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ORIGINAL RESEARCH

Laryngoscope Investigative Otolaryngology

Relationship between infected tooth extraction and improvement of odontogenic maxillary sinusitis

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Abstract

Objective: Odontogenic maxillary sinusitis (OMS) is a well-recognized disease in otolaryngology and oral and maxillofacial surgery. It is diagnosed comprehensively based on the presence of dental disease and radiographic evaluation. Although the disease involves a combination of dental and otorhinolaryngological features, appropriate criteria have not been well established for prioritizing dental procedures in the initial treatment of OMS. We investigated whether computed tomography (CT) score, including the Lund–Mackay score, can help prioritize tooth extraction as the initial treatment for OMS.

Methods: We also investigated the radiographic features of 32 patients with OMS treated by tooth extraction alone. Both pre-and post-extraction CT images of OMS cases were evaluated.

Results: Lund–Mackay scores before tooth extraction were significantly lower in postoperatively healed patients than in non-healed patients. Furthermore, CT scores of the anterior and posterior ethmoid sinuses and frontal sinuses, obtained before tooth extraction, were significantly lower in postoperatively healed patients than in non-healed patients.

Conclusions: Collectively, low Lund–Mackay and CT scores of the ethmoid and frontal sinuses are significantly associated with healing of OMS treated by tooth extraction alone. The sinus CT score can help identify a treatment strategy for OMS.

KEYWORDS
computed tomography, Lund–Mackay score, odontogenic maxillary sinusitis, sinusitis, tooth extraction

1 | INTRODUCTION

Odontogenic maxillary sinusitis (OMS) is a well-recognized disease in otolaryngology and oral and maxillofacial surgery. OMS can be

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classified as bacteria-associated maxillary sinusitis secondary to adjacent infectious dental disease or complications caused by dental treatment in the maxillary region, with or without extension into other sinuses.[1,2] The causes of OMS include periodontitis, radicular cysts, post-extraction intraoral fistulas, peri-implantitis, dental caries, odontogenic foreign bodies, and inappropriate root canal or implant treatment.[1,2] Its estimated approximate prevalence is 10%–40% of all maxillary sinusitis.[3–5] Comprehensive diagnosis of OMS in clinical settings is based on nasal and oral symptoms, presence of dental disease, and radiographic evaluation findings.[6] In particular, computed tomography (CT) is crucial in the diagnosis of OMS, as it reveals the extent of OMS-related dental disease and sinus involvement.[7,8]

Since OMS has both dental and otorhinolaryngological features, it is necessary for otorhinolaryngologists and dentists to collaborate in treating OMS. The treatment options include either oral antibiotics, dental treatment, or endoscopic sinus surgery (ESS) alone, or combined dental treatment and ESS. Although the timing of the treatment has been investigated,[9] appropriate management guidelines after OMS diagnosis have not been sufficiently established.

Currently, the most popular sinus CT score is the Lund–Mackay (L–M) score.[10] This has been designed to optimize therapeutic interventions for patients with chronic sinusitis, with good outcomes.[11,12] The L–M score quantifies the radiographic findings of a sinus CT scan.[10] There are emerging reports on the use of the L–M score in the radiographic evaluation of OMS; these reports have demonstrated that dental treatment, including tooth extraction, improves the L–M score of patients with OMS.[13,14] However, the criteria for prioritizing dental procedures in the initial treatment of OMS are not well established. Therefore, the aim of this study was to investigate the healing of OMS, as defined using CT score (including L–M score), and to evaluate the radiographic features of OMS, cured after tooth extraction. Our results provide evidence that the sinus CT score can help determine a treatment strategy for OMS.

2 | PATIENTS AND METHODS

2.1 | Study design and sample

This was a retrospective, single-center study. Patients diagnosed with OMS at the University of Fukui Hospital from April 2010 to March 2020 were included in this study. The diagnosis of OMS was based on fulfillment of the following three criteria on pre-treatment sinus CT: (1) apical root lesion in a maxillary tooth, (2) maxillary bone defect between the maxillary sinus floor and periapical root, and (3) maxillary sinus opacification. Patients for whom only CT imaging was performed pre-and postoperatively, and those who underwent tooth extraction for OMS treatment were included in the study, and those who underwent ESS alone or ESS with dental treatment as the first-line treatment for OMS were excluded. In addition to apical root lesions, teeth with large alveolar bone loss, excessive tooth movement, or repeated acute inflammation were extracted. After tooth extraction, the socket was thoroughly cleaned. There was no post-extraction infection. The study protocol was approved by the Ethics Committee of the Faculty of Medical Sciences, University of Fukui (reference: 20200166). The need for informed consent was waived owing to retrospective nature of the study.

