Low Bone Mineral Density and Temporomandibular Joint Derangement in Young Females

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Aims: *To analyze the bone mineral density (BMD) in a group of young female patients with a disc displacement in at least 1 temporomandibular joint (TMJ) as well as in a group of age-matched young females with a normal condyle-disc relationship.* ***Methods:*** *Fifty-six young female patients with anterior disc displacement based on magnetic resonance imaging (MRI) and 40 age- and gender-matched controls with asymptomatic TMJs were recruited for this study. Subjects between 18 and 30 years were recruited. Based on the MRI findings, 10 of the 40 subjects in the control group also had anterior disc displacement. In all, 16 subjects had an anterior disc displacement with reduction (DDwR), 50 had an anterior disc displacement without reduction (DDw/oR), and 30 had a normal condyle-disc relationship. BMD was measured in the lumbar area by means of dual-energy x-ray absorptiometry. The relationship between the 3 types of condyle-disc relationship and BMD was then analyzed.* ***Results:*** *Patients with a DDw/oR had a significantly lower mean BMD value in the lumbar area than the subjects with a normal condyle-disc relationship (*$P < .05$*, analysis of variance, post-hoc with Bonferroni test). Twenty-two (44%) of 50 patients with DDw/oR had osteopenia.* ***Conclusion:*** *Low BMD is often associated with DDw/oR in young Taiwanese female patients.* J OROFAC PAIN 2007;21:143–149

Key words: anterior disc displacement, bone mineral density, internal derangement, temporomandibular joint

Internal derangement (ID) of the temporomandibular joint (TMJ) is a term used to describe a common TMJ condition associated with disturbed condylar movements generally caused by a misaligned disc. Its clinical manifestation and severity vary, ranging from simple joint noise to a permanent mouth opening limitation, with or without pain. TMJ ID is more prevalent in females than in males[1–3]; the difference in prevalence may begin as early as adolescence.[4–6]

TMJ remodeling or even degenerative changes may be associated with anterior disc displacement, especially in the case of a nonreducible disc.[7–10] These changes are more prominent in females than males.[11] Case reports as well as the authors' own observations have shown that severe bony changes associated with a misaligned disc can appear as early as the first half of the second decade of life.[12,13] Furthermore, the authors recently reported that all of the TMJs of 13 young female patients who had developed an anterior open bite had severe degenerative changes associated with anterior disc displacement without reduction (DDw/oR), as shown by magnetic resonance imaging (MRI).[14]

In vivo real-time dynamic TMJ MRI scans show how the condyle is pressed and rubbed against the nonreducing disc during mouth opening.[15] Such unfavorable contact mechanics between the condyle and the misaligned disc might cause predisposition and/or enhancement of TMJ remodeling or degeneration. The severity of these bony changes in the presence of an anterior DDw/oR varies to a great extent interindividually.[16] Inspired by the observation of in vivo real-time dynamic MRI scans and the severe degenerative changes associated with DDw/oR found in young women and girls with an anterior open bite, the authors postulated that the TMJ bony counterparts might react in a less favorable manner to the abnormal loading conditions caused by the misaligned disc if their mechanical strength were decreased.

In a pilot study, the bone mineral density (BMD) of the lumbar spine was measured in order to estimate the general mechanical strength of the bone in 6 young female patients with severe TMJ condylar remodeling or degeneration. Surprisingly, 4 of them showed significantly lower BMD values than the norm for a healthy Taiwanese female of similar age.[17] The present study was conducted to further investigate these results. The aim of this study was therefore to analyze the BMD in the lumbar spine in a group of young women with anterior disc displacement with or without reduction as well as in a group of age-matched women with a normal condyle-disc relationship.

Materials and Methods

Subjects

The MRI database of the Temporomandibular Disorders and Orofacial Pain Clinic of the National Taiwan University Hospital was screened to find patients having at least 1 joint with disc displacement. From this list, 56 young female patients 18 to 30 years of age in treatment at this institution agreed to participate in the study. Since the prevalence of TMJ disc displacement increases up to approximately 25 years of age,[18] the age range was limited to 18 to 30 years. The lowest age was set at 18 years because the BMD normal value of younger females is unknown. Patients who reported intake of steroids or hormones during the previous 6 months were excluded. Forty age-matched asymptomatic female subjects 18 to 29 years of age, most of them dental students, dental assistants, or dentists, were recruited to serve as the control group. The maximum jaw opening had to be pain-free, symmetrical, larger than 40 mm, and free from joint noise. Exclusion criteria were otherwise the same as for the experimental group.

