



T2 relaxation times of the retrodiscal tissue in patients with temporomandibular joint disorders and in healthy volunteers: a comparative study

Naoya Kakimoto, DDS, PhD,^a Hiroaki Shimamoto, DDS, PhD,^b Jira Kitisubkanchana, DDS, PhD,^c Tomomi Tsujimoto, DDS, PhD,^b Yurie Senda, DDS,^b Yuri Iwamoto, DDS,^b Rinus G. Verdonshot, PhD,^a Yoko Hasegawa, DDS, PhD,^d and Shumei Murakami, DDS, PhD^b

Objective. The aims of this study were to compare the temporomandibular joint (TMJ) retrodiscal tissue T2 relaxation times between patients with temporomandibular disorders (TMDs) and asymptomatic volunteers and to assess the diagnostic potential of this approach.

Study Design. Patients with TMD (n = 173) and asymptomatic volunteers (n = 17) were examined by using a 1.5-T magnetic resonance scanner. The imaging protocol consisted of oblique sagittal, T2-weighted, 8-echo fast spin echo sequences in the closed mouth position. Retrodiscal tissue T2 relaxation times were obtained. Additionally, disc location and reduction, disc configuration, joint effusion, osteoarthritis, and bone edema or osteonecrosis were classified using MRI scans. The T2 relaxation times of each group were statistically compared.

Results. Retrodiscal tissue T2 relaxation times were significantly longer in patient groups than in asymptomatic volunteers ($P < .01$). T2 relaxation times were significantly longer in all of the morphologic categories. The most important variables affecting retrodiscal tissue T2 relaxation times were disc configuration, joint effusion, and osteoarthritis.

Conclusions. Retrodiscal tissue T2 relaxation times of patients with TMD were significantly longer than those of healthy volunteers. This finding may lead to the development of a diagnostic marker to aid in the early detection of TMDs. (Oral Surg Oral Med Oral Pathol Oral Radiol 2019;128:311–318)

The most widespread clinical symptoms of patients with temporomandibular joint (TMJ) disorders (TMDs) are noise, TMJ pain, and other disturbances associated with closing and opening the mouth. TMDs are characterized by an internal derangement (ID) of the TMJ. ID is a general orthopedic term, which suggests a mechanical fault that interferes with the smooth action of a joint.¹ The most common ID is displacement of the articular disc (AD) of the TMJ.² This displacement can be easily diagnosed with magnetic resonance imaging (MRI).² However, the cause and mechanism of ID have not yet been identified, and it has been suggested that the retrodiscal tissue of the TMJ might be involved.³

The retrodiscal tissue of the TMJ contains loosely associated collagen fibers, a branching system of elastic fibers, fat deposits, a specialized arterial blood

supply, a large venous plexus, lymphatics, and an abundant nerve supply.⁴ Some histologic studies have identified increased retrodiscal tissue vascularization in patients with TMD.⁵

Several qualitative and morphologic studies investigating TMDs with MRI have been reported.⁶ Moreover, clinical MRI studies have reported decreased or increased T2 signal intensity in the retrodiscal tissue of patients with TMD.^{3,4,7,8} The high signal intensity of retrodiscal tissue on T2-weighted images (T2 WIs) can, in some patients, be clinically observed through visual inspection without advanced assessment (Figure 1). However, visual inspection does not provide an unequivocal answer as to what would statistically constitute significantly high signal intensity on T2 WIs. Quantitative MRI studies investigating the AD of the TMJ or the masseter muscle have been recently reported.⁹⁻¹⁴ Although T2 relaxation time, a quantitative MRI parameter, is potentially related to TMDs, a comparison of retrodiscal tissue T2 relaxation

^aDepartment of Oral and Maxillofacial Radiology, Graduate School of Biomedical and Health Science, Hiroshima University, Hiroshima, Japan.

^bDepartment of Oral and Maxillofacial Radiology, Osaka University Graduate School of Dentistry, Osaka, Japan.

^cDepartment of Oral and Maxillofacial Radiology, Faculty of Dentistry, Mahidol University, Bangkok, Thailand.

^dDivision of Comprehensive Prosthodontics, Niigata University Graduate School of Medical and Dental Sciences, Niigata, Japan.

Received for publication Sep 11, 2018; returned for revision Jan 31, 2019; accepted for publication Feb 9, 2019.