2.2 | Imaging evaluation of OMS

Both pre- and post-extraction CT images were used for evaluation of OMS. CT findings of the maxillary, frontal, anterior ethmoidal, posterior ethmoidal, and sphenoidal sinuses were scored using the L–M

TABLE 1 Characteristics of the patients with OMS included in the study

Study variable	
Age at operation, years (mean ± SD)	50.6 ± 14.7
Sex, *n* (%)	
Male	12 (37.5)
Female	20 (62.5)
Site, *n* (%)	
Right sinus	18 (56.2)
Left sinus	14 (43.8)
Symptoms at presentation, *n* (%)	
Oral symptoms (pain in the maxillary region, gingival swelling, pus discharge)	12 (37.5)
Nasal symptoms (postnasal drip, nasal obstruction, foul smell)	10 (31.2)
Facial symptoms (facial swelling, facial pain)	6 (18.8)
No symptom	4 (12.5)
Responsible teeth, *n* (%)	
Maxillary molars	30 (93.8)
Maxillary premolars	2 (6.2)
Pathology associated with sinusitis, *n* (%)	
Apical periodontitis	18 (56.2)
Apical periodontitis with radicular cyst	14 (43.8)
Type of oral antibiotic used, *n* (%)	
Clarithromycin	22 (68.8)
Amoxicillin	8 (25)
Cefdinir	2 (6.2)
Duration of antibiotic therapy, days (mean ± SD)	
Clarithromycin	60.0 ± 42.0
Amoxicillin	27.6 ± 41.6
Cefdinir	4.0 ± 1.4
Sinus opacification, *n* (%)	
Maxillary sinus	32 (100)
Ethmoid sinus	16 (50)
Frontal sinus	4 (12.5)
Sphenoid sinus	2 (6.2)

Abbreviations: OMS, odontogenic maxillary sinusitis; SD, standard deviation.