MRI Scanning

For all patients and asymptomatic subjects, static and dynamic MRI of the right and left TMJ were obtained with a 1.5 Tesla MRI scanner with TMJ coils (Sonata; Siemens, Erlangen, Germany). The subjects were scanned in a supine position in the MRI gantry. The scanning procedure began with axial and frontal localizers, which were used to determine the angulation of the condylar axis on both axial and frontal views. Next, a series of bilateral static oblique 2-mm-thick sagittal images (9 images for each side) were obtained with the subject slightly biting in maximum intercuspation. Images that were perpendicular to both the axial and frontal condylar long axes were obtained by using the scanning parameters summarized in Table 1. Thereafter, a series of 30 consecutive oblique sagittal dynamic TMJ MRI scans 4.5 mm thick was obtained. Each scan had a temporal resolution of 0.4 second. Subjects were asked to open and close their mouth at an arbitrary but slow pace.[15] Spontaneous and continuous movement of the TMJ disc/condyle complex could thus be captured without using any instrument to maintain different jaw-opening positions. The scanning parameters used are summarized in Table 2.

MRI Interpretation

The condyle-disc relationship was analyzed on each static image with the modified clock-face criterion proposed by Katzberg and Westesson.[19] A normal condyle-disc relationship was diagnosed when the disc possessed a biconcave form and the anterior condylar surface was in contact with the intermediate zone. Anterior disc displacement was diagnosed if the posterior band of the disc was located anteriorly to the condyle vertex on at least 1 image of the series. Differentiation between reducing and nonreducing discs was based on analysis of the dynamic MRI scans. If the condyle regained its position underneath the intermediate zone of the disc during mouth opening, the condi-

Table 1 MRI Scanning Parameters Used for Static Sagittal Images

Pulse sequence	Gradient echo sequence (me2d pulse sequence, Software version: Syngo MR 2002B 4VA21A)
Repetition time (TR)	393 ms
Echo time (TE)	23 ms
Flip angle	35 degrees
Number of excitation	3
Field of view (FOV)	120 mm
Percentage phase FOV	62.5%
Scanning matrix	256 × 256
Slice thickness	2 mm
No. of slices	9
Acquisition time	3 minutes and 50 seconds

Table 2 MRI Scanning Parameters Used for the Oblique Sagittal Dynamic Scans

Pulse sequence	True FISP sequence (tfiperf2d1 pulse sequence, Software version: Syngo MR 2002B 4VA21A)
TR	423.6 ms
TE	1.87 ms
Flip angle	25 degrees
Number of excitation	1
FOV	150 mm
Percentage phase FOV	81.25%
Scanning matrix	128 × 73
Slice thickness	4.5 mm

tion was classified as "with reduction"; otherwise, it was classified as "without reduction." The MRI diagnosis was made by a dentist experienced in interpreting TMJ MRI (Y-JC) but unaware of the BMD measurements.

The condyle-disc relationship for each subject was placed given 1 of the following diagnoses:

- DDw/oR, if at least 1 TMJ had a displaced but nonreducing disc
- DDwR, if at least 1 TMJ had a reducible displaced disc but neither had DDw/oR
- Normal, if both discs were normal in shape and position

BMD Measurement

The BMD of the lumbar spines (L1 to L4) was measured by using a dual-energy x-ray absorptiometry (DXA) (Hologic QDR 4500A, version 11.2.1, S/N 45511). The measuring protocol was the same as that used in routine clinical practice for medical services. BMD was expressed as g/cm^2, and the DXA machine provided also the T-score of the measured BMD value by calculating its position within the distribution of the norm for BMD for a sample of young Taiwanese women (1.087 ± 0.027 g/cm^2).[17] The T-score was then used to make a diagnosis of osteoporosis or osteopenia. According to the standard of the WHO, a T score less than –2.5 standard deviations (SDs) from the norm indicates osteoporosis, and a T-score between –2.5 and –1 SDs from the norm indicates osteopenia.[20]

Body Mass Index

The body height and body weight of each subject were also recorded to calculate the corresponding body mass index (BMI).

