# A modified Lund–Mackay system for radiological evaluation of chronic rhinosinusitis

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ABSTRACT

*Objective:* The Lund–Mackay system (L–M system) is widely used for computed tomography (CT) evaluation of chronic rhinosinusitis (CRS). However, a major drawback of the L–M system is its insufficiency of gradation. To avoid this deficiency, a new staging system proposed by American societies and the Zinreich system were reported as modifications of the L–M system. The aim of this study was to investigate the efficiency of gradation and the accuracy of the visual quantification of these modified staging systems.
*Methods:* Preoperative CT scanning was performed on 20 adult patients with CRS. A computer workstation was used to measure the volume of each sinus and the volume of inflammatory disease in each sinus. Then the soft tissue density rate (STDR) and objective scores, which were adapted to each system, were calculated. Visual evaluation of the CT images was performed using these systems. The visual score with each staging system and STDR value were evaluated for a correlation, and the rate of agreement was determined between the visual and objective scores obtained with each staging system.
*Results:* The correlation between the visual scores and the STDR values was shown with all staging system including L–M system. The coefficients of correlation between the visual scores and the STDR values with these modified systems were higher than with the L–M system. While the agreement rates with these modified systems were significantly lower than with the L–M system, differences of 2 or greater between the subjective and objective scores were rare.
*Conclusion:* We cannot conclude that one of these three staging systems is superior to the other. With this study, the simple grading system such L–M staging score was considered easy and accurate method to use the clinical level. The modified staging systems showed more efficient ability to gradate in evaluating rhinosinusitis inflammation compared with the L–M system and also showed acceptable accuracy.

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## 1. Introduction

Computed tomography (CT) is being used to assess the volume of inflammatory load within the paranasal sinuses in chronic rhinosinusitis (CRS) and also as an aid in diagnosing and deciding the treatment of CRS [1–3]. CT is also a useful tool for objectively evaluating the degree of improvement in CRS before and after drug therapy or surgery [2].

The Lund–Mackay system [4] (L–M system) is widely used for CT evaluation of CRS. The familiarity of L–M system is owing to its simple staging (Table 1). When rhinosinusitis inflammation occupies 0% of the CT image, a score of 0 is assigned, while a score of 2 is assigned when the inflammation occupies 100% of the image. All other degrees of inflammation are scored as 1. However, it is often pointed out that this system seems to lack sufficient levels of gradation for tracking progression or reduction of the disease volume [5]. Two more detailed staging systems have been reported in recent years as modifications of the L–M system, aimed at resolving those deficiencies.

One is a staging system proposed by an expert panel formed by five American societies [5]: The American Academy of Allergy, Asthma and Immunology; The American Academy of Otolaryngic Allergy; The American Academy of Otolaryngology Head and Neck Surgery; The American College of Allergy, Asthma and Immunology; and the American Rhinologic Society. This proposed rhinosinusitis staging system (Proposed system) is shown in Table 2. It

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**Table 1**
Lund–Mackey system.

| Sinus | Right sinus | Left sinus |
|---|---|---|
| Frontal | 0–2 | 0–2 |
| Anterior ethmoids | 0–2 | 0–2 |
| Posterior ethmoids | 0–2 | 0–2 |
| Maxillary | 0–2 | 0–2 |
| Sphenoid | 0–2 | 0–2 |
| Ostiomeatal complex | 0 or 2 | 0 or 2 |

For the sinuses: 0 = no inflammation; 1 = partial inflammation; 2 = 100% inflammation.
For the ostiomeatal complex: 0 = not occluded; 2 = occluded.
Maximum total score: 24.

**Table 3**
Zinreich system.

| Sinus | Right sinus | Left sinus |
|---|---|---|
| Frontal | 0–5 | 0–5 |
| Anterior ethmoids | 0–5 | 0–5 |
| Posterior ethmoids | 0–5 | 0–5 |
| Maxillary | 0–5 | 0–5 |
| Sphenoid | 0–5 | 0–5 |

For the sinuses: 0 = 0% inflammation; 1 = 1–25% inflammation; 2 = 26–50% inflammation; 3 = 51–75% inflammation; 4 = 76–99% inflammation; 5 = 100% inflammation.
Maximum total score: 50.

classifies the volume of inflammatory disease in each sinus into four strata using intervals of 33% and evaluates the inflammation score using a 4-point system.

The second staging system is the Zinreich system, shown in Table 3 [6]. This system divides the rhinosinusitis inflammation on CT images into four strata using intervals of 25% and evaluates the inflammation score using a 5-point system. The Zinreich system does not evaluate the ostiomeatal complex (OMC).

