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Original Article

Investigation of incidental findings of temporomandibular joint disorders on brain magnetic resonance imaging in three-dimensional T2-weighted SPACE sequence performed for brain imaging

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ABSTRACT

Objectives: The study aimed to determine the temporomandibular joint (TMJ) findings, to investigate the prevalence contribution of this sequence on cases in which cranial magnetic resonance examination was performed and three-dimensional (3D) T2-SPACE (T2-weighted sampling perfection with application-optimized contrasts using different flip-angle evolutions) sequence was used by retrospectively scanning the magnetic resonance imaging (MRI) archive of our hospital, and to reveal the advantages of the 3D-T2 SPACE sequence in patients with TMJ disorders.

Patients and methods: The cross-sectional retrospective study was conducted with 499 patients (289 females, 210 males; mean age: 50.1±17.7 years; range, 8 to 92 years) who underwent brain MRI and had 3D-T2 SPACE between March 1, 2021 and March 1, 2022. Two radiologists analyzed the TMJs of the subjects included in the study in 3D-T2 SPACE sequences.

Results: At least one incidental finding was detected in the TMJ in 37.1% (n=185) of the patients included in our study. In our study, the most common (13.6%) MRI findings were osteoarthritic changes and synovial cysts. Joint effusion (13.2%) and disc displacement (9%) were less frequent. When the relationship between the age of the patients and the presence of incidental findings, degeneration, effusion, disc displacement, and cyst was examined, the age of the patients with incidental findings ($p=0.001$) and osteoarthritic changes ($p<0.001$) was statistically significantly higher.

Conclusion: Incidental findings, particularly osteoarthritic changes and synovial cysts, can be seen quite commonly in the TMJ in brain MRI using 3D T2-SPACE sequences in the general population. The 3D T2-SPACE sequence provides valuable information in the recognition of TMJ disorders.

Keywords: 3D T2-SPACE, incidental findings, temporomandibular joint.

The temporomandibular joint (TMJ) is located between the mandible and temporal bone, just in front of the external auditory canal. The TMJ, which has a crucial role in chewing and speaking, is one of the most complex joints in our body, consisting of the articular disc, ligaments, and synovial membrane and its fluid.[1] Due to the complex anatomy and localization of the joint, TMJ disorders (TMDs) are common, and various imaging techniques are needed to help with diagnosis and treatment planning.[2] Magnetic resonance imaging (MRI) is considered the gold standard for diagnosing TMDs.[2,3] It provides a detailed evaluation of the soft tissue and bone marrow.[2] Adequate information about the bilaminar zone, fibrocartilaginous joint surfaces, and the fibrocartilaginous disc cannot be obtained with different imaging methods.[2] Magnetic resonance imaging is a technique that is constantly renewed and changing with the developing technology. The developing MRI technologies will help in early diagnosis and treatment planning, therapeutic

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efficacy evaluation, and even image-guided interventional procedures.[4] Three-dimensional (3D) T2-SPACE (T2-weighted sampling perfection with application-optimized contrasts using different flip-angle evolutions) is an emerging sequence that is slowly entering routine use. In recent years, this sequence has been studied in the literature.[5,6] This sequence has many advantages, such as being less affected by artifacts, obtaining slices in submillimetric voxel sizes, obtaining 3D and high-resolution images with reformat images, and having low SAR (specific absorption rate) values.[5,6] Three-dimensional volumetric MRI sequences with excellent spatial and contrast resolution have been used by physicians in clinical practice to image joints with complex anatomy, such as the knee, ankle, shoulder, and wrist.[7] These recent advances in image quality have led to an increase in unexpected findings, often referred to as incidental findings (IFs), that are not directly relevant to the study.[8] There are studies in the literature examining the prevalence of IFs in adult populations with brain MRI.[9] While the percentage of clinically significant findings is low (0.3-3.4%), IFs are surprisingly common (5-20%).[10] However, evaluation with TMJ was not performed in these studies. Rather, these are studies that evaluate pathologies such as space-occupying lesions, structural vascular anomalies, and cysts.[9] There is only one study in the literature evaluating the prevalence and clinical relevance of incidental TMJ findings using brain MRI scans.[11] However, only standard brain MRI sequences were used in this study.

