Clinical Implications of Magnetic Resonance Imaging in Temporomandibular Disorders Patients Presenting Ear Fullness

Sang Yeon Lee, MD 2; Ji Woon Park, MD, PhD; Seo Eun Park, MD; Dong Woo Nam, MD; Hyun Jung Lim, MD; Young Ho Kim, MD, PhD 3

Objectives/Hypothesis: The aim of this study was to investigate whether findings detected by temporomandibular joint magnetic resonance imaging (TMJ-MRI) can provide pathognomonic evidence of temporomandibular disorders (TMD) in patients with nonspecific ear fullness (EF). The association of nonspecific EF with clinical characteristics of TMD based on TMJ-MRI findings was examined.

Study Design: Retrospective analysis.

Methods: Thirty-four subjects (42 ears) who had no detectable otologic problems as a cause of EF were enrolled in this study. Each subject underwent TMJ-MRI to identify pathology of the TMJ as a possible cause of nonspecific EF. All subjects participated in the re-evaluation process following TMD treatment.

Results: Anatomical abnormalities in TMJ-MRI, irrespective of TMD signs, were observed in 34 of the 42 ears (80.9%), such as degenerative change of the TMJ (16 ears), articular disc displacement (11 ears), and joint effusion (seven ears). Specific abnormalities of the TMJ were associated with nonspecific EF, and this symptom showed improvement following individualized TMD treatment in those with internal derangement and/or effusion of the TMJ. However, abnormal TMJ-MRI findings were also observed in seven of nine ears with no TMD signs, and there was no significant association between the presence of TMD signs and abnormal TMJ-MRI findings (χ2 = 0.075, P = .784).

Conclusions: Patients presenting with nonspecific EF may have TMD, which can be effectively diagnosed using TMJ-MRI. The present study revealed the causal relationship between nonspecific EF and abnormal TMJ findings based on MRI. Individualized TMD treatments based on TMJ-MRI led to improved treatment outcomes with special regard to nonspecific EF

Key Words: Temporomandibular disorder, magnetic resonance imaging, EF.

Level of Evidence: 4.

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INTRODUCTION

Ear fullness (EF) is generally a clinical symptom characterized by ear pressure or a clogging sensation in the ear due to defects in the peripheral hearing organs from the external auditory canal to the inner ear.4 Although EF is a common otologic symptom in the otolaryngology field, its underlying etiologies are yet to be clearly elucidated. Interestingly, less than 50% of adult patients presenting with EF are diagnosed with actual ear diseases.5,6 In addition, unlike other common ear diseases, the cause of EF is not commonly identified through regular otologic examinations. Therefore, more specific and refined investigation methods are needed for correct diagnosis on the initial evaluation.7–11

Temporomandibular disorders (TMD) is a collective term referring to musculoskeletal disorders affecting the temporomandibular joints (TMJ) and the muscles of mastication.7 Several studies have shown that TMD is associated with otologic symptoms such as tinnitus, otalgia, and vertigo, suggesting the possibility of TMJ pathologies as a contributor to EF.8–10 EF was reported to be manifested in approximately 75% of TMD patients.11 It has been suggested that EF associated with TMD is the result of stomatognathic dysfunction, which transmits unnecessary charges to the middle ear muscles or bony network between the TMJ and middle ear.12 In spite of this potential underlying mechanism, TMD tends to be neglected by otolaryngologists when evaluating otologic symptoms in a clinical setting.13 Etiologies of nonspecific EF could therefore be misdiagnosed, and the inadequate assessment may lead to ineffective or inappropriate treatment that prolongs the patient’s suffering. Therefore, etiology-specific rehabilitation should be provided by thorough evaluation and identification of TMD-related EF at an early stage of diagnosis. Previous studies have argued that TMD-related EF cannot be reliably evaluated
solely based on routine clinical examinations. Considering that EF is one of the most common otologic symptoms associated with TMD, additional evaluations including imaging to locate the cause of this symptom, are crucial.

