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Effectiveness of Temporomandibular Joint Disorder Follow-Up Using Bone Scans

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Purpose: To evaluate the effectiveness of temporomandibular joint (TMJ) disorder follow-up and determine the factors that affect the TMJ bone scan hot spot numerical value (bone scan value), and to compare this value to the diagnosis of patients with temporomandibular joint disorders (TMD), their treatment options, and the resolution of their symptoms.

Materials and Methods: A retrospective cohort study was performed on 24 patients (four males, 20 females) who received TMD treatment in the Section of Dentistry, Seoul National University Bundang Hospital (Seongnam, Korea) from 2007 to 2014. An analysis of the significance test and correlation between TMD diagnosis, treatment options, a baseline the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) questionnaire, treatment before and after the clinical examination and subjective progress, and TMJ bone scan value change were completed by using SPSS version 12.0.

Result: Although only 14 patients had bony factors that caused TMD, the average pre-treatment bone scan value of the all patients was 4.29±0.31, which is higher than the finding for osteoarthritis (3.88), and reduced post-treatment bone scan value was found to be without a statistically significant difference (P=0.056). After the treatments, clinical symptoms in 18 patients disappeared, and six patients did not require additional treatment, although they still displayed subjective symptoms. It was observed that the higher the pre-treatment bone scan value, nonspecific physical symptoms, chronic pain index, characteristic pain intensity, disability score, were, the lower the post-treatment bone scan value was. And this reduced post-treatment bone scan value tendency was not shown with the pre-treatment depression index, but there was not a statistical difference.

Conclusion: The post-treatment TMJ bone scan value tended to be insignificantly reduced in the 24 patients whose clinical symptoms were improved (P=0.056). Moreover, the TMJ bone scan value showed no relation to the TMD type or its related symptoms.

Key Words: Scintigraphy; Temporomandibular disorders; Temporomandibular joint

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Introduction

It is known that a variety of factors are involved in temporomandibular joint disorders (TMD), such as neuromuscular disaccord, temporomandibular joint (TMJ) generation incongruity, malocclusion, oral habits, trauma, malnutrition, hormonal disorders and disturbance of metabolism[1]. Therefore, TMD therapy requires an exact diagnosis through a useful diagnosis method and a multiple application of various treatment methods that can remove the major factor and other related factors. But even when the complained symptoms have been improved after treatments, the subjective discomfort of patients could continue in many cases, with a tendency to recur depending on the psychological state of the patient. Therefore, there is a necessity for a more definitive diagnosis method for TMD and its re-evaluations.

Various imaging techniques such as plain radiographs, computed tomography (CT), magnetic resonance imaging, bone scan, and single-photon emission CT are used to diagnose TMD[2].

However, plain radiographs such as panoramic and transcranial radiographs have limitations in diagnosing TMD since they cannot evaluate the center of condylar heads until the composition of bone mineral in the area changes by 30%~50%[3].

With the help of bone scans, diagnosis of osteoarthritis based on a clinical aspect and radiological opinion can become quicker and more exact. Bone scans are highly sensitive, enough to detect an increase of 10% in osteoblast activation, and thus are very useful in finding lesions in their early stages. But the specificity of a bone scan is relatively low[4]. According to research that has been published in our hospital, a patient can be diagnosed with osteoarthritis of TMJ if the bone scan value exceeds 3.88, with 72.2% sensitivity[5]. According to Shim et al.[6], the clinical sign and bone scan opinion were similar, and the panoramic radiograph also resembled the bone scan to some degree in most TMD patients. Therefore, the bone scan was suggested as a useful tool for the diagnosis, choice of a treatment method, and prognosis evaluation of TMD.

This research has been conducted to evaluate the effectiveness of bone scans for the diagnosis of TMD and its progress with the TMJ bone scan hot spot uptake value.

Materials and Methods

Among the patients who received TMD treatments from 2007 to 2014 in the Section of Dentistry, Seoul National University Bundang Hospital (Seongnam, Korea), 24 patients (four males and 20 females; mean±standard deviation, 26.2±10.47 years) with proper medical records who went through bone scan tests before and at the end of treatment received Seoul National University Bundang Hospital's institutional review board approval (B-1305-204-109) and corresponding the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) was ready.

The 24 patients were divided into three major types of TMD groups. Group I is a masticatory muscle disorder, and groups II and III are internal derangement and osteoarthritis, respectively[7]. Upon initial examination, five patients were categorized into group I (20.8%), 16 into group II (66.7%), and 12 into group III (50.0%) (Table 1, Fig. 1).