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2212-4403/\$-see front matter

<https://doi.org/10.1016/j.oooo.2019.02.005>

Statement of Clinical Relevance

T2-relaxation time is an important quantitative diagnostic markers which is possibly predictive of TMD pathology. T2-relaxation time of the TMJ's retrodiscal tissue correlates well with a progressive TMD and is suitable as an early diagnostic marker for TMD.

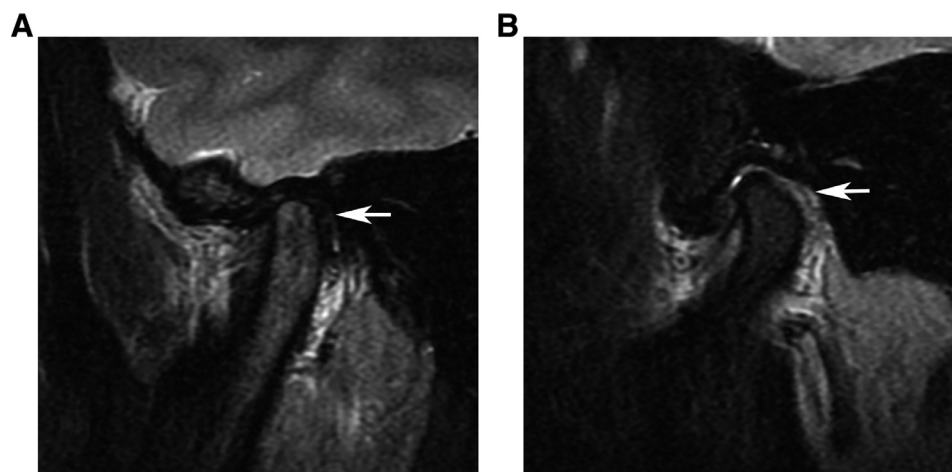


Fig. 1. A 26-year-old woman (volunteer) and 69-year-old man with a temporomandibular disorder. (A) The retrodiscal tissue (arrow) of the temporomandibular joint (TMJ) in a volunteer shows low signal intensity (T2 relaxation time: 26.9 ms) on T2-weighted image (T2 WI). (B) The retrodiscal tissue (arrow) of the TMJ in a patient with anterior disc displacement without reduction shows high signal intensity (T2 relaxation time: 52.7 ms) on T2 WI.

times between healthy volunteers and patients with TMD has not yet been reported.

We hypothesize that the T2 relaxation time of the TMJ retrodiscal tissue correlates with qualitative and morphologic variations in TMJ pathology. Therefore, the aims of the present study were to (1) measure TMJ retrodiscal tissue T2 relaxation times in patients with TMD and healthy volunteers and (2) identify any associations between T2 relaxation times and TMD MRI findings, which could serve as a diagnostic marker.

MATERIALS AND METHODS

Study population

This study was approved by the Institutional Review Board of the Osaka University Graduate School of Dentistry. After explaining the nature of the procedures to the participants, informed consent was obtained from all those who were included in the study.

From 2009 to 2014, a total of 183 consecutive patients with TMD were referred for MRI for TMJ or facial pain, mandibular dysfunction, or suspicion of ID. These patients were registered for the study. Ten patients were excluded from the study because of excessive motion or the presence of metallic artifacts on MRI scans. Consequently, 173 cases (46 men and 127 women; median age, 35 years; age range 11–80 years; 50 and 123 patients with bilateral and 123 unilateral symptoms, respectively) were analyzed. Additionally, 21 healthy volunteers underwent MRI examination. MRI scans of the TMJs of 4 volunteers demonstrated abnormal findings, such as anterior disc displacement. Therefore, data from these volunteers were excluded from the present study. The remaining 17 healthy volunteers with superior AD position (12 men and 5 women; median age 26 years; age range 23–32 years) were

deemed to have normal TMJs. In an earlier study, the T2 relaxation time of the TMJ AD was investigated;¹³ in the present study, we report on the T2 relaxation time of TMJ retrodiscal tissue.