The aim of this study was to determine the TMJ findings, to investigate prevalence estimates of this sequence on cases in which cranial MR examination was performed and 3D T2-SPACE sequence was used by retrospectively scanning the MRI archive of our hospital, and to reveal the advantages of the 3D T2-SPACE sequence in patients with TMDs.

PATIENTS AND METHODS

Patients who underwent brain MRI and had 3D T2-SPACE sequences in the Department of Radiology, Duzce University Hospital between March 1, 2021 and March 1, 2022, were included in this cross-sectional retrospective study. In addition, the clinical and sociodemographic information of the cases included in the study and the reasons for the examination request were obtained from the automation system of our hospital. Patients with a known active rheumatic disease, fracture involving the facial region, and any history of surgery related to the TMJ were excluded from the study. For this purpose, 499 patients (289 females, 210 males; mean age: 50.0±17.7 years; range, 8 to 92 years) were included in our study.

MRI technique

The patients included in the study were cases with cranial symptoms and were sent for routine brain MRIs. All patients' MRIs had axial turbo spin echo (TSE) T1, axial TSE T2, coronal TSE T2, axial T2 FLAIR (fluid-attenuated inversion recovery), and DWI (diffusion-weighted imaging) sequences. Since we had included the sagittal 3D T2-SPACE sequence in brain MRI examinations since January 2020, all patients also had the sagittal 3D T2-SPACE sequence in this study. Sequence parameters for 3D T2-SPACE were TR/TE=3200/400 msec, flip angle=variable, slice thickness=1 mm, and FOV=256×256 mm.

Image evaluation

Two radiologists with at least 15 and five years of experience in the field, blind to the patients' clinical information and identity, analyzed the TMJs of the subjects included in the study in 3D T2-SPACE sequences. Diagnoses were based purely on radiographic appearance using conventional MRI interpretation procedures. The first radiologist analyzed the whole brain MRI cases within four weeks. Then the second radiologist made a detailed analysis of 185 cases. As a result, the data of the second radiologist were collected for use in the study. The collected data were analyzed under the following headings: *(i)* joint effusion, *(ii)* osteoarthritic changes, *(iii)* synovial cysts, and *(iv)* disc displacement with or without degeneration.

Statistical analysis

Power analysis was made using the G*Power version 3.1.9.4 software (Heinrich-Heine-Universität, Düsseldorf, Düsseldorf, Germany) and in accordance with a similar study.[11] The sample size was calculated as 499 participants, with a type 1 error of 0.05 and 90% power.

Statistical analysis was performed with the IBM SPSS version 20.0 software (IBM Corp., Armonk, NY, USA). While making the descriptive statistics of the study, numerical variables were given as mean ± standard deviation (SD), and categorical variables were given as numbers and percentages. The distribution of numerical variables was analyzed with histogram graphics. Student's t-test and one-way analysis of variance were used while evaluating numerical variables. The Pearson chi-square test was used in the analysis of categorical variables. Pearson correlation

analysis was used for correlation. The statistical significance level was accepted as $p<0.05$.

RESULTS

At least one IF was detected in the TMJ in 37.1% (n=185) of the patients included in our study. An IF was not found in 62.9% of them. Incidental findings were detected at a rate of 45.13% in people aged 65 and over and 34.72% in people under 65 years of age. When the status of having IF was analyzed according to the sex of patients, it was statistically significantly higher in females ($p<0.001$).

In our study, the most common (13.6%) MRI findings were osteoarthritic changes and synovial cysts (Figure 1). Joint effusion (13.2%) and disc displacement (9%) were less frequent (Figure 2). Osteoarthritic changes were seen in 30.97% of people aged 65 and over and 8.55% of people under 65 years of age. Joint effusion was detected in 13.27% of people aged 65 and over and 13.21% of people under 65 years of age.