Clinical examination (opening volume, pain, joint sound, pain during palpation, etc.), medical examination by interview, the RDC/TMD, standard panoramic and TMJ panoramic radiographs, and bone scan value were used to diagnose the TMD[8].

Bone scan imaging was shot three hours after intravenous settling of $^{99}Tc^{m}$-hydroxymethylene diphosphonate (HDP) 1,295 MBq (35 mCi). The right and left sides of the skulls of each patient were shot with a low-dose, high-resolution gamma camera (double-head gamma camera, ADAC Forte; Philips Healthcare, Andover, MA, USA), and

500,000 counts were collected from the lateral side of the right and left areas of the cranium.

The TMJ bone scan value was analyzed by a skilled nuclear medical scientist through visual analysis, which was the comparison of the concentrated level of $^{99}Tc^{m}$ HDP of both sides of the TMJ and temporal bone based on a square shape (13 by 13 pixels). The TMJ bone scan hot spot numerical value was calculated through the following formula with the temporal bone scan value as an index of a normal TMJ (Fig. 2)[9].

TMJ bone scan hot spot numerical value (ratio)=(number of TMJ hot spots–number of temporal bone hot spots)/number of temporal bone hot spots

We evaluated the diagnosis of TMD, treatment method, TMD/RDC questionnaire (nonspecific physical symptoms [NPS, pain included], chronic pain index [CP], characteristic pain intensity [CPI], disability score [DS], and depression index [DI]), and the changes of the TMJ bone scan hot spot numerical value for each patient.

A paired t-test, one-way ANOVA, one-sample t-test, and Pearson correlation significance test (SPSS version 12.0; SPSS Inc., Chicago, IL, USA) were used for the statistical analysis of each factor.

Table 1. Number of patients by type of temporomandibular joint disorder

Group	Sex		Total
	Male	Female	
Group Ⅰ	1	0	1
Group Ⅱ	2	5	7
Group Ⅲ	0	6	6
Group Ⅰ+Ⅱ	1	2	3
Group Ⅰ+Ⅲ	0	1	1
Group Ⅱ+Ⅲ	0	6	6
Group Ⅰ+Ⅱ+Ⅲ	0	0	0

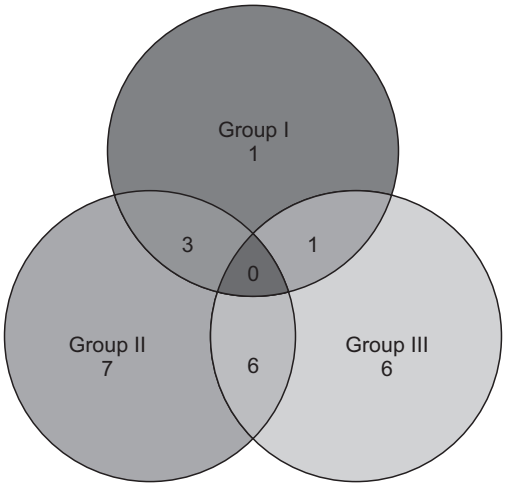

Fig. 1. Number of patients by type of temporomandibular joint disorder.

Result

Out of the 24 patients, 18 (three males and 15 females) did not show any more clinical symptoms. The other six patients (one male and five females) who showed subjective discomfort were only routinely followed since additional treatment was

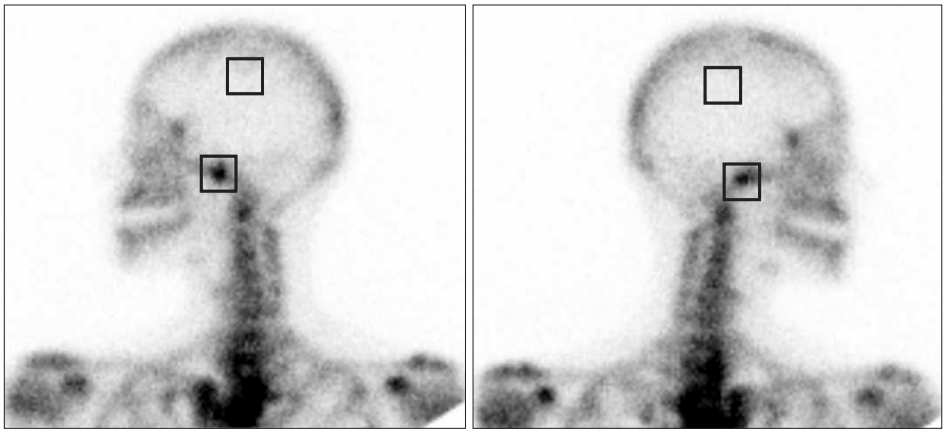

Fig. 2. Bone scan on both temporomandibular joints. The hot spot uptake value of the temporomandibular joint (both lower squares) is calculated by comparing it to the temporal bone (both upper squares).