MRI

All patients were examined by using a 1.5-T MRI scanner (Signa HDxt 1.5 T; GE Healthcare, Milwaukee, WI) equipped with a TMJ surface coil.¹³ The imaging protocol for TMD diagnosis consisted of oblique sagittal and coronal fast spin echoproton density-weighted image sequences (TR [repetition time]/TE [echo time]/echo train length [ETL]/number of excitations [NEX], 2500 ms/20 ms/8/2) and fat-suppressed T2 WI sequences (TR/TE/ETL/NEX, 2000 ms/85 ms/16/3) at right angles and parallel to the long axis of the mandibular condyle in the closed mouth position. Additionally, sagittal fast spin echoproton density-weighted image sequences (TR/TE/ETL/NEX, 800 ms/24 ms/4/2) were obtained in the closed and open mouth positions by using the following parameters: field of view 120 × 120 mm; matrix size 256 × 160; slice thickness 3 mm; and gap 1 mm. To measure T2 relaxation times, oblique sagittal 8-echo fast spin echo sequences at right angles to the long axis of the mandibular condyle were obtained in the closed mouth position by using the following parameters: TR/TE/NEX 1000 ms/8.9, 17.8, 26.7, 35.6, 44.5, 53.4, 62.4, 71.3 ms/2; field of view 120 × 120 mm; matrix size 256 × 160; slice thickness 4 mm; and gap 1 mm. For this sequence, the total acquisition time was 5 minutes and 22 seconds.

MRI scan evaluation

All MRI scans were independently assessed by 2 experienced oral and maxillofacial radiologists. In case of

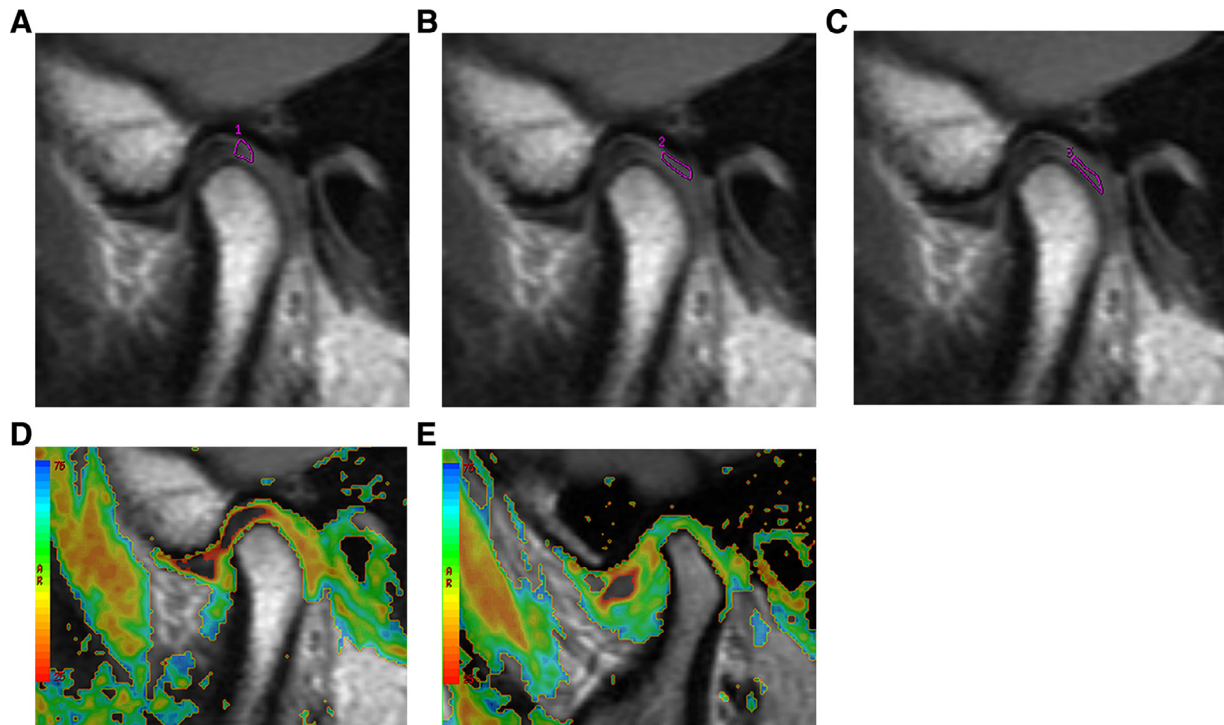


Fig. 2. A 25-year-old woman (volunteer) and a 37-year-old woman with a temporomandibular disorder. Magnetic resonance imaging (MRI) scans of the retrodiscal tissue of the temporomandibular joint of a volunteer (A–C). The regions of interest used for measuring the T2 relaxation time in the retrodiscal tissue included the bilaminar zone adjacent to the articular disc (A) as well as the upper (B) and lower (C) portions of the bilaminar zone. T2 relaxation times on a color map ranged from 25 (red color) to 75 ms (blue color) in a volunteer (D) and in a patient with anterior disc displacement without reduction (E).