Statistical Analyses

One-way analysis of variance (ANOVA) with the post-hoc Bonferroni test was used to test for differences in the raw BMD values, and χ^2 tests were used for differences in the prevalence of osteoporosis/osteopenia among the 3 different groups (normal, DDwR, DDw/oR). The significance level was set at .05. All calculations were performed with SPSS 10.0 for Windows.

Table 3 Condyle-disc Relationships for each TMJ and Subject-Related Diagnosis

Diagnosis of paired TMJs	Patients (n = 56)	Controls (n = 40)	Subject-related diagnosis
Normal + Normal	0	30	Normal (30)
Normal + DDwR	7	5	DDwR (16)
DDwR + DDwR	3	1	
Normal + DDw/oR	13	2	DDw/oR (50)
DDwR + DDw/oR	9	0	
DDw/oR + DDw/oR	24	2	

Table 4 BMD (Mean and SD) and BMI (Mean and SD) in Control Subjects, Patients with DDwR, and Patients with DDw/oR

	BMD (g/cm²)		BMI (kg/m²)	
	Mean	SD	Mean	SD
Controls (n = 30)	1.002	0.115*	20.7	2.2*†
DDwR (n = 16)	0.952	0.074	19.4	1.1†
DDw/oR (n = 50)	0.924	0.099*	18.9	1.5*

*Significant difference (ANOVA, post-hoc with Bonferroni test, $P < .05$) between control and DDw/oR.
†Significant difference (ANOVA, post-hoc with Bonferroni test, $P < .05$) between control and

Results

Condyle-Disc Relationship

Fifty-six young female patients and 40 clinically asymptomatic subjects participated in this study. According to the static and dynamic MRI scans, 10 of the 40 controls had disc displacement (6 DDwR, 4 DDw/oR). Therefore, there were 30 subjects with a normal condyle-disc relationship and 66 (56 + 10) subjects with an anterior disc displacement (Table 3). Fifty of these 66 subjects with anterior disc displacement had DDw/oR (mean age, 22.6 ± 2.7 years old) and 16 had DDwR (mean age, 22.3 ± 2.7 years old). The mean age of the 30 subjects with a normal condyle-disc relationship was 23.2 ± 2.6 years.

BMD

The BMD raw values are summarized in Table 4. The lowest mean BMD value was found for the DDw/oR group (0.924 ± 0.099 g/cm²), followed by the DDwR group (0.952 ± 0.074 g/cm²) and the control group (1.002 ± 0.115 g/cm²). The mean BMD value of the DDw/oR group was significantly lower than that of the control group (ANOVA, post-hoc with Bonferroni test, $P < .05$). No subject was diagnosed with osteoporosis in any of the 3 groups. The prevalence of osteopenia varied significantly among the 3 groups: Osteopenia was diagnosed in 5 of 30 subjects with a normal condyle-disc relationship (17%), in 3 of 16 subjects with DDwR (19%), and in 22 of 50 subjects with DDw/oR (44%)(χ^2 test, $P = .003$) (Table 5). The mean BMD value of the 10 clinically asymptomatic subjects with anterior disc displacement was 0.938 g/cm²; the 6 subjects with DDwR had a mean BMD of 0.961 g/cm², and the 4 with DDw/oR had a mean BMD of 0.904 g/cm². A diagnosis of osteopenia was made in 2 asymptomatic subjects with DDwR and 3 with DDw/oR.

BMI

The BMI values are summarized in Table 4. The lowest mean BMI value (18.9 ± 1.5 kg/m²) was found for the DDw/oR group, followed by the DDwR group (19.4 ± 1.1 kg/m²) and the control group (20.7 ± 2.2 kg/m²). The mean BMI values of the DDw/oR and DDwR groups were significantly lower than that of the control group (ANOVA, post-hoc with Bonferroni test, $P < .05$). However, there was no statistically significant difference between the mean BMI of the 2 disc-displacement groups.

Table 5 Prevalence of Normal BMD and Osteopenia Control Subjects, Patients with DDwR, and Patients with DDw/oR

	Normal	Osteopenia	Total
Controls	25	5	30
DDwR	13	3	16
DDw/oR	28	22	50
Total	66	30	96

χ^2 test, $P = .003$.