Although these modifications of the L–M staging system have the possibility to present more sufficient level of inflammatory gradation compared with the L–M system, there were few reports evaluating the actual advantage of these systems. Furthermore, in clinical practice, most of ENT doctors evaluate the inflammatory volume visually using these systems. As a result, it can be thought that the evaluation of the accuracy of the visual quantification with these systems is needed. We thus compared the efficiency of gradation and the accuracy of the visual quantification of these staging systems with the L–M system.

## 2. Subjects and methods

### 2.1. Subjects

Between April 2007 and March 2008, 552 patients who underwent endoscopic sinus surgery (ESS) for CRS in the Department of Otorhinolaryngology of the Jikei University School of Medicine satisfied the inclusion/exclusion criteria described below. For inclusion, a patient had to be an adult with CRS who underwent ESS based on the criteria reported by Meltzer et al. [5] CRS was diagnosed on the basis of the symptoms, endoscopic findings, CT imaging and allergy test results. Surgery was indicated for patients who did not respond to 3 or more months of conservative treatment.

The exclusion criteria consisted of unilateral CRS, presence of a sinus defect, a history of sinus surgery, presence of a systemic disease that would affect the nose, presence of a sinus bone lesion (e.g., Wegener's granulomatosis, cystic fibrosis, Kartagener's syndrome, sarcoidosis, etc.) and a history of facial trauma.

**Table 2**
Proposed system.

| Sinus | Right sinus | Left sinus |
|---|---|---|
| Frontal | 0–4 | 0–4 |
| Anterior ethmoids | 0–4 | 0–4 |
| Posterior ethmoids | 0–4 | 0–4 |
| Maxillary | 0–4 | 0–4 |
| Sphenoid | 0–4 | 0–4 |
| Ostiomeatal complex | 0 or 2 | 0 or 2 |

For the sinuses: 0 = 0% inflammation; 1 = 1–33% inflammation; 2 = 34–66% inflammation; 3 = 67–99% inflammation; 4 = 100% inflammation.
For the OMC: 0 = not occluded; 2 = occluded.
Maximum total score: 44.

For the present study, twenty patients (40 nasal sides) were selected from the 552 patients. To prevent imbalance in the severity of inflammatory disease, 552 patients were divided into four strata based on L–M staging score except for OMC score using intervals of 5 (strata 1: L–M staging score = 0–5, strata 2: L–M staging score = 6–10, strata 3: L–M staging score = 11–15, strata 4: L–M staging score = 16–20). L–M staging score was referred from clinical records. Each number of four strata was 154 in strata1, 228 in strata 2, 112 in strata 3, 58 in strata4, respectively. A random sample from each stratum was taken in a number proportional to the stratum's size (6 samples from strata1, 8 samples from strata 2, 4 samples from strata 3, 2 samples from strata 4). The study was approved by the Ethics Committee of Jikei University School of Medicine.

Because the OMC is not included in the evaluations performed by the Zinreich system, the OMC was also not evaluated by the L–M system or the Proposed system in this study. Therefore, in this study, the maximum possible total score was 20 with the L–M system and 40 with the Proposed system.

### 2.2. Soft tissue density rate

To quantify the volume of inflammatory opacification, the soft tissue density rate (STDR; %) was assessed with a computer workstation. Axial images were acquired preoperatively with Multi-slice CT helical scanning using a Siemens SOMATOM Sensation 16 (Siemens, Berlin, Germany) (parameters: 120 kV, 500 mA, and 2-s scan time). A computer workstation (Synapse ver. 3.1.1; Fujifilm Medical Systems, CT, USA) was used to measure the area of each nasal sinus and the area of soft tissue density for each slice in the CT axial sections of the patients (Fig. 1). Then the approximate values for the volume of each sinus and the volume of soft tissue density in each sinus were calculated by adding the respective areas for each slice and multiplying by the slice width. The CT axial section slice width ranged from 3 to 5 mm, with a mean of 4.1 mm. STDR was calculated by dividing the volume of soft tissue density in each sinus by the volume of each sinus (STDR = volume of soft tissue density in each sinus/volume of each sinus × 100%).

### 2.3. Objective score

To evaluate the exact scores for each sinus, the STDR value for each sinus was compared with the scores assigned in accordance with the L–M system, the Proposed system and the Zinreich system, and then the objective scores generated with each staging system were calculated for each sinus (example: STDR = 61% → L–M score = 1, Proposed score = 2, Zinreich score = 3).

### 2.4. Visual score

Three rhinologists, specializing in sinus diseases and having undergone training in evaluation of the volume of soft tissue