disagreement, the final diagnosis was made by consensus following discussion. The radiographic features evaluated were AD position and reduction, AD configuration, joint effusion, osteoarthritis, and bone marrow abnormalities.¹³

AD position and reduction were classified into 5 categories, according to Tasaki et al.,¹⁵ with some minor modifications. On sagittal PDWIs in closed and open mouth positions, the possible classifications were normal superior (NorSup), partial anterior disc displacement with reduction (PADDWR), partial anterior disc displacement without reduction (PADDWOR), anterior disc displacement with reduction (ADDWR), or anterior disc displacement without reduction (ADDWOR). AD configuration was further divided into 6 categories, according to Murakami et al.,¹⁶ with some slight modifications. On oblique sagittal PDWIs in the closed mouth position, the AD was classified as biconcave, biplanar, hemiconvex, thickening of the posterior band, biconvex, or folded. According to Larheim et al.,¹⁷ joint effusion was classified into 4 categories: (1) none observed or minimal fluid, (2) moderate fluid, (3) marked fluid, or (4) extensive fluid on oblique sagittal fat-suppressed T2 WIs in the closed mouth position. When osteophytes and/or erosion was observed, the joint was classified as positive for osteoarthritis, and when neither was observed, the joint was classified as

negative for osteoarthritis (see also the article by Kirk¹⁸). As suggested by Larheim et al.,¹⁹ when bone marrow edema and/or osteonecrosis was present on oblique sagittal PDWIs and T2 WIs in the closed mouth position, the joint was classified as positive for bone marrow abnormalities, and if these features were absent, the joint was classified as negative.

Measuring T2 relaxation times

Eight-echo fast spin echo image data were initially transferred to an independent workstation (Advantage Workstation ver. 4.4; GE Healthcare, Milwaukee, WI). To measure T2 relaxation times, 2 independent observers (N.K. and H.S.) manually and independently generated regions of interests (ROIs) in the retrodiscal tissue, which included the bilaminar zone adjacent to the AD as well as the upper and lower portions of the bilaminar zone (Figure 2). The average T2 relaxation time value of the 3 retrodiscal tissue ROIs was defined as the retrodiscal tissue T2 relaxation time. The T2 relaxation time of the retrodiscal tissue was calculated by using Functool 4.4.5 software (GE Healthcare, Milwaukee, WI). The average of the T2 relaxation time values determined by the independent observers was defined as the definitive T2 relaxation time.

Statistical analysis

To assess whether reliable intraobserver reproducibility could be obtained, one observer (N.K.) positioned the ROIs on the retrodiscal tissue of asymptomatic volunteers 10 times on different days. To assess intraobserver reproducibility, the variation coefficient of 10 normal volunteer retrodiscal tissue data sets was calculated. To evaluate interobserver reproducibility, an intraclass correlation coefficient was calculated for the retrodiscal tissue T2 relaxation time data obtained from normal volunteers and patients by the 2 observers.

For healthy volunteers, paired *t* tests were used to compare retrodiscal tissue T2 relaxation times between the right and left TMJs. A *P* value less than .05 was considered significant. To compare retrodiscal tissue T2 relaxation times between healthy volunteers and patients, Kruskal-Wallis tests were performed. A *P* value less than .05 was considered significant. Post hoc pairwise analysis was performed by using the Mann-Whitney U test with Bonferroni correction, with *P* values less than .05/6 for AD position and reduction, less than .05/7 for AD configuration, less than .05/5 for joint effusion, and less than .05/3 for osteoarthritis and bone marrow abnormalities considered significant. Stepwise multiple regression analyses were performed to identify important variables related to retrodiscal tissue T2 relaxation times between MRI scan interpretations, and patient age and gender were considered potentially confounding variables. Significance needed for removal was set at a *P* value greater than .10, and significance for re-entry was set at a *P* value less than .05. All statistical analyses were performed by using a commercially available software package (SPSS, version 22.0; SPSS, Inc., Chicago, IL).

RESULTS

Intraobserver reproducibility determined with a variation coefficient of normal volunteers' retrodiscal tissue T2 relaxation times ranged from 1.5% to 5.5%. Interobserver reproducibility determined with an intraclass correlation coefficient for retrodiscal tissue T2 relaxation time data obtained from normal volunteers and patients by the 2 observers was 0.818 (*P* < .001).