Table 2. One-sample t-test for the pre-treatment bone scan average value

	One-sample statistics			One-sample test (test value=3.88)					
	Number	Mean	Standard deviation	t	df	Sig. (2-tailed)	Mean difference	95% CI of the difference	
								Lower	Upper
Pre-treatment bone scan average value	24	4.29813	0.622123	3.293	23	0.003	0.418125	0.15543	0.68082

df: degree of freedom, Sig. (2-tailed): significance level at 2 tailed, CI: confidence interval.

Table 3. Paired t-test for pre- and post-treatment bone scan value

	Correlations			Paired samples test						
				Paired differences				t	df	Sig. (2-tailed)
	Number	Correlation	Sig.	Mean	Standard deviation	95% CI of the difference				
						Lower	Upper			
Pair 1. Pre- and post-treatment bone scan value	24	0.729	0.000	0.068125	0.466250	–0.128755	0.265005	0.716	23	0.481

Sig. (2-tailed): significance level at 2 tailed, CI: confidence interval, df: degree of freedom.

Table 4. One-sample t-test for reducing post-treatment bone scan value

	One-sample statistics			One-sample t-test (test value=0)					
	Number	Mean	Standard deviation	t	df	Sig. (2-tailed)	Mean difference	95% CI of the difference	
								Lower	Upper
Bone scan change value	24	–0.29806	0.409789	–2.051	23	0.056	–0.798056	–0.40184	0.00573

df: degree of freedom, Sig. (2-tailed): significance level at 2 tailed, CI: confidence interval.

considered to be unnecessary.

In the results of comparing the pre- and post-treatment bone scan values for all patients, the pre-treatment bone scan average value was 4.29±0.31, which was significantly higher than 3.88, the condition that can be regarded as osteoarthritis[5] (P=0.003), and the post-treatment bone scan average value was 4.06±0.30, which was also higher than 3.88, but not a statistically significant result (P=0.481; Tables 2, 3). For some TMD patients, despite improvement in the subjective clinical symptoms, the TMJ bone scan hot spot value increased.

According to the comparison of pre- and post-treatment TMD/RDC Axis II questionnaire, the DI increased by 51.75%±0.50%, the NPS by 44.04%±0.61%, the CP by 65.40%±0.64%, the CPI by 28.01%±0.44%, and the DS by 44.42%±0.60%. The overall bone scan value was reduced by 0.30%±0.01%, but this decrease was statistically insignificant (P=0.056; Table 4). The bone scan value after treatment was shot at an average of 9.41±0.37

Table 5. Pearson correlation analysis of bone scan change value and interval of taking bone scan

		Interval of taking bone scan
Bone scan change value	Pearson correlation	0.020
	Sig. (2-tailed)	0.927
	Number	24

Sig. (2-tailed): significance level at 2 tailed.

Table 6. Pearson correlation analysis of post-treatment bone scan change value and questionnaire of the Research Diagnostic Criteria for Temporomandibular Disorders

		Depression index	Nonspecific physical symptoms	Graded pain score	Characteristic pain intensity	Disability score
Bone scan change value	Pearson correlation	0.118	–0.105	–0.178	–0.297	–0.146
	Sig. (2-tailed)	0.581	0.626	0.406	0.159	0.496
	Number	24	24	24	24	24

Sig. (2-tailed): significance level at 2 tailed.