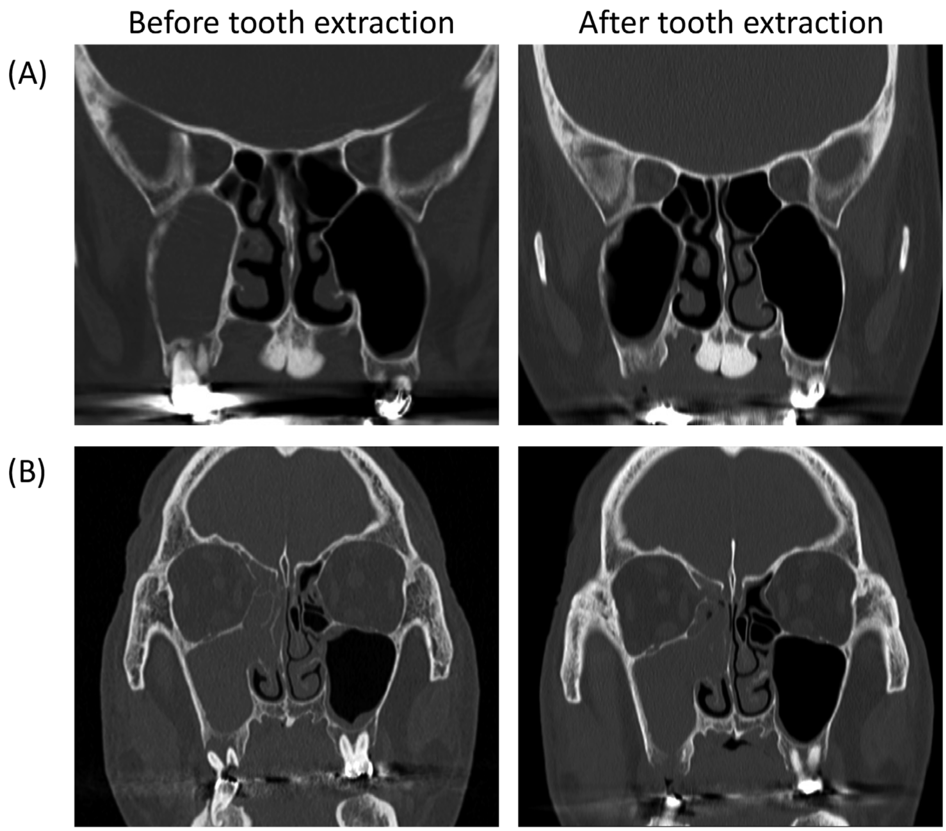

FIGURE 1 Computed tomography (coronal plane) image obtained before and after extraction. (A) Image of a representative case showing an improvement in the total opacification of the right maxillary sinus after tooth extraction. (B) Image of a representative case showing no change in the total opacification of the right maxillary sinus and ethmoid sinus after tooth extraction

scoring system on the following scale[10]: 0, no opacity; 1, partial opacity; and 2, complete opacity. The ostiomeatal complex obstruction was scored as 0 (not occluded) or 2 (occluded). The percentage of the total score divided by the maximum possible score (12 points per side) was used as the CT score.

2.3 | Study endpoints

Patients were categorized according to their post-extraction healing status. The primary study endpoints were the L–M scores obtained from CT images. A post-extraction L–M score of 0 was defined as post-extraction healing. CT scan was performed 3–4 months after tooth extraction to evaluate the healing of OMS. At that point, the presence of oral, nasal, and facial symptoms was also confirmed. Patients whose OMS was determined not to be healed based on the L-M score were referred to an otolaryngologist for additional treatment, including ESS. The secondary endpoints were demographic characteristics (age and sex), site of onset, symptoms at presentation, causative teeth, pathology associated with sinusitis, and type of oral antibiotic used. All available clinical data were obtained by retrospective review of electronic medical records.

2.4 | Statistical analysis

All statistical analyses were performed using GraphPad Prism 9 software (GraphPad Software Inc). Associations between categorical variables (L–M scores, sex, site of onset, symptoms at presentation, causative teeth, pathology associated with sinusitis, type of oral antibiotic used, and sinus opacification) in post-extraction healing status were analyzed using the chi-square test or Fisher's exact test, as appropriate. Between-group differences in continuous variables (e.g., patients' age, CT score) were analyzed using the Mann–Whitney *U* test. The calculated values are presented as the mean ± standard deviation. *P*-values < .05 were considered statistically significant.

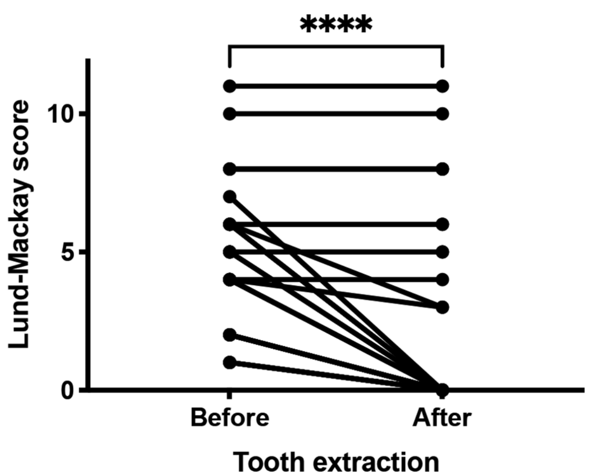

FIGURE 2 Lund–Mackay score before and after tooth extraction in patients with odontogenic maxillary sinusitis. A significant difference in Lund–Mackay score is noted before and after tooth extraction. The data are presented as mean and standard deviation. ****$P < .0001$