Discussion

Young female patients with anteriorly displaced but nonreducing TMJ discs (DDw/oR) had a significantly lower BMD, as measured in the lumbar area, than young female subjects with a normal disc-condyle relationship. Furthermore, 44% of the young female patients with DDw/oR had osteopenia in their lumbar spine. Young females with DDw/oR or DDwR also had significantly lower BMI than those of the control group. This can be partially explained by the fact that low BMI and low BMD are significantly correlated.[21–23]

Several factors, including genetic factors,[24,25] race,[26] or lifestyle,[27,28] may predispose an individual to osteoporosis. The factors that led to osteopenia in the present study sample are unclear; this is a topic for future investigation.

These data do not imply a causal relationship between low BMD and anterior disc displacement. As the patients were in therapy because of acute symptoms of TMD dyfunction, the possibility that the low BMD and BMI were the consequence of dysfunction-related malnutrition cannot be excluded. According to patient statements analyzed retrospectively, the mean period from first appearance of TMD signs/symptoms to the time treatment was sought was longer than 2 years (range, 1 month to 6 years). This timeframe could be long enough to lead to malnutrition, low BMI, and low BMD, if the TMD resulted in a long-lasting and severe enough masticatory dysfunction. However, it is worth mentioning that half of the 10 subjects with asymptomatic anterior disc displacement (2 with DDwR and 3 with DDw/oR) also had a reduced BMD in the lumbar area. It is therefore unlikely that malnutrition caused by TMD pain was the cause of the reduced BMD in these young female patients.

Osteoporosis is related to aging and decreased gonadal function. Most studies on osteoporosis are on postmenopausal osteoporosis; thus, the results cannot be compared directly to those of the present study. For instance, Klemetti et al have shown that 48- to 56-year-old postmenopausal patients with signs/symptoms of TMD had significantly lower BMD in the lumbar and femoral neck.[29] Based on this finding, Klemetti et al hypothesized that the habits and conditions that provoke general bone loss in the skeleton might disturb the functional harmony of the masticatory system, thus increasing the risk of craniomandibular disorders. Following this line of thought, under the assumption that a low lumbar BMD correlates with a low condylar BMD, and with the understanding that the condyle undergoes remodeling over a lifetime in order to adapt to the biomechanical demands,[30] the following was hypothesized: Once the TMJ disc becomes displaced, the biomechanically unfavorable loading condition between the displaced disc and the condyle during jaw motion might lead to more pronounced morphologic changes of condyles with lower-than-normal BMD, as BMD accounts for 66% to 74% of the variance in bone strength.[31–35] Such morphologic changes might prevent the displaced disc from reducing during condylar translation. However, since the condylar BMD values before the displaced disc became nonreduced are unknown, the hypothesis cannot be proven.

Shortcomings of this study were *(1)* the sampling method, *(2)* the recording of lumbar rather than condylar BMD, and *(3)* the fact that the sample included far more patients with a DDw/oR than with DDwR (50 versus 16). In a clinical setting, most of the patients scheduled for an MRI examination of the TMJs have severe functional problems, which resulted in a much higher prevalence of patients with DDw/oR. Many more patients with DDwR should be analyzed in order to elucidate the possible role that the low BMD may play in the etiology or pathogenesis of the processes involved with a disc displacement.

The lumbar BMD was used instead of the condylar BMD for the following reasons. First, in the pilot study, an unexpected low lumbar BMD was found in young female patients with a severe condylar remodeling or degeneration. Second, mandibular BMD assessed by DXA correlates significantly with BMD measurements of other important skeletal sites, such as the lumbar spine, the right femoral neck, and the proximal and distal forearm.[36] Therefore, the BMD measurement of the lumbar spine should also reflect the BMD status of the mandible, and hopefully also that of the condyle. However, the last relationship has yet to be proven.

In conclusion, young Taiwanese female patients with DDw/oR had significantly lower BMD in the lumbar area than young women with a normal disc-condyle relationship. In addition, 44% of the patients with DDw/oR had osteopenia. This finding can be used in the early screening of patients at risk for developing osteoporosis, which is a well-known public health issue because of the higher incidence of bone fractures.

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