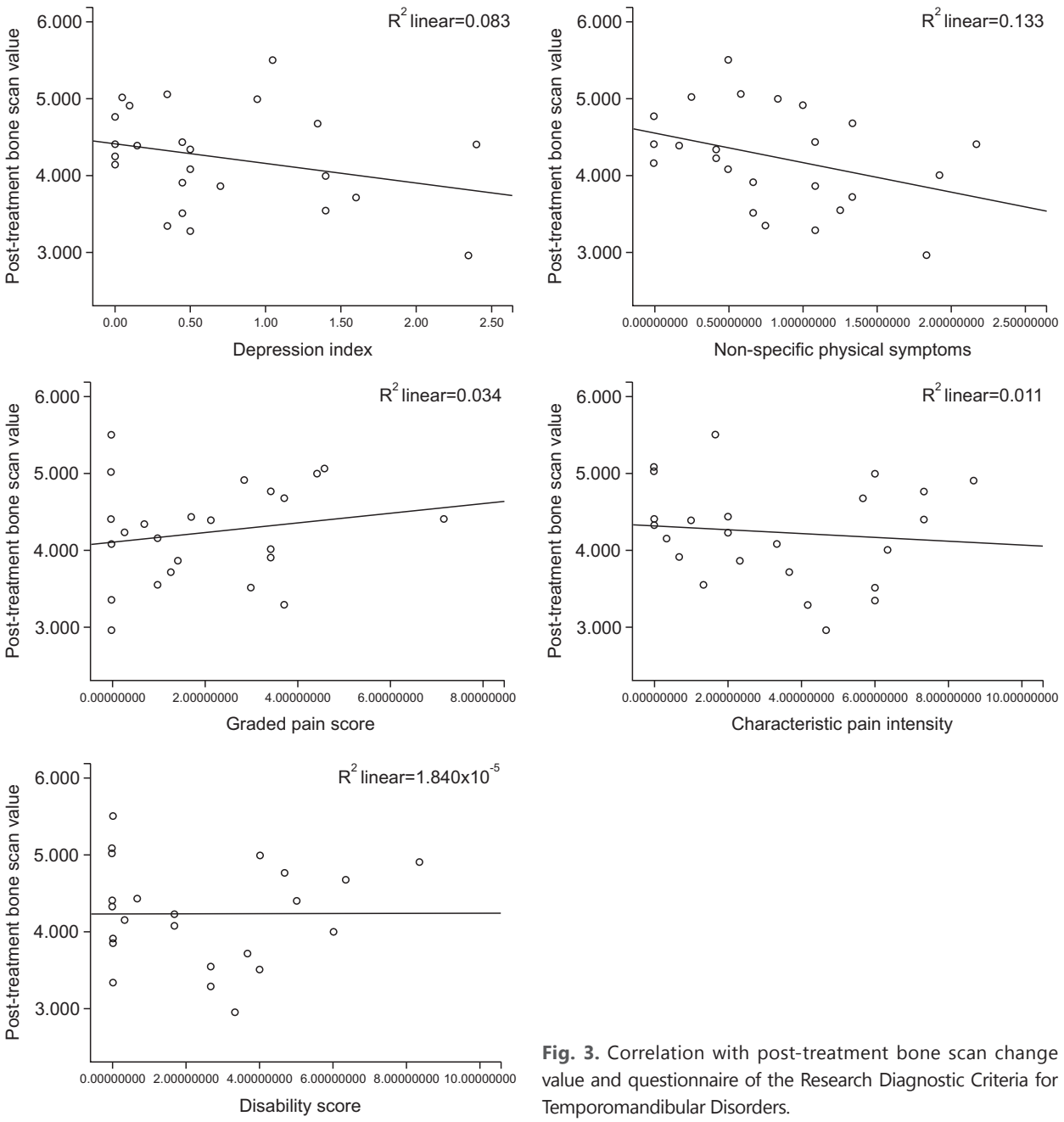

Fig. 3. Correlation with post-treatment bone scan change value and questionnaire of the Research Diagnostic Criteria for Temporomandibular Disorders.

months after the initial treatment. However, the changes in the bone scan had no correlation with the interval of time for taking the bone scan after treatment (P=0.927; Table 5).

The change in the bone scan values showed a negative correlation with pre-treatment NPS, CP, CPI, and DS. In other words, the higher the above four indexes were, the less the post-treatment bone scan value was. Meanwhile, it showed a positive correlation with the DI. The DI was higher before treatment, and the bone scan value after treatment was not reduced, but there was no significance (Table 6, Fig. 3). Also, the higher initial bone scan value showed a more reduced TMJ bone scan value after treatment without a statistically significant difference (Table 7, Fig. 4).

However, there were no significant differences observed in the changes of the TMJ bone scan value with TMD type, complained symptoms, treatment method, treatment time, NPS, CP, CPI, DS, and DI of each patient. Also, in the comparison of the TMD types whose reason was bone abnormality and the TMD types classified with other reasons, both the initial bone scan value and its change value had no significant difference (P>0.05; Table 8).