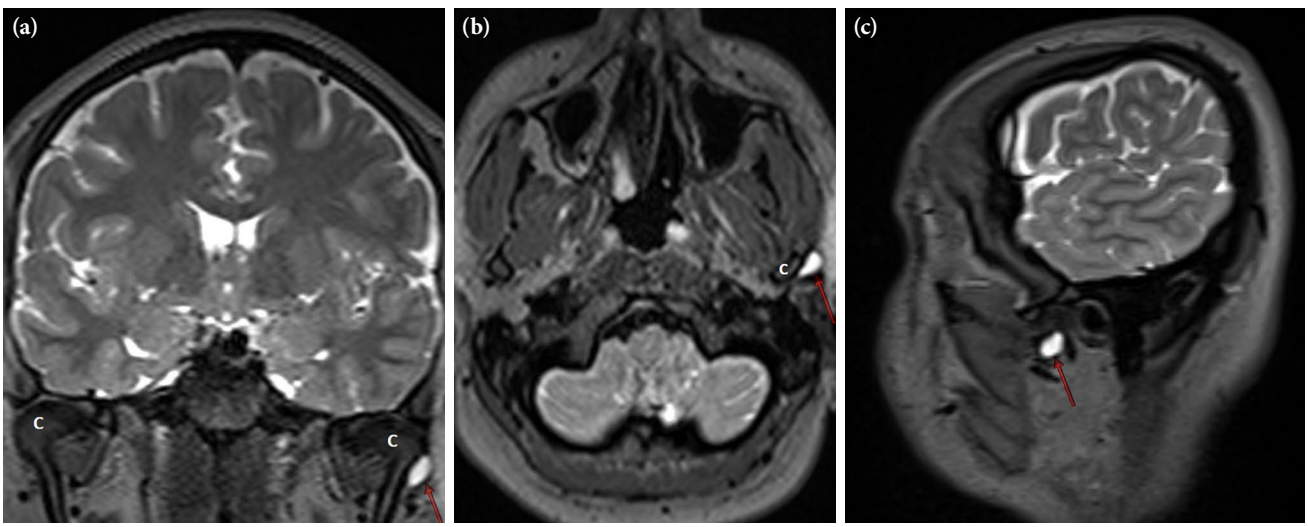

Figure 1. Coronal **(a)**, axial **(b)**, and sagittal **(c)** reformat T2-weighted SPACE MRI scans reveal a synovial cyst (red arrows) originating from the left TMJ.

T2-SPACE: T2-weighted sampling perfection with application-optimized contrasts using different flip-angle evolutions; MRI: Magnetic resonance imaging; TMJ: Temporomandibular joint; C: Mandibular condyle.