The TMJ MRI findings in normal volunteers and patients are summarized in Table I. The mean retrodiscal tissue T2 relaxation times are shown in Table II. In normal volunteers, there were no significant differences in retrodiscal tissue T2 relaxation times between the left and right TMJs (34.4 ± 3.5 and 34.4 ± 3.0 ms; *P* = .888). There were significant differences in mean retrodiscal tissue T2 relaxation times between the normal volunteers and patients with TMD (34.4 ± 3.2 and 39.3 ± 6.4 ms; respectively, *P* < .001).

With regard to AD position and reduction, mean retrodiscal tissue T2 relaxation times of the NorSup,

Table I. Characteristics and magnetic resonance findings of volunteers and patients

	Volunteers	Patients
Number of cases	17	173
Male	12	46
Female	5	127
Age		
Range	23–32	11–80
Median	26	35
Anterior disc position and reduction (joints)		
NorSup	34	141
PADDWR	0	22
PADDWOR	0	4
ADDWR	0	53
ADDWOR	0	126
Anterior disc configuration (joints)		
Biconcave	32	179
Biplanar	2	21
Hemiconvex	0	43
Thickening of the posterior band	0	39
Biconvex	0	7
Folded	0	57
Joint effusion (joints)		
None or minimal fluid	34	209
Moderate fluid	0	90
Marked fluid	0	30
Extensive fluid	0	17
Osteoarthritis (joints)		
Negative	34	288
Positive	0	58
Bone marrow abnormality (joints)		
Negative	34	317
Positive	0	29

ADDWR, anterior disc displacement with reduction; ADDWOR, anterior disc displacement without reduction; NorSup, normal superior; PADDWR, partial anterior disc displacement with reduction; PADDWOR, partial anterior disc displacement without reduction.

PADDWR, PADDWOR, ADDWR, and ADDWOR patient groups were 37.7 ± 5.9, 39.5 ± 5.2, 41.1 ± 5.9, 36.6 ± 4.7, and 42.1 ± 6.8 ms, respectively. The mean retrodiscal tissue T2 relaxation times of the NorSup, PADDWR, and ADDWOR patient groups were significantly longer than that of the volunteer group (*P* < .01/6 for volunteer group vs PADDWR or ADDWOR patient group; *P* < .05/6 for volunteer group vs NorSup patient group). Moreover, the mean retrodiscal tissue

Table II. T2 relaxation time of the retrodiscal tissue

	T2 relaxation time (ms)	<i>P</i>
Volunteers		
Left TMJ	34.4 ± 3.5	
Right TMJ	34.4 ± 3.0	.888
All TMJs	34.4 ± 3.2	
Volunteers: All TMJs	34.4 ± 3.2	
Patients: All TMJs	39.3 ± 6.4	<.001*

*The T2 relaxation times of all TMJs in patients were significantly different from those of all TMJs in volunteers. TMJ, temporomandibular joint.