Table 7. Pearson correlation analysis of pre-treatment bone scan value and bone scan change value after treatment

		Bone scan change value
Pre-treatment bone scan value	Pearson correlation	–0.329
	Sig. (2-tailed)	0.117
	Number	24

Sig. (2-tailed): significance level at 2 tailed.

Discussion

The TMJ is mainly composed of muscle, bone, ligament, and articular capsule. According to the Japanese Society for Temporomandibular Joint[10], TMD is divided into five types. First, a masticatory muscle disorder type can be caused by muscle tone, muscle spasm, or myositis. The symptoms of this type of TMD include pain that occurs during mandibular movement, motor disorder by pain, and pain in the moving part of the muscle and head, without much abnormality in radiographs. The second type of TMD is usually caused by the articular capsule, ligament, or extension or

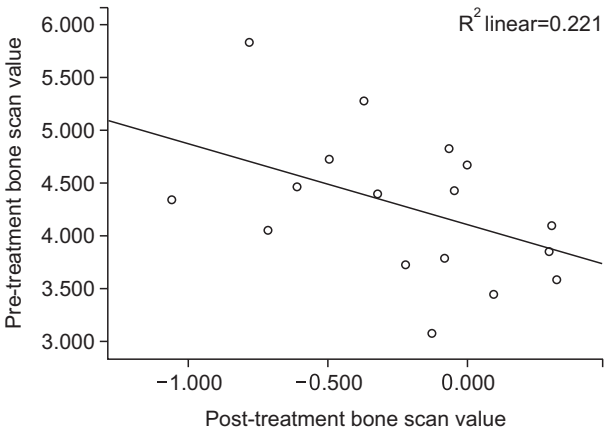

Fig. 4. Pearson correlation analysis of pre-treatment bone scan value and post-treatment bone scan change value.

Table 8. One-way ANOVA for initial bone scan value and bone scan change value among classified temporomandibular joint disorder groups

		Sum of squares	df	Mean square	F	Sig.
Pre-treatment bone scan value	Between groups	3.391	7	0.484	1.406	0.269
	Within groups	5.511	16	0.344		
	Total	8.902	23			
Bone scan change value	Between groups	2.153	7	0.308	1.729	0.172
	Within groups	2.847	16	0.178		
	Total	5.000	23			

df: degree of freedom, Sig.: significance level.

contusion of the articular disc. Its symptoms include pain that occurs during mandibular movement, pain in the mandibular joint part during palpation, motor disorder by pain, pain in the moving part of the muscle, and headaches. When the TMJ superior joint space is observed through arthroscopy, fibrosis or adhesion is sometimes observed. But there is usually no abnormality on a radiograph. The third type is TMD caused by the denaturation, perforation, or transposition of the articular disc or synovial membrane, or fibrillation. This type of TMD can cause pain that occurs during mandibular movement, pain in the TMJ part during palpation, or mandibular motor disorder. Also, clicking or a crepitus sound can occur during mandibular movement, and when the TMJ superior joint space is observed through arthroscopy, fibrosis or adhesion is sometimes observed. And the transposition of the articular disc is observed on a radiograph. The fourth type is caused by the destruction of articular cartilage or bony change or deformity of the mandibular condyle. Although its symptoms are similar to the transposition of the articular disc or synovial membrane, a radiograph shows bone changes such as bone absorption or addition. When the TMJ superior joint space is observed through arthroscopy, inflammation, fibrosis or adhesion is observed. And the final type is the TMD caused by psychological problems that do not fall under any category as described above.

The cause of TMD is a mixture of physical factors such as bones, muscle, or ligaments, and psychological factors such as depression or chronic fatigue syndrome. Therefore, its diagnosis and classification could be ambiguous. According to research in the past[8], an analysis of subjective symptoms due to psychological factors such as the DI, NPS, chronic fatigue index, and disorder index is effective in the diagnosis and treatment of TMD. For this purpose, the Temporomandibular Joint Center, Section of Dentistry, Seoul National University Bundang Hospital is using a carefully designed TMD/RDC questionnaire as a tool for TMD diagnosis.