Among the various diagnostic imaging tools, temporomandibular joint magnetic resonance imaging (TMJ-MRI) has been considered the most reliable imaging modality for the evaluation of TMD-related pathologies. The current literature lacks evidence on the effectiveness and clinical applicability of TMJ-MRI in the evaluation of TMD-associated EF, especially in those who present with nonspecific EF.

The aim of this study was to investigate whether TMJ-MRI can provide pathognomonic evidence of TMD in patients with nonspecific EF. The association of nonspecific EF with clinical characteristics of TMD based on TMJ-MRI findings was examined.

MATERIALS AND METHODS

Participants

Medical records of patients who visited the Seoul National University Boramae Medical Center with nonspecific EF from May 2010 to November 2016 were reviewed retrospectively. Patients with no audiological test results and TMJ-MRI were excluded from the study. Otologic examinations included endoscopic ear inspection, pure-tone audiometry (PTA), impedance audiometry, speech audiometry, and tinnitus test. The patients were excluded if 1) presence of hearing loss of more than 20 dB hearing level in at least one ear (calculated by averaging the PTA thresholds at 0.5, 1, 2, and 3 kHz) or deformities in the conductive components; 2) abnormalities in tympanic membrane, oropharynx, and/or nasopharynx, which may cause EF observed during endoscopic/radiologic examinations; 3) history of otologic or craniofacial operations; and 4) onset of symptoms of EF is uncertain. The included patients were preliminarily interviewed for a triad of clinical signs at the initial evaluation: muscle and/or TMJ area pain; TMJ clicking noise; and restriction on mouth opening, asymmetry, or deflection of the mouth opening path. Based on this screening, those with possible TMD were then referred to the Department of Oral Medicine, Seoul National University Dental Hospital to be evaluated according to the Research Diagnostic Criteria for TMD (RDC/TMD) by a single orofacial pain specialist with more than 10 years of experience in the field. Accordingly, 34 eligible subjects (42 ears) were finally enrolled, and TMJ-MRI was performed on each subject to determine the anatomical characteristics in relation to TMJ-MRI findings and clinical evaluation for TMD, subjects were classified into four groups (Table I). This study was approved by the Seoul National University Boramae Medical Center Institutional Review Board and was conducted in accordance with the Declaration of Helsinki (IRB 16-2014-2).

MRI Protocol

TMJ-MRI was performed with a 3T MRI scanner (Achieva and Ingenia; Philips Healthcare, Best, the Netherlands), equipped with SENSE head coil (Philips Healthcare) for signal reception. The acquired MRI scans were three-dimensional T2-weighted volume isotropic axial turbo spin echo (repetition time [TR]/echo time [TE]: 2,090/275 ms; flip angle: 90°; slice thickness: 0.7 mm; no slice gap; field of view [FOV]: 160 × 160 mm²).

<table>
<thead>
<tr>
<th>Group I</th>
<th>Group II</th>
<th>Group III</th>
<th>Group IV (control group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMD Signs</td>
<td>+</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>TMJ-MRI Findings</td>
<td>–</td>
<td>–</td>
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</tr>
</tbody>
</table>

MRI = magnetic resonance imaging; TMD = temporal mandibular disorder; TMJ = temporomandibular joint.

TMD-Related Pathologies on TMJ-MRI

Both radiologist and dentist, blinded to all subject's information, evaluated TMJ-related pathologies separately. Anatomical abnormalities revealed by TMJ-MRI were reviewed based on the presence of structural deviations and categorized into three groups: I, disc displacement; II, degenerative change of the TMJ condyle; III, presence of effusion in the joint cavity.

The normal position of the disc is superior to the condyle in the closed-mouth position, and it maintains this location in the open mouth. Anterior disc displacement with reduction means that the disc is displaced anteriorly in the closed-mouth position, but the disc is relocated between the condyle and the articular eminence when the mouth is opened. Anterior disc displacement without reduction is defined when a displaced disc in the closed mouth position does not achieve a location between the condyle and the articular eminence in the open-mouth position (Fig. 1a,b). Osteoarthritis (OA) is a degenerative disease that is characterized by progressive cartilage deterioration, subchondral bone remodeling, and synovitis. Diagnosis of OA is based on the form of the TMJ condyle and articular eminence on imaging. It is characterized by erosive resorption, sclerosis, osteocyte formation, and cyst-like changes of the bone. Degenerative changes were diagnosed in the presence of flattening, subchondral sclerosis, surface irregularities, and erosion of the TMJ condyle based on TMJ-MRI (Fig. 1c,d). Joint effusion is a sign of synovitis in the presence of internal derangement of the TMJ. T2-weighted imaging is useful for the detection of TMJ effusion. Effusion appears as an area or a thin line of hyperintensity within the articular space (Fig. 1e,f).