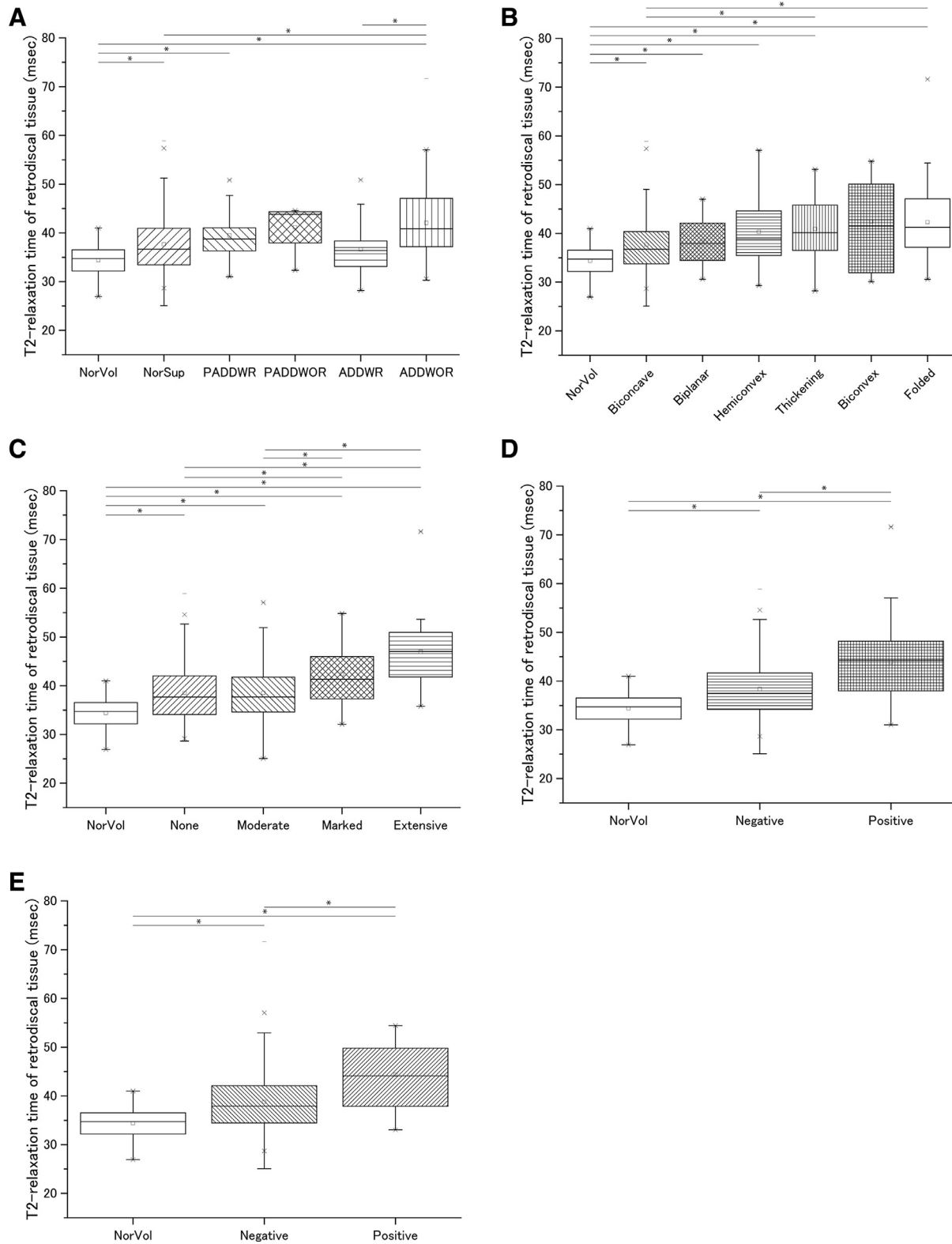


Fig. 3. Box-and-whisker plots of the distribution of retrodiscal tissue T2 relaxation times (A–E). Outlier data points are also shown. (A) T2 relaxation times of the retrodiscal tissue according to the anterior disc (AD) position and reduction categories ($*P < .05/6$; Mann-Whitney U test with Bonferroni correction). (B) T2 relaxation times of retrodiscal tissue according to AD configuration categories ($*P < .05/7$; Mann-Whitney U test with Bonferroni correction). (C) T2 relaxation times of retrodiscal tissue according to joint effusion categories ($*P < .05/5$; Mann-Whitney U test with Bonferroni correction). (D) T2 relaxation times of

T2 relaxation time of the ADDWOR group was significantly longer than those of the NorSup and ADDWR patient groups ($P < .01/6$; Figure 3A).

With regard to AD configurations, mean retrodiscal tissue T2 relaxation times of the biconcave, biplanar, hemiconvex, thickening of the posterior band, biconvex, and folded groups were 37.7 ± 5.8 , 38.2 ± 5.1 , 40.3 ± 6.4 , 40.9 ± 6.2 , 42.4 ± 9.2 , and 42.3 ± 7.3 ms, respectively. The mean retrodiscal tissue T2 relaxation times of the biconcave, biplanar, hemiconvex, thickening of the posterior band, and folded groups were significantly longer than that of the volunteer group ($P < .05/7$; Figure 3B). The mean retrodiscal tissue T2 relaxation times of the thickening of the posterior band and folded groups were significantly longer than that of the biconcave group ($P < .01/7$; see Figure 3B).

With regard to joint effusion, mean retrodiscal tissue T2 relaxation times of the “none observed or minimal fluid,” “moderate fluid,” “marked fluid,” and “extensive fluid” patient groups were 38.5 ± 6.0 , 38.5 ± 5.9 , 42.4 ± 5.9 , and 47.0 ± 8.7 ms, respectively. The mean retrodiscal tissue T2 relaxation times of all joint effusion category groups were significantly longer than that of the volunteer group ($P < .01/5$; Figure 3C). The mean retrodiscal tissue T2 relaxation times of the marked and extensive fluid patient groups were significantly longer than those of the “none observed or minimal fluid” patient group and the “moderate fluid” group ($P < .01/5$; see Figure 3C).