3 | RESULTS

Thirty-two patients were diagnosed with OMS and underwent tooth extraction as the initial treatment during the study period (April 2010 to March 2020). The demographic, clinical, imaging, and therapeutic data of the patients are shown in Table 1. The mean patient age was 50.6 ± 14.7 years, 37.5% of the patients were men, and in 56.2% of the patients, the site of onset was the right sinus. The symptoms at OMS onset were oral (37.5%), nasal (31.2%), and facial (18.8%). There were four patients whose OMS was found incidentally on CT scan. Maxillary molars comprised 93.8% of the causative teeth. Apical periodontitis (AP) is a chronic inflammatory disease that can develop in the apical tissues due to bacterial infection of the root canal system, and is classified into abscesses, granulomas, and radicular cysts. All patients had AP, but 43.8% had AP with radicular cysts. The major oral antibiotics prescribed after tooth extraction were clarithromycin (68.8%), amoxicillin (25.0%), and cefdinir (6.2%). The duration of clarithromycin therapy was 60.0 ± 42.0 days. The opacification of the maxillary, ethmoid, frontal, and sphenoid sinuses was 100%, 16%, 12.5%, and 6.2%, respectively.

CT images of patients with OMS, acquired before and after tooth extraction, are shown in Figure 1. In patients with total opacification only in the maxillary sinus, the opacification improved after tooth extraction. In contrast, when total opacification was observed beyond the maxillary sinus, extending to the ethmoid sinus, the opacification remained even after tooth extraction. The L–M scores of patients with OMS before and after tooth extraction are shown in Figure 2. There was a significant difference in the L–M score before and after tooth extraction (4.6 ± 2.6 vs. 2.4 ± 3.5, $P < .0001$), suggesting that the patients could be divided into healing and non-healing groups according to their L–M scores. Therefore, the association between post-extraction healing and clinical and imaging parameters based on pre-extraction L–M scores were investigated (Table 2). As shown in Table 2, post-extraction healing was not associated with demographic characteristics (age and sex), site of onset, symptoms at presentation, causative teeth, pathology associated with sinusitis, and type of oral antibiotic used. However, L–M scores were significantly lower in the postoperatively healed patients than in non-healed patients ($P = .0006$). Ultimately, OMS resolved in 62.5% of patients after tooth extraction. CT scores for each sinus before tooth extraction are shown in Table 3. The CT scores

TABLE 2 Comparison of post-extraction healing in patients with OMS

Study variable	Post-extraction healing		*P* value
	Yes	No	
Age at operation, years (mean ± SD)	50.2 ± 13.9	51.3 ± 16.1	.8369
Sex, *n* (%)			
Male	7 (21.9)	5 (15.6)	.7238
Female	13 (40.6)	7 (21.9)	
Site, *n* (%)			
Right sinus	11 (34.4)	7 (21.9)	.9999
Left sinus	9 (28.1)	5 (15.6)	
Symptoms at presentation, *n* (%)			
Oral symptoms (pain in the maxillary region, gingival swelling, pus discharge)	8 (25.0)	4 (12.5)	.8537
Nasal symptoms (postnasal drip, nasal obstruction, foul smell)	6 (18.7)	4 (12.5)	
Facial symptoms (facial swelling, facial pain)	3 (9.4)	3 (9.4)	
No symptom	3 (9.4)	1 (3.1)	
Responsible teeth, *n* (%)			
Maxillary molars	19 (59.4)	11 (34.4)	.9999
Maxillary premolars	1 (3.1)	1 (3.1)	
Pathology associated with sinusitis, *n* (%)			
Apical periodontitis	9 (28.1)	9 (28.1)	.1467
Apical periodontitis with radicular cyst	11 (34.4)	3 (9.4)	
Type of oral antibiotic used, *n* (%)			
Clarithromycin	12 (37.5)	10 (31.3)	.3123
Amoxicillin	6 (18.8)	2 (6.2)	
Cefdinir	2 (6.2)	0 (0)	
Lund–Mackay score before tooth extraction	3.3 ± 1.9	6.5 ± 2.5	.0006

Abbreviations: OMS, odontogenic maxillary sinusitis; SD, standard deviation.

before tooth extraction of the anterior and posterior ethmoid sinuses and frontal sinuses were significantly lower in the postoperatively healed patients than in non-healed patients. Therefore, we examined the relationship between the extension of OMS into the ethmoid sinus or frontal sinus and healing after tooth extraction. The relationship between sinus opacification before tooth extraction and post-extraction healing is shown in Table 4. Note that the cases that progressed to the sphenoid bone were excluded. There was a significant difference in the sinus opacification before tooth extraction among maxillary, maxillary/ethmoid, and maxillary/ethmoid/frontal sinuses ($P = .007$). OMS that extended into the ethmoid or frontal sinuses tended to be difficult to heal after tooth extraction.