Treatment Strategy

All subjects in groups I, II, and III underwent individualized treatment structured for TMD according to TMJ-MRI findings. Generally, TMD treatment begins with conservative, nonsurgical therapies first, with surgery left as the last option for those with intractable pain and persistent mouth opening limitations. In the current study, the strategy for TMD treatment retained a conservative and reversible approach. Subjects were treated for 4 months, following individualized treatment approaches according to each TMJ-MRI finding group. Treatment for disc displacement was noninvasive and selected based on individual symptoms including physical therapy, behavioral therapy, medications including nonsteroid
anti-inflammatory drugs (NSAIDs), benzodiazepines, and stabilization splint. Clinical physical therapies included active relaxation exercises, spray and passive stretch, ultrasound, moist heat, and transcutaneous electrical nerve stimulation. All patients were educated to remove contributing factors that may aggravate TMD, and home care of applying heat to the painful areas, postural training, and exercises were instructed.

OA treatment aimed to reduce joint and muscle pain, increase joint function, and prevent further joint damage. As with the disc displacement group, noninvasive therapies were considered first. Treatment always included stabilization splint, medications including NSAIDs and glucosamine, physical therapy, and behavioral therapy. Physical and behavioral therapy were identically applied as in the disc displacement group.

NSAIDs were primarily prescribed with the presence of joint effusion on the TMJ-MRI. In addition, the above-mentioned basic TMD treatments, such as physical therapy and behavioral therapy, were combined. Splint therapy was considered as needed.

**Treatment Outcomes**

All subjects participated in the re-evaluation process following TMD treatment. A visual analogue scale (VAS) of 0 to 10 was used to assess pre- and post-treatment severity of EF. TMD treatment was considered as effective if the VAS of post-treatment decreased more than 50% compared to that of pretreatment.

**Statistical Analysis**

All data were analyzed using the Statistical Package for Social Sciences software (SPSS 22.0; IBM, Armonk, NY). To determine significant differences among the four groups according to presence of TMD and TMJ-MRI findings in the screened continuous and categorical variables, one-way analysis of variance tests were performed. To analyze the relationships between EF and TMD diagnosis, $z^2$ tests and odds ratio analyses were performed. To substantiate improvement of nonspecific EF based on individualized TMD treatment, a paired t test was used. Furthermore, we compared the treatment effectiveness using a Kruskal-Wallis test and Mann-Whitney U test among the four groups. A $P$ value < .05 was considered statistically significant.

**RESULTS**

**Demographic and Clinical Characteristics of the Subjects**

The clinical otologic characteristics of the 34 subjects (42 ears) are summarized in Table II. The mean age of the subjects was 48.7 years (±15.1 years), and 14.7% (n = 5) of the subjects were men and 85.3% (n = 29) were women. Of the affected 42 ears, 10 presented right-sided unilateral nonspecific EF, 16 presented left-sided unilateral nonspecific EF, and eight presented...
bilateral nonspecific EF. The mean duration of nonspecific EF was 6.8 months (±16.8 months). The mean PTA thresholds in the affected ears and the normal ears were 11.5 ± 6.4 and 13.0 ± 10.4, respectively (P = .117). There were no significant differences in demographic and clinical characteristics between affected ears and normal ears. In addition, there was no significant difference in any of the demographic and otologic characteristics according to the four TMD groups (Table III).