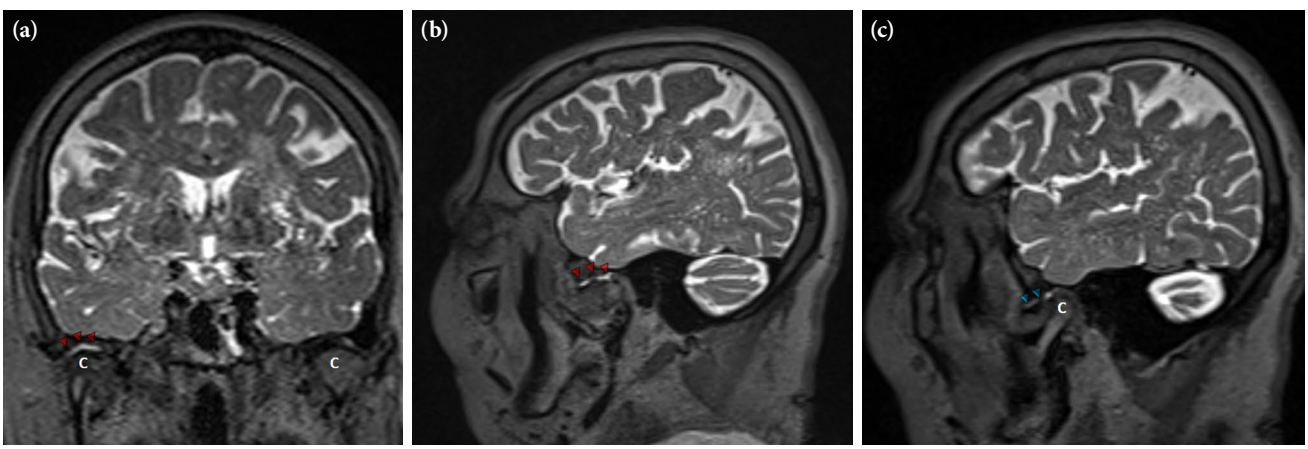

Figure 2. **(a)** Coronal and **(b and c)** consecutive sagittal T2-weighted SPACE MRIs show effusion (red arrow heads) of the right TMJ. The last frame sagittal MRI image **(c)** also demonstrates anterior disc displacement (blue arrow heads).

T2-SPACE: T2-weighted sampling perfection with application-optimized contrasts using different flip-angle evolutions; MRI: Magnetic resonance imaging; TMJ: Temporomandibular joint; C: Mandibular condyle.

TABLE 1
Anatomical distribution of MRI findings

	Bilateral		Unilateral			
			Right		Left	
	n	%	n	%	n	%
Joint effusion	17	25.76	24	36.36	25	37.88
Osteoarthritic changes	43	63.24	12	17.65	13	19.12
Synovial cysts	3	4.41	32	47.06	33	48.53
Disc displacement	14	31.11	17	37.78	14	31.11

Synovial cysts were seen in 12.39% of people aged 65 and over and 13.99% of people under 65 years of age. Disc displacement was found in 6.19% of people aged 65 and over and 9.84% of people under 65 years of age.

In our study, we found bilateral synovial cysts in three cases. Of these patients, two were female and one was male, and their ages were 16, 41, and 51, respectively. When IFs were examined according to their anatomical localization, osteoarthritic changes were mostly observed bilaterally. Joint effusion, synovial cysts, and disc displacement tended to be more unilateral (Table 1).

The mean value of the diameters of the cysts was 0.65±1.46 mm on the right and 0.75±1.75 mm on the left. The relationship between cyst diameter and the age of the patients was evaluated with Pearson correlation analysis, and no significant correlation was found ($r=-0.233$, $p=0.056$).

When the relationship between the age of the patients and the presence of IFs, degeneration, effusion, disc displacement, and cysts was examined, the age of the patients with IFs ($p=0.001$) and osteoarthritic changes ($p<0.001$) was statistically significantly higher. There was no statistically significant difference between age and joint effusion, synovial cysts, and disc displacement ($p=0.632$, $p=0.537$, and $p=0.703$, respectively; Table 2).

The relationship between the sex of the patients and the osteoarthritic changes, joint effusion, disc displacement, and the presence of cysts in the TMJ were examined. IFs ($p<0.001$), osteoarthritic changes ($p=0.023$), joint effusion ($p<0.001$), and disc displacement ($p=0.012$) was statistically significantly higher in females than in males. There was no statistically significant relationship between the sex of the patients and synovial cysts ($p=0.138$, Table 3).

When the patients were divided into two groups according to their sex and age, and their relationship with IFs, osteoarthritic changes, joint effusion, synovial cysts, and disc displacement was examined, there was a statistically significant relationship only with osteoarthritic changes ($p<0.001$, Table 3).

When the relationship between age and anatomical localization of degeneration, effusion, disc displacement, and cyst presence was evaluated, there was no statistically significant difference ($p=0.209$, $p=0.147$, $p=0.234$, and $p=0.372$, respectively; Table 4).

There was an additional cranial pathology in 82.2% of the patients with IFs, and no additional cranial pathology was found in 17.8%. Headache

TABLE 2
Relationship between age and incidental findings, degeneration, effusion, disc displacement, and presence of a cyst

		Age (year)	
	n	Mean±SD	*p**
Incidental findings			
Present	185	53.37±17.02	0.001
Absent	314	48.13±17.84	
Osteoarthritic changes			
Present	68	63.62±14.45	<0.001
Absent	431	47.94±17.23	
Joint effusion			
Present	66	51.05±16.42	0.632
Absent	433	49.92±17.91	
Synovial cysts			
Present	68	48.84±16.31	0.537
Absent	431	50.27±17.92	
Disc displacement			
Present	45	49.11±15.26	0.703
Absent	454	50.17±17.94	

SD: Standard deviation; *Student t-test.