We used the TMD/RDC Axis I, II for clinical diagnosis. Throughout the survey, the DI was used for the examination of the patient's psychological state, and NPS were the tool for evaluating pain, fatigue, the cardiorespiratory circulating system, and how much the nonspecific symptoms were complained about. And for the further evaluation of TMD, the CP was used to measure the degree of pain the patient felt and the disruption of function and usual activity[11]. This study was conducted to measure the effectiveness of the bone scan test in the follow-up after the diagnosis and treatment of TMD.

The bone scan evaluates the $^{99}Tc^{m}$ hot spot numerical value three hours after settling $^{99}Tc^{m}$. The hot spot value depends on blood volume and phosphorous and calcium contents in the bone crystal area. Therefore, areas of smooth blood circulation have a high activation of osteoblasts and high TMJ hot spot value compared to other areas where blood circulation is not smooth[12]. Since arthritis plays an important role in TMD, the inflammation and its accompanied increase of blood circulation could play a role in numerical value uptake in the bone scan[13].

Although bone scans are highly sensitive, enough to find lesions in their early stages, the results could be similar to metabolic diseases such as squamous cell carcinoma, chondrosarcoma, metastatic disease, eosinophilic granuloma, cyst, osteomyelitis, trauma, Paget's disease, hyperthyreosis, and other bone or soft tissue diseases such as fibrous dysplasia, osteoporosis, and arthritis, along with bone grafts, because its specificity is relatively low. Therefore, the clinical symptoms of patients and radiological interpretations should be combined for a definitive diagnosis[14].

Also, according to Kigami et al.[15], the TMJ hot spot value is clearly higher in women than in men. Epstein et al.[12], have shown the usefulness of bone scans in measuring the stability of the TMJ and

inflammatory responses. Goldstein and Bloom[3], have also reported that a bone scan is a more useful tool than plain radiographs or tomography for the diagnosis of TMJ deformity. According to Keller et al.[16], a bone scan is also an effective method for differentiating TMJ internal disc derangement from osteoarthritis.

According to Kircos et al.[17], the sensitivity and specificity of the bone scan in TMD patients are 93% and 86%, respectively. While bone scans in the past were used just as a diagnosis tool to observe the changes of metabolism of bone, recent research showed that bone scan results coincided 78% with disc displacement without reduction, and 89% with disc displacement with reduction[18]. Also, there is research that found that pain and joint noise coincide 93%[17]. Therefore, these indicate that the bone scans could be affected by changes either inside or outside of bones and their surrounding conditions[5].

According to this study, the bone scan value was relatively low in patients who felt subjective pain, pain during palpation of the TMJ, or pressure pain. The reasons for the subjective pain that TMD patients feel include various factors such as neuromuscular disaccord, mental stress, malocclusion, wrong restoration, oral habits, trauma, malnutrition, hormonal disorders, and disturbance of metabolism. Since various reasons are complexly involved, it is difficult to identify specific reasons[19]. Also, according to the research of Koo, 110 out of 190 TMJ joints (57.90%) that had tenderness showed bone changes from which osteoarthritis was suspected[20]. However, there were no reports about research on the relationship between the bone scan hot spot value and the subjective pain and symptoms patients felt. Therefore, it is considered that there is a need for additional research on the subjective pain or pressure pain of TMJ that patients feel, and the changes of bone scan value and TMJ bone.

According to the results of our research, for 11 patients out of 24, the major reason for TMD was related to bony problems. Nine of the 11 patients showed a high bone scan value, which was 3.88. Also, though statistically insignificant, the bone scan value decreased on average as the symptoms improved along with the treatment. There was no correlation between TMD type and early bone scan value and post-treatment bone scan value.

But although the TMJ bone scan value tended to be reduced in patients who had a high DI, its reduction amount was low. Despite the improved symptoms, it is considered that there was no significant change in the bone scan value, which was a physical functional test, because psychological factors were also applied, and not only physical factors due to the nature of TMD, which is accompanied by psychological disorder as well as physical disorder. Moreover, bone scan showed the possibility of being useful in the follow-up of even those TMD types not directly related to the abnormality of osseous tissue.

Although the bone scan value tended to be clearly reduced as the clinical symptoms of all the TMD patients improved, there was no statistical significance. Therefore, it is considered that future research with additional long-term follow-up periods and larger patient cohorts will be needed.

Conclusion

The post-treatment TMJ bone scan value tended to be insignificantly reduced in the 24 patients whose clinical symptoms were improved. Moreover, the TMJ bone scan value showed no relation to the TMD type or its related symptoms.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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