### TMJ-MRI Findings in Subjects With Nonspecific EF

Among the 42 ears, 33 ears (78.6%) presenting nonspecific EF were diagnosed to have TMD of the TMJ on the corresponding side. Other clinical signs and symptoms of TMD besides EF were TMJ pain (15 ears), clicking noise (10 ears), and asymmetric TMJ movement on mouth opening (eight ears), in the order of prevalence. Abnormalities in TMJ-MRI, irrespective of TMD clinical signs and symptoms, were observed in 34 of the 42 ears (80.9%). Degenerative change of the TMJ was the most common finding on imaging (16 ears), followed by articular disc displacement (11 ears), and joint effusion (seven ears).

### Association Between Clinical Characteristics and TMJ-MRI Findings

Clinical signs and symptoms of TMD based on TMJ-MRI abnormalities are presented in Table IV. Among the eight ears with normal TMJ-MRI findings, TMJ pain was noted in two ears, TMJ clicking noise was noted in two ears, and deviations in the mouth opening path were noted in two ears, whereas two ears were normal. Out of 15 ears presenting degenerative change based on TMJ-MRI, seven exhibited TMJ pain, four reported TMJ clicking noise, two had deviations in mouth opening, whereas two were normal. There was no significantly prevalent TMD signs and symptoms finding for degenerative change. Among 12 ears with disc displacement based on TMJ-MRI, five showed TMJ pain, three reported TMJ clicking noise, three had deviations in mouth opening, whereas one was normal. There were also no significantly prevalent TMD signs and symptoms for disc displacement. Lastly, among seven ears with joint effusion based on TMJ-MRI, one exhibited TMJ

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**TABLE II.**
Diagnostics and Clinical Otologic Features.

<table>
<thead>
<tr>
<th>Nonspecific EF, n = 34, Total = 42 Ears</th>
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<tbody>
<tr>
<td><strong>Sex, no.</strong></td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td><strong>Age, yr</strong></td>
</tr>
<tr>
<td>Mean ± SD</td>
</tr>
<tr>
<td>Range</td>
</tr>
<tr>
<td><strong>EF side, no.</strong></td>
</tr>
<tr>
<td>Right</td>
</tr>
<tr>
<td>Left</td>
</tr>
<tr>
<td>Bilateral</td>
</tr>
<tr>
<td><strong>EF duration, mo</strong></td>
</tr>
<tr>
<td>Mean ± SD</td>
</tr>
<tr>
<td>Range</td>
</tr>
<tr>
<td><strong>Hearing threshold, dB HL, mean ± SD</strong></td>
</tr>
<tr>
<td>Affected ear</td>
</tr>
<tr>
<td>Normal ear</td>
</tr>
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</table>

dB HL = decibel hearing level; EF = ear fullness; SD = standard deviation.
All subjects with nonspecific EF participated in the TMD treatment program. Patients in groups I and III showed significant improvement of EF following TMD treatment (pre-VAS: 7.1 ± 0.5, post-VAS: 3.1 ± 0.2, P < .001; pre-VAS: 8.1 ± 0.6, post-VAS: 2.1 ± 0.5, P = .024, respectively). Treatment was especially effective in groups I (21 out of 27) and III (seven out of seven), showing a decrease in VAS greater than 50%. On the other hand, there was no significant improvement of EF following treatment in groups II and group IV (control) (pre-VAS: 6.3 ± 0.5, post-VAS: 5.0 ± 0.6, P = .711; pre-VAS: 6.2 ± 0.4, post-VAS: 4.2 ± 0.4, P = .472, respectively). Treatment was not effective in group II (five out of six) and group IV (two out of two), showing a decrease of less than 50% in VAS. The difference of change in VAS among the four groups was statistically significant (Kruskal-Wallis test, P = .03). With regard to change of VAS among four groups, there was a significant difference between group I and group III, EF = ear fullness; MRI = magnetic resonance imaging; TMD = temporal mandibular disorders; TMJ = temporomandibular joint; VAS = visual analog scale. [Color figure can be viewed at www.laryngoscope.com.]