With regard to osteoarthritis, the mean retrodiscal tissue T2 relaxation times of patients with negative and positive findings were 38.3 ± 5.9 and 43.9 ± 7.2 ms, respectively. The mean retrodiscal tissue T2 relaxation time of the osteoarthritis-positive patient group was significantly longer than those of the volunteer and osteoarthritis-negative patient groups ($P < .01/3$; Figure 3D). The mean retrodiscal tissue T2 relaxation time of the osteoarthritis-negative patient group was significantly longer than that of the normal healthy volunteer group ($P < .01/3$; see Figure 3D).

With regard to bone marrow abnormalities, the mean retrodiscal tissue T2 relaxation times of patients with negative and positive findings were 38.8 ± 6.3 and 44.4 ± 6.4 ms, respectively. The mean retrodiscal tissue T2 relaxation time of the bone marrow abnormality-positive patient group was significantly longer than those of volunteer and bone marrow abnormality-negative patient groups ($P < .01/3$; Figure 3E). The

mean retrodiscal tissue T2 relaxation time of the bone marrow abnormality-negative patient group was significantly longer than that of the normal healthy volunteer group ($P < .01/3$; see Figure 3E).

The stepwise multiple regression analyses showed that AD configuration ($P = .033$), joint effusion ($P < .001$), and osteoarthritis ($P = .001$) were the most important variables affecting retrodiscal tissue T2 relaxation times (Table III). The multiple correlation coefficient (R), the coefficient of determination (R^2 , which depicts the explanatory power of the model), and the adjusted coefficient of determination (adjusted R^2 , i.e., a version of R^2 adjusted for the number of predictors in a model) of the stepwise multiple regression analyses with regard to retrodiscal tissue T2 relaxation times of were 0.626, 0.392, and 0.384, respectively ($P < .001$).

DISCUSSION

The measurement of T2 relaxation times is widely used as a quantitative MRI technique.¹² T2 relaxation times reflect structural changes in the organization of cartilage collagen fibers. The interaction between water and collagen fibers is used to visualize collagen organization, extracellular matrix structure, and water content.²⁰ A change in the T2 relaxation time is an early sign of structural change in tissues. Differences in the TMJ AD T2 relaxation times of volunteers and patients with TMD were previously reported to reflect TMD structural and functional properties and correlate with TMD progression.^{9,10,12,13}

The retrodiscal tissue extends from the posterior margin of the posterior band to the retroarticular process.²¹ This tissue mainly consists of loose connective tissue, such as elastin and collagen fibers, and includes a large venous plexus in its deeper layers.²² Although the AD and its attachments contain the same major histologic constituents, the relative amounts of these components vary, depending on the functional requirements of the tissue.²³ Therefore, quantitative measurements of retrodiscal tissue T2 relaxation times is possible, and pathologic changes can be detected at early stages.

Histologic studies have shown that TMDs often display increased retrodiscal tissue vascularization.²⁴⁻²⁷ Kurita et al.²⁶ showed that the number of blood vessels in retrodiscal tissue increased significantly in patients with TMDs. Holmlund et al.²⁷ reported findings associated with inflammation, such as hyperemia and perivascular infiltration, in the retrodiscal tissue of patients

retrodiscal tissue according to osteoarthritis categories ($*P < .05/3$; Mann-Whitney U test with Bonferroni correction). (E) T2 relaxation times of retrodiscal tissue according to bone marrow abnormality categories ($*P < .05/3$; Mann-Whitney U test with Bonferroni correction). ADDWOR, anterior disc displacement without reduction; ADDWR, anterior disc displacement with reduction; Extensive, extensive fluid; Marked, marked fluid; Moderate, moderate fluid; None, none observed or minimal fluid; NorSup, normal superior patients; NorVol, normal volunteers; PADDWOR, partial anterior disc displacement without reduction; PADDWR, partial anterior disc displacement with reduction; Thickening, thickening of the posterior band.

Table III. Stepwise multiple regression model for T2 relaxation time of the retrodiscal tissue

Variable	Unstandardized coefficient (β)	Unstandardized coefficient (SE)	Standardized coefficient (β)	t	P	95% confidence interval	
Articular disc configuration	1.408	0.658	0.098	2.139	.033	0.114	2.702
Joint effusion	2.137	0.559	0.161	3.823	<.001	1.038	3.236
Osteoarthritis	2.646	0.808	0.150	3.274	.001	1.057	4.235

with TMDs. These histologic findings may be associated with increased retrodiscal tissue T2 relaxation times. Conversely, Isberg et al.²⁵ observed nerve fibers and thickened adventitia of the vessels in retrodiscal tissue in a small subset of patients with ADDWOR. Hall et al.²⁴ reported that patients with TMD who experienced pain did not exhibit inflammation; however, thickened arterial walls were confirmed in 54% of patients. These histologic findings seem to suggest decreased retrodiscal tissue T2 relaxation times. Therefore, histologic differences in retrodiscal tissue may be dependent on the exact stage of the disease.

