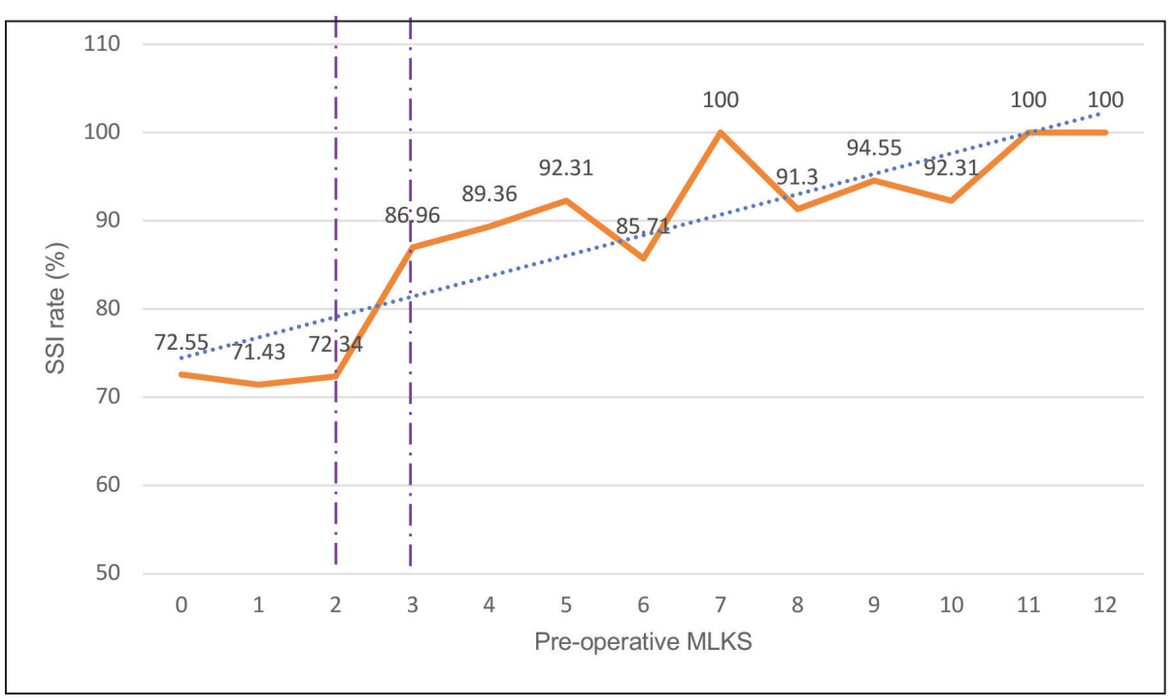

Figure 1 Showing pre-operative MLKS and SSI rate (%).

While the adjusted calculation of a 2% increase in SSI rate per point increase in the MLK score was based on an average across the full range of MLK scores from 0 - 12, the likelihood of achieving SSI varied differentially within subsets of MLK scores (Figure 1). In the segment with the lowest pre-operative MLK scores of 0 - 2,[5] there were no significant predictive differences between MLK = 0 vs = 1 vs = 2 in terms of SSI rates (P = 0.407) (Table 3), with the SSI rate between 71 - 73%. (Table 3). Patients with MLK scores of 0 - 2 had the lowest chance of achieving SSI, with a 13% lower chance of achieving SSI compare to patients with MLK > 2 (P = 0.014). However, a MLK score of 3 appeared to be a notable breakpoint for predicting successful achievement of SSI, with a 14.62% increase in SSI rate between MLK = 2 (72.34%) vs. MLK = 3 (86.96%). For MLK ⩾ 3, there was a near-linear increase in SSI rate by 1.11% for each point increase in MLK up to the maximum score of 12, which was associated with an SSI rate of 100% (P = 0.003) (Table 3).

We also assessed whether other clinical variables demonstrated any association with SSI after surgery. Bivariable analysis showed that the following variables were positively associated with higher SSI rates: higher pre-operative Lund-Mackay CT score; higher pre-operative SNOT 22 score; younger age; longer disease duration by 10 months; having nasal polyp; and having AERD (aspirin-exacerbated respiratory disease) (all are $P < 0.05$) (Table 2). However, after multivariable analysis, only longer duration of disease and pre-operative SNOT 22 score retained its significant positive association with higher SSI rates ($P < 0.05$) (Table 3). The procedure type, revision case, or extent of surgery did not demonstrate any significant association with rate of SSI after surgery (Table 2).

Discussion

Endoscopic sinus surgery has evolved to become standard of care treatment of medically refractory chronic rhinosinusitis. Despite a high success rate reported by many studies,[2 - 6, 22, 23] significant symptomatic improvement is not a guarantee, and attempts to identify predictors of clinical improvement after ESS have been met with varied results. The reason might be due to self-evaluation of symptom's severity vary from person to person, while imaging score can be abnormal even in normal person. Our study found that the MLK endoscopic score can be used as a predictor for SSI after endoscopic sinus surgery. Lower MLK scores of 0 - 2 were associated with lower SSI rates, whereas MLK = 3 appeared to be a significant breakpoint for increased SSI (86.96% SSI rate). For MLK scores > 3, the SSI rate increased in a near linear fashion towards an SSI rate of 100% at the maximum MLK score of 12.

Pre-operative SNOT22 score was also found to be independently associated with achieving SSI. Alakarppa et al and Singla et al reported that pre-operative SNOT22 score ⩾ 20 points predicted higher success rates of ESS.[3, 11, 24] Levy et al reported that pre-operative SNOT 22 score < 20 points decreased the likelihood of a successful surgical outcome.[14] We also found that higher pre-operative SNOT22 scores were associated with higher SSI rates.

Alt et al found that patient with longer duration of symptom reported greater mean of post-operative quality of life improvement.[25] We also found similar association between longer duration of disease and higher SSI rates.

To eliminate the potential confounding influence of duration of disease and pre-operative SNOT 22 on the predictive value of pre-operative MLK score, we performed multivariable analysis, which controlled for duration of disease and pre-operative SNOT 22. The result still showed a significant association between pre-operative modified Lund-Kennedy endoscopic score and SSI rate, strengthening the case that pre-operative MLK score can be used an independent predictor of achieving SSI.

Although surgical success is not solely dictated by whether the minimal clinically important difference in the SNOT 22 was achieved or not, objective endoscopic scores may be a helpful adjunct when counseling patients regarding the relative likelihood of symptomatic improvement after surgery. This study was limited by the retrospective methodology, which introduces inherent biases and limitations such as inadequacies in the medical record. This study was also limited by single institution and surgeon, which may not be generalizable to all populations. This study also uses single time point evaluation. Future study should be considered

using multiple pre-operative evaluations to increase reliability of predicting surgical outcome.

Our study proved that pre-operative modified Lund-Kennedy endoscopic scores can be used as an objective tool to help predict the success of endoscopic sinus surgery. MLK scores of 3 or greater are associated with greater rates of significant symptomatic improvement, while MLK scores of 2 or less are associated with lower rates of significant improvement. The MLK scores may be a useful adjunct to other pre-operative evaluations in selecting appropriate patients for endoscopic sinus surgery.

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