**TABLE IV.**
TMD Signs and Symptoms According to TMJ-MRI Findings.

<table>
<thead>
<tr>
<th>TMJ-MRI Findings</th>
<th>TMD Signs and Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal, n = 8</td>
<td>Normal (2)</td>
</tr>
<tr>
<td></td>
<td>TMJ pain (2)</td>
</tr>
<tr>
<td></td>
<td>TMJ clicking noise (2)</td>
</tr>
<tr>
<td>Degenerative change, n = 15</td>
<td>Deviations in mouth opening path (2)</td>
</tr>
<tr>
<td></td>
<td>TMJ pain (7)</td>
</tr>
<tr>
<td></td>
<td>TMJ clicking noise (4)</td>
</tr>
<tr>
<td>Disc displacement, n = 12</td>
<td>Deviations in mouth opening path (2)</td>
</tr>
<tr>
<td></td>
<td>TMJ pain (5)</td>
</tr>
<tr>
<td></td>
<td>TMJ clicking noise (3)</td>
</tr>
<tr>
<td>Joint effusion, n = 7</td>
<td>Deviations in mouth opening path (1)</td>
</tr>
<tr>
<td></td>
<td>TMJ pain (1)</td>
</tr>
<tr>
<td></td>
<td>TMJ clicking noise (1)</td>
</tr>
</tbody>
</table>

MRI = magnetic resonance imaging; TMD = temporal mandibular joint disorder; TMJ = temporomandibular joint.

**TABLE V.**
Association Between the Presence of TMD Signs and TMJ-MRI Findings in Subjects With Nonspecific Ear Fullness.

<table>
<thead>
<tr>
<th>TMD Signs</th>
<th>TMJ-MRI Findings</th>
<th>Normal</th>
<th>Abnormal</th>
<th>Total</th>
<th>\chi^2</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td></td>
<td>6</td>
<td>27</td>
<td>33</td>
<td>0.075</td>
<td>.784</td>
</tr>
<tr>
<td>−</td>
<td></td>
<td>2</td>
<td>7</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>8</td>
<td>34</td>
<td>42</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MRI = magnetic resonance imaging; TMD = temporal mandibular joint disorder; TMJ = temporomandibular joint.

**DISCUSSION**

The aim of this study was to investigate whether TMJ abnormalities are pathognomonic for nonspecific EF by examining the TMJ-MRI findings. The results showed that specific abnormalities in the TMJ were associated with nonspecific EF. Furthermore, subjects with TMJ abnormalities experienced improvement of their EF following TMD treatment. These results suggest that TMJ-MRI may be an effective diagnostic tool for both initial evaluations of the pathology and treatment selection in patients with EF. In addition, the results of the present study support previous theories, which state that nonspecific EF may develop from stomatognathic dynamics involving alternations in the anatomical link between TMJ-related regions and neuromuscular dysfunction of the middle ear muscles.30,31 We strongly believe this...
study, as a first of its kind, will assist in accelerating this process and increasing awareness of TMD as a possible cause of EF.

**Plausible Speculations on the Pathophysiology of Nonspecific EF**

Although several studies have reported the association between EF and TMD, this is the first study to demonstrate the association between EF and specific TMJ pathologies based on TMJ-MRI. The current study supports that in the absence of ear infection or dysfunction of the auditory-related central nervous system, TMJ related pathologies may be the underlying condition for the development of EF.12

The TMJ and middle ear are small and compact structures that share ligamentous (disco-malleolar and anterior malleolar) components through a bony communication known as the Huguiier channel.23 In this study, abnormalities due to structural or inflammatory changes of the TMJ, such as condyle degeneration, disc displacement, and TMJ effusion, were observed regardless of the TMJ diagnosis. Such abnormalities reflecting deterioration of the articular tissue may be the etiology of nonspecific EF, as the abnormalities may lead to overtration of the disco-malleolar and anterior malleolar ligament, causing ossicular chain tension leading to EF.12

In line with a previous study, TMJ effusion was found to be the most common abnormality among the subjects without TMD signs.34 TMJ effusion may result in an alternation of the ligamentous components via inflammatory synovial changes, and such changes may consequently lead to EF. In addition, because several structures in the TMJ region form a network with the malleus via the petrotympanic fissure, the excursion of the disc and condyle during mandibular movement may induce displacement of the malleus and alter the tension of the tympanic membrane leading to EF.35

Disorders of the masticatory muscles resulting from habitual parafunction may induce dysfunction of the tensor tympani muscle, as they are both innervated by the trigeminal nerve.12 The tensor tympani muscle can be sensitized by repetitive stimulation originating from TMJ related pathology. Some abnormalities in the TMJ region may be too subtle to be recognized on MRI. Eight subjects in group II who exhibited TMD signs without TMJ abnormalities based on TMJ-MRI may have functional problems of the masticatory muscles or minimal changes that could not be detected on the MRI but could still induce EF.