Clinical MRI studies have reported decreased and increased retrodiscal tissue T2 signal intensities in patients with TMDs.^{3,4,7,8,21} Westesson et al.³ investigated the posterior attachment of the area near the AD and found that the decreased signal intensity in this area on T2 WIs and PDWIs was linked to fibrosis. However, Sakuma et al.²¹ reported that decreased signal intensity on T1-weighted images of retrodiscal tissue did not reflect a dense construction of collagen fibers. Sano et al.⁷ reported that T2 WI signal intensity (which is not equivalent to the T2 relaxation time) in the retrodiscal tissue of patients with TMDs reporting pain was significantly higher than that in patients without pain. Katzberg et al.⁴ reported that T2 WI signal intensity in the posterior attachment was typically higher in the patient group than in the healthy volunteer group. Both studies indicated that these findings might be related to retrodiscal tissue vascularity or the presence of edema. Chiba et al.²⁸ also suggested an association between increased T2 WI signal intensity of the retrodiscal tissue and pain and reported that observations of ADDWOR and osteoarthritis correlated with pain. Lee et al.⁸ reported that the signal intensity ratio of the retrodiscal tissue may be associated with disc displacement, joint effusion, condylar degenerative change, and joint pain. In dynamic contrast-enhanced MRI studies, an increase in retrodiscal tissue contrast was confirmed in joints that elicited pain.^{5,29} These findings suggest that if contrast accurately reflects increased blood flow, then blood flow to the retrodiscal tissue of the painful joint should increase.

The results of our study indicate that the T2 relaxation time can be a valuable predictor of TMD progression. These findings are consistent with qualitative reports associating pain with increased signal intensity in diagnostic MRI findings and T2 WIs. Consequently,

the retrodiscal tissue T2 relaxation time likely correlates well with perceived TMJ pain⁷ and may serve as an early diagnostic marker for TMD.

In a previous study, TMJ AD T2 relaxation times were significantly different with respect to disc position, joint effusion, osteoarthritis, and bone marrow abnormality.¹³ However, there were no significant differences in AD configuration. In the present study, retrodiscal tissue T2 relaxation times were significantly different for all morphologic categories, including AD configuration. This suggests that the retrodiscal tissue T2 relaxation time may be more sensitive than the AD T2 relaxation time.

This study has some limitations. First, no histologic comparison was made between the T2 relaxation time and retrodiscal tissue. According to a recent treatment plan for patients with TMDs, pharmacotherapy, splinting, and physiotherapy are the primary treatment options, and no patients included in the present study had undergone surgery. Therefore, comparison of MRI findings and tissue samples was impossible. Second, subjective clinical findings, such as patient-reported pain and discomfort, were not evaluated and compared with the retrodiscal tissue T2 relaxation time. Therefore, future studies comparing clinical findings are necessary. Third, it is possible that the signal of the retrodiscal tissue was influenced by a partial volume effect (i.e., influenced by the surrounding tissue); however, this is difficult to prove. Finally, the number of patients (n = 173) was significantly higher than that of healthy volunteers (n = 17). Future studies of T2 relaxation times associated with TMDs would benefit from a more balanced ratio of patients and healthy volunteers.

CONCLUSIONS

The retrodiscal tissue T2 relaxation times of patients with TMDs were significantly longer than those of healthy volunteers. The most important variables affecting retrodiscal tissue T2 relaxation times were AD configuration, joint effusion, and osteoarthritis. Thus, the TMJ retrodiscal tissue T2 relaxation time likely correlates with TMD progression and may be used to predict the course of TMDs.

ACKNOWLEDGMENTS

We wish to pay our respects to the late Professor Souhei Furukawa for his invaluable guidance for this study.

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Reprint requests:

Naoya Kakimoto,
 Department of Oral and Maxillofacial Radiology,
 Graduate School of Biomedical and Health Science,
 Hiroshima University,
 1-2-3 Kasumi,
 Minami-Ku,
 Hiroshima 7348553,
 Japan.
 kakimoto-n@hiroshima-u.ac.jp