TABLE 3
The relationship between IFs, osteoarthritic changes, joint effusion, synovial cysts, and disc displacement in the TMJ by sex and age groups

	Age (year)							Sex				
			<65		>65			Males		Females		
Findings	n	%	n	%	n	%	*p**	n	%	n	%	*p**
IFs	185	37.1	134	34.72	51	45.13	0.044	57	11.4	128	25.6	**<0.001**
Osteoarthritic changes	68	13.6	33	8.55	35	30.97	**<0.001**	20	4	48	9.6	**0.023**
Joint effusion	66	13.2	51	13.21	15	13.27	0.986	14	2.8	52	10.4	**<0.001**
Synovial cysts	68	13.6	54	13.99	14	12.39	0.663	23	4.6	45	9	0.138
Disc displacement	45	9.0	38	9.84	7	6.19	0.234	11	2.2	34	6.8	**0.012**

IFs: Incidental findings; * Chi-square test.

TABLE 4
Relationship between age and anatomical localization of degeneration, effusion, disc displacement, and cysts

	Age			
	Bilateral	Right	Left	
	Mean±SD	Mean±SD	Mean±SD	*p**
Joint effusion	56.65±18.44	46.50±19.06	51.60±10.61	0.147
Osteoarthritic changes	65.91±14.14	61.08±15.22	58.38±14.16	0.209
Synovial cysts	36.00±18.03	49.94±17.39	48.94±15.07	0.372
Disc displacement	48.79±15.17	45.00±17.22	54.43±11.87	0.234

SD: Standard deviation; * One-Way Anova test

was the most common reason for requesting tests in patients with IFs, with a rate of 44.3%. Subsequently, examination requests were made for the following reasons: intracranial mass or metastasis (12.4%), vertigo 9.7%, cerebrovascular disease (8.1%), neck and arm pain (5.4%), loss of balance and weakness 4.3%, demyelinating disease (3.2%), numbness in the face and tongue (2.7%), forgetfulness (2.7%), ringing in the ear (1.6%), loss of balance and weakness (1.6%), facial paralysis (1.6%), operated cranial lesion (1.1%), and confusion (1.1%).

DISCUSSION

Temporomandibular joint disorders are an important public health problem affecting approximately 5-12% of the general population and negatively affecting the quality of life of patients.[12] Studies show that the prevalence of TMDs in the population is approximately 10-15% for adults and 4-7% for adolescents.[13-15] According to a meta-analysis, the overall prevalence of TMDs was reported to be approximately 31% for adults and the elderly and approximately 11% for children and adolescents.[12] In this study, at least one IF was detected in any TMJ at a rate of 45.13% in patients aged 65 and over and 34.72% in patients under 65 years of age. The reason for our higher rate compared to the literature may be related to the examination method we used.

With the developments in imaging modalities, IFs can be observed widely by radiologists. Incidental findings pose a diagnostic dilemma for radiologists. They usually partially enter the view area, or when fully visualized, special identifying sequences are often not available.[16] In a retrospective study examining IFs in the maxillofacial region using 3D cone-beam computed tomography, at least one finding was found in 15.4% of TMJs.[17] In this study, we detected IFs in approximately one of three patients.