**Clinical Implication of TMJ-MRI**

Considering the strong association between otology symptoms and TMD, EF could also be regarded as a consequence of TMD.37 Several studies observed a significant improvement of otologic symptoms after TMD treatment.38–40 Diagnosis based solely on clinical examination yields high false-positive and false-negative rates, leading to unclear interpretations of study results. There were several cases in this study where the side presenting clinical signs and symptoms of TMD did not correlate with the side with abnormalities on TMJ-MRI. Structural TMJ abnormalities cannot be reliably assessed by physical examination; accordingly, imaging including MRI is recommended for the appropriate initial evaluation of neuroanatomical pathologies associated with TMD.41 There has been a lack of evidence supporting the association between otology symptoms and abnormalities of the TMJ based on findings from imaging. MRI is regarded as the most reliable radiological method for the assessment of TMJ status, as joint abnormalities of both soft and hard tissue can be detected on it.22,42,43 In our study, MRI successfully identified pathologic changes in the TMJ and associated structures, especially in those without clinical signs of TMD. Abnormal TMJ-MRI findings were obtained in seven of nine patients with no signs of TMD, highlighting the effectiveness of TMJ-MRI in identifying TMJ abnormalities such as the underlying pathology of nonspecific EF (78.9% sensitivity, 100% specificity). Such results are in line with previous studies that show shortcomings of clinical diagnosis of TMD and the need of MRI to truly reveal structural problems of the TMJ. In one recent study,34 pain on palpation of the masticatory muscles and TMJ area was not related to MRI findings such as joint effusion in TMD patients. In other words, abnormal TMJ-MRI findings, can be observed among subjects without TMD signs, suggesting that clinical examination should be supported by imaging.42

In addition, nonspecific EF of the subjects with abnormal TMJ-MRI findings significantly improved following TMD treatment. This suggests that TMJ-MRI can provide not only diagnostic evidence of TMD causing nonspecific EF, but also decisive information for developing effective treatment strategies. Rather than relying on subjective TMD symptoms, objective evaluation of TMJ abnormality by TMJ-MRI analysis could be crucial to obtain favorable treatment outcomes. The fact that the patients do not have clinical TMD signs may mean that immediate TMD treatment is not necessary, but such TMJ abnormalities could still cause EF, and if so, TMD treatment should be initiated to improve EF in spite of the lack of TMD sings and symptoms. In this perspective, TMJ-MRI should be performed to identify TMJ pathologies when the cause of EF is not identified and symptoms persist. A thorough evaluation of the causal relationship between anatomical abnormalities associated with TMD and nonspecific EF is recommended in clinical practice.

**Limitations and Future Perspectives**

Although this study showed that TMJ-MRI findings could play a diagnostic role in TMD patients presenting with EF, there are some limitations that should be addressed in future studies. First, a relatively small number of subjects were included in our study. The verification of a causal relationship with regard to discrepancies between TMD clinical signs and TMJ-MRI findings awaits further confirmation. Considering that some cases of EF might resolve without treatment during the follow-up period,1 we cannot conclude that the improvement of nonspecific EF in subjects with TMD was absolutely due to TMD treatment. To prove the effectiveness of treatment
CONCLUSION

TMD may be identified in patients with nonspecific EF, and abnormal findings on TMJ imaging are common. The present study investigated the causal relationship between nonspecific EF and abnormal imaging findings of the TMJ based on MRI. TMD causing nonspecific EF can be effectively diagnosed using TMJ-MRI. Individualized TMD treatments based on TMJ-MRI diagnosis led to improved treatment outcomes with special regard to nonspecific EF.

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