The clinical course of patients in whom OMS did not heal after tooth extraction is as follows. Three patients with no second treatment preferences were excluded from the table. Healing was observed in all six patients (66.7%) in whom ESS was performed as a second treatment. Three patients were treated with antibiotics, which did not cure the OMS. Figure 3 shows the CT images of one of the

TABLE 3 Computed tomography scores of each sinus before tooth extraction

	Post-extraction healing				
	Yes	**Sinus opacification *n* (%)**	**No**	**Sinus opacification *n* (%)**	***P* value**
Maxillary sinus	1.7 ± 0.5	20 (100)	1.9 ± 0.3	12 (100)	.2117
Anterior ethmoid sinus	0.5 ± 0.8	6 (30)	1.5 ± 0.8	10 (83.3)	.0028
Posterior ethmoid sinus	0.1 ± 0.4	1 (5)	0.7 ± 0.8	6 (50)	.0057
Frontal sinus	0	0 (0)	0.6 ± 0.9	4 (33.3)	.0138
Sphenoid sinus	0	0 (0)	0.2 ± 0.4	2 (16.6)	.1331

TABLE 4 Sinus opacification before tooth extraction

	Post-extraction healing		
	Yes	**No**	***P* value**
Sinus opacification, *n* (%)			
Maxillary sinus	14 (46.7)	2 (6.7)	.007
Maxillary/ethmoid sinus	6 (20)	5 (16.6)	
Maxillary/ethmoid/frontal sinus	0 (0)	3 (10)	
Total	20 (66.7)	10 (33.3)	

Note: The cases that progressed to the sphenoid bone were excluded.

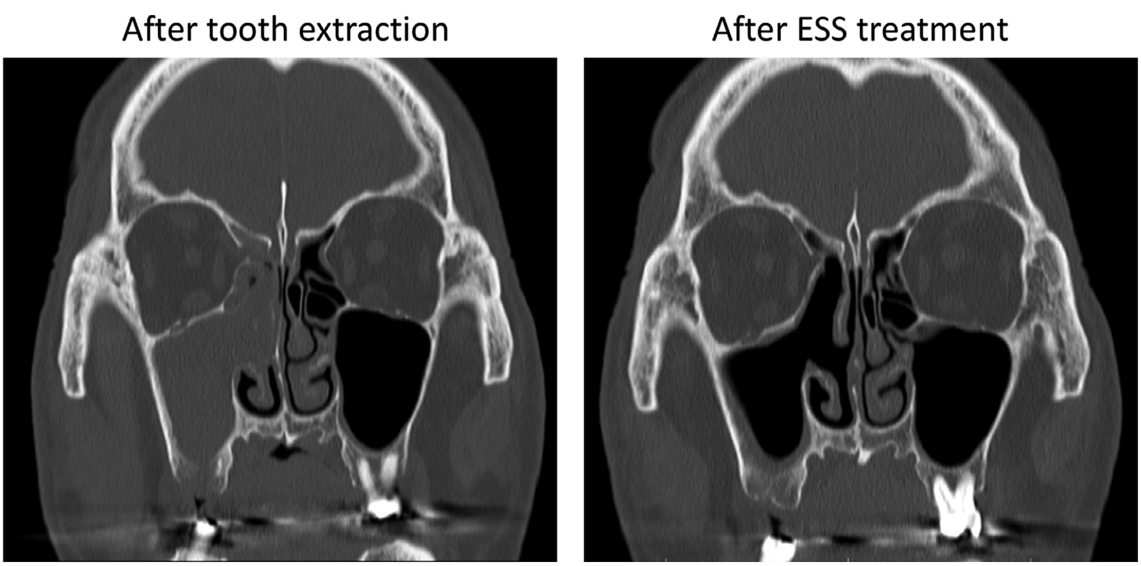

FIGURE 3 Computed tomography (coronal plane) image acquired after tooth extraction and endoscopic sinus surgery (ESS) treatment. The previously unchanged total opacification of the right maxillary and ethmoid sinus after tooth extraction shows improvement after ESS

patients in whom the OMS was successfully cured by ESS. Total opacification of the right maxillary and ethmoid sinuses, which remained after tooth extraction, improved with ESS.