In the study by Simonovich et al.,[11] which examined the prevalence of incidental TMJ findings using brain MRI scans in the literature, the most common finding was disc displacement, followed by flattening of the condyle. In our study, the most common MRI findings were osteoarthritic changes and synovial cysts. Joint

effusion and disc displacement were less frequently observed. The higher incidence of joint effusion and synovial cysts in our study can be explained by the thin section of the 3D T2-SPACE sequence we used and the fact that it is a fluid-sensitive sequence. According to the literature, the prevalence of disc displacement in at least one TMJ on MRI performed in asymptomatic participants has been reported to be approximately 21-33%.[18-20] The number of studies investigating the joint effusion rate in asymptomatic participants is limited; however, in a study, they found moderate TMJ fluid in about one out of five.[20] In our study, the joint effusion rate was 13.2% and the disc displacement was 9% in any TMJ. The prevalence of osteoarthritis in TMJ has been reported in 8-16% of the general population, which is similar to generalized osteoarthritis.[21] Little is known about the prevalence of TMJ osteoarthritis due to the complex anatomy of the TMJ and its proximity to other functional structures.[22] In this study, we found 13.6% of osteoarthritic changes, consistent with the prevalence of generalized osteoarthritis.

Degenerative joint disease can occur at any age, but it is more common in older age groups due to the effect of cumulative exposure to various risk factors and biological changes that occur with aging.[17,22] In our study, osteoarthritic changes were significantly more common in individuals aged 65 and over, consistent with the literature.

Common symptoms of TMDs include jaw pain, impaired jaw joint movement, headache, neck pain, and stiffness.[23,24] Temporomandibular joint disorders can cause referred pain, particularly undifferentiated headaches.[24] Some studies have shown that up to 55% of patients with chronic headaches referred to a neurologist have significant signs and symptoms of TMDs.[25] In our study, the most common reason for requesting examination in patients with IFs was headaches, with a rate of 44.3%. We did not retrospectively question the complaints of our patients, but Simonovich et al.[11] found that about half of their patients had headache complaints when they retrospectively questioned the complaints of the patients. Therefore, TMDs should also come to mind in complex cases.

While synovial cysts are mostly seen in joints, such as knees, hands, and ankles, they rarely affect the TMJ. Synovial cysts are different from ganglion cysts because they contain synovial fluid and are associated with the joint.[26] In a study by Partridge et al.,[26] 14 patients treated for TMJ cysts were evaluated by immunohistochemical analysis. They found 69% of them had synovial cysts and 31% had ganglion cysts. They reported that synovial cysts are more common than ganglion cysts in the TMJ and that the frequency of synovial cysts in TMJ may be higher than the literature suggests. Our study also supports the hypothesis of Partridge et al.[26] In another study, 29 unilateral and two bilateral synovial cysts were reported in the TMJ joint.[27] In our study, we found unilateral synovial cysts in 32 (17.3%) cases on the right and 33 (17.8%) cases on the left, and bilateral synovial cysts were present in three (1.6%) cases.

Based on data from the literature, we can conclude that TMDs are more common in females than males.[15,19,28-30] In our study, IFs, osteoarthritic changes, joint effusion, and disc displacement were significantly more common in females than males.

Only a small percentage of individuals affected by TMJ are known to seek or need treatment.[12] Therefore, physicians should be aware that some TMJ findings that may affect the general population may be seen at relatively high rates.

There are some limitations to this study. First, it was a single-center study. Therefore, its validity should be confirmed by multicenter studies. Another limitation of our study is that it was not questioned whether the findings in TMJ caused any symptoms in the patients. In addition, due to the retrospective nature of the study, the fact that the group of patients who requested brain MRI for any purpose constituted the population of our study may affect the prevalence of IF.

In conclusion, IFs, particularly osteoarthritic changes and synovial cysts, can be seen quite commonly in the TMJ in brain MRI using 3D T2-SPACE sequence in the general population. Incidental findings were more common in females and advanced age. The 3D T2-SPACE sequence provides valuable information in the recognition of TMDs. We believe that the use of 3D volumetric MRI in TMDs will gradually increase with new studies.

Ethics Committee Approval: The study protocol was approved by the Duzce University Non-invasive Health Research Ethics Committee (date: 25.04.2022, no: 2022/47). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Concept or design: R.S., H.O.; Search of literature and interpretation of data: R.S; Acquisition of data: A.G.; Analysis or interpretation of data: A.K.; Critical revision for important intellectual content: S.A.

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