4 | DISCUSSION

In the present study, we found that L–M scores were significantly lower after tooth extraction than before in patients with OMS. This result is consistent with the findings of a previous study by Tsuzuki et al.,[13] which demonstrated that tooth extraction improves the L–M score in patients with OMS. Additionally, our results reveal that L–M scores before tooth extraction were significantly lower in patients with healed OMS than in patients with non-healed OMS. Yoo et al.[14] reported that 67% of patients with OMS were cured, without ESS, by dental treatment such as root canal therapy without tooth extraction alone, and that the L–M scores of the healed patients were significantly lower than those of the non-healed patients. Considering this along with the results of our present study on patients who underwent tooth extraction as the initial treatment for OMS, it may be suggested that the lower the L–M score, the likelier it is to cure OMS by dental treatment alone without ESS.

The CT scores of the postoperatively healed patients were significantly lower for the pre-extraction anterior and posterior ethmoid and frontal sinuses, with no significant differences in the maxillary and sphenoid sinuses, compared to the scores of the non-healed patients. These results indicate that when OMS spreads to the anterior and posterior ethmoid and frontal sinuses, it cannot be cured by tooth extraction alone. Longhini et al. reported frontal and ethmoid sinus opacification in 43% and 65% of OMS patients, respectively.[15] Thus, CT scores of the ethmoid sinus and frontal sinus can be used to determine the initial treatment approach for OMS. Tomonatsu et al. defined the aperture wide of the osteomeatal complex on coronal CT and examined the distance in patients for whom dental treatment was performed initially for OMS.[16] They found a significantly narrower distance in patients with non-effective dental treatment. Although there are different ways to evaluate OMS using sinus CT, it is useful in the diagnosis of OMS prioritizing dental treatment.

When dental treatment is not effective in patients with OMS, additional treatments, such as ESS, may be considered. In our study, ESS was performed by otolaryngologists when the OMS did not heal despite tooth extraction, following which healing was achieved. Yoo et al. reported that ESS after non-effective dental treatment was successful in treating OMS.[14] Many case series have reported high cure rates of 90%–100% when both dental treatment and ESS are performed for OMS.[9] In Japan, OMS is treated by otorhinolaryngologists and dentists; their collaboration is necessary to improve the cure rate. To achieve favorable outcomes for patients, well-defined criteria are crucial for prioritizing the treatment of OMS; therefore, this study on the usefulness of CT scan scores, including the L–M score, is significant.

In this study, clarithromycin was used in nearly 70% of the cases. Macrolide therapy is effective in the treatment of patients with chronic rhinosinusitis (CRS) with symptoms of hypersecretion of rhinorrhea and nasal discharge, and in the treatment of neutrophil-associated inflammation with purulent or mucopurulent rhinorrhea. According to the Japanese guidelines for macrolide therapy in the treatment of CRS, macrolide antimicrobial agents are generally administered for a period of 1–3 months.[17]

A limitation of the present study is the inclusion of only extractions in the treatment of OMS and other dental procedures, such as endodontic treatment of infected teeth, were excluded. This is because the success rate of endodontic treatment depends on conditions such as satisfactory obturation and coronal restoration.[18] Hence, changes in CT scores of OMS owing to dental treatments other than extractions need to be explored in the future. Furthermore, it is better to divide the ethmoid sinus into anterior and posterior ethmoid sinuses. However, the sample size in this study is small. Therefore, dividing the anterior and posterior ethmoid sinuses would reduce the power of the analysis. There are several options for dental treatment of AP. Since this is a retrospective study, the indications for tooth extraction are not clear. Therefore, tooth extraction may be considered as overtreatment in some cases. In such cases, tooth extraction should be carefully considered because the patient's quality of life will decrease.

5 | CONCLUSION

In conclusion, the healing of OMS by tooth extraction alone is significantly associated with both low L–M scores and low CT scores of the ethmoid and frontal sinuses before tooth extraction. Therefore, the results suggest that sinus CT score is useful in treatment planning for patients with OMS.

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CONFLICT OF INTEREST
The authors declare no conflict of interests.

PATIENT CONSENT
Not required.

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