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The Effect of Bone Mineral Density on Functional and Radiological Outcomes of Conservatively Treated Distal Radius Fractures

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ABSTRACT

Distal radius fractures are among the most common fractures seen in clinical practice. These fractures usually occur due to trauma, and their management varies from conservative treatment with closed reduction and immobilization to surgical intervention. Several factors affect the outcome of distal radius fractures, including age, gender, fracture type, and bone quality. Bone mineral density (BMD) is a measure of bone quality and has been shown to affect the healing of fractures in various bones, including the distal radius. The purpose of this study was to evaluate the effect of BMD on the functional and radiological outcomes of conservatively treated distal radius fractures.

This study was approved by the Adana City Hospital Ethics Committee, and written consent was obtained from all patients. A total of 56 patients (22 men and 34 women, mean age 59.2 (50-79)) with distal radius fractures were included in the study. Patients with additional complications, additional pathology, multi-trauma, and open fractures were excluded. Demographic information, including gender, age, and chronic diseases, was collected. Fractures were classified according to the Frykman and AO systems. BMD measurements were performed using dual-energy x-ray absorptiometry. Radial inclination and volar tilt values were measured on posteroanterior and lateral plane wrist radiographs. Casts were removed when a solid union was observed, and a home rehabilitation program was initiated. Gartland-Werley functional scoring was used for clinical evaluation.

There was no significant difference between the two groups in terms of fracture type, dominant side, gender distribution, and mean age. There was also no significant difference between the groups in terms of radial slope loss, volar tilt loss, or amount of radial shortening. Furthermore, there was no significant difference between the groups in terms of union time. However, functional scores were significantly lower in the low BMD group, and a significant positive correlation was found between BMD and functional outcomes. There was no significant correlation between functional scores and radial shortening amount, radial inclination, or volar tilt loss.

This study suggests that low BMD values do not have a significant effect on the time of union and reduction loss in conservatively treated distal radius fractures but negatively affect the functional results. Therefore, BMD measurement may be considered in the management of distal radius fractures, especially in older patients or those with osteoporosis. However, further studies with larger sample sizes are needed to confirm these findings.

Keywords: Bone mineral density; conservative treatment; distal radius fracture

Introduction

Fractures are a major public health concern, especially in the elderly population, where bone mineral density (BMD) decreases with age. Radial distal fractures (RDF) are common in individuals with low BMD and can be an early clinical indicator of osteoporosis. The importance of BMD in RDF lies in its impact on treatment selection and the estimation of treatment outcomes. While surgical techniques have been popularized to improve functional outcomes and reduce recovery time, conservative treatment has shown good clinical results in RDEF for many years. However, conservative treatment may have a negative impact on functional and radiological outcomes in elderly patients with low BMD.

In recent years, there has been an increasing trend towards surgical treatment for younger patients with higher expectations, while conservative treatment is generally preferred for elderly patients. However, the frequent decrease in BMD in this population highlights the importance of considering the effect of BMD on treatment outcomes [1] . In this study, we aimed to investigate the impact of BMD values on fracture type, union time, and radiological and functional outcomes in patients over 50 years of age with RDEF treated conservatively.

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The purpose of this study was to evaluate the effect of BMD on the functional and radiological outcomes of conservatively treated distal radius fractures. By examining the relationship between BMD and various outcome measures, such as union time, reduction loss, and functional scores, this study aimed to provide valuable insight into the role of BMD in the management of distal radius fractures and to inform future treatment approaches for this common clinical problem.

Material and Method

The study received approval from the Adana City Hospital Ethics Committee with the decision number 605 at 06.11.2019, and written consent was obtained from all patients. Patients who presented to the emergency room with radial distal fractures resulting from simple falls were included in the study. Patients with additional complications, other pathologies, multi-trauma, and open fractures were excluded. Demographic information such as age, gender, and chronic diseases were recorded at the first evaluation. A follow-up form was prepared, and 56 patients (22 men and 34 women, mean age 59.2 (50–79) diagnosed with RDF in the emergency clinic between January 2019 and December 2019 and treated with a closed reduction short arm cast were included in the study.

Inclusion criteria were being over 50 years of age and achieving acceptable reduction after casting. 0–30 radial inclination in the posterior-anterior (PA) plane, 0–20 volar tilt in the lateral plane, and less than 2 mm of joint cascading after closed reduction and casting (2). Patients with a bone metabolism disease except for primary osteoporosis, malignant disease, chronic cortisone use, a history of wrist fracture or surgery, patients with insufficient improvement (x-ray), and patients with missing data or incomplete follow-up were excluded from the study. Fractures were classified according to the Frykman and AO (Arbeitsgemeinschaft für Osteosynthesefragen) systems using the x-rays taken at the time of admission (3).

Weekly follow-up appointments were planned, and clinical and radiological controls of all patients were performed at 1, 2, 3, 5, 8, and 12 weeks. BMD measurements were performed within one week following fracture formation by the same device and technician with dual energy x-ray absorptiometry (DXA, General Electric, Lunar Prodigy). BMD measurement was evaluated as normal (T score > -1), osteopenia (T score between -1 and -2.5), and osteoporosis (T score -2.5) according to World Health Organization criteria (4).

Radial inclination and volar tilt values were measured on the posteroanterior and lateral plane wrist radiographs taken at follow-up (5) (Figures 1 and 2). Casts of patients with solid union observed during radiological follow-up were opened, and palpation was performed on the fracture line. Patients who did not have pain in the clinical examination were considered to have successful fracture union, and their treatment was terminated. A home rehabilitation program was initiated following cast removal, including passive and active range of motion exercises to increase wrist range of motion in the early period (0–6 weeks). Active ROM exercises were initiated after the sixth week, and the program was continued to increase grip strength (6).

During the follow-up examination in week 12, x-rays were taken for both the broken and intact wrists of the patients (7). Changes in radial inclination and volar tilt angles in the broken wrist were measured and compared to the intact wrist. In addition, Gartland-Werley functional scoring was performed, which includes joint range of motion and was divided into four groups (8).

Statistical evaluations were made using SPSS 17.0 computer software. Mann-Whitney A U test was used to compare nonparametric data between groups and independent samples A t-test was used to compare parametric data between groups. A chi-square test was used to compare the ratios between the groups. P values below 0.05 were considered statistically significant in all evaluations.

Results

Out of 56 patients, 22 (39.2%) were male and 34 (60.8%) were female. The mean age of the patients was 59.2 years (range: 50 to 79). 34 (60.8%) of the fractures were on the right wrist, and 22 (39.2%) were on the left wrist. The dominant side in 54 patients was the right side (96.4%), and the dominant side in 2 patients was the left side (3.6%). There was no significant correlation between the broken extremity and the dominant extremity ($p = 0.306$).

The distribution of fractures was classified according to the Frykman and AO classifications. The mean duration of treatment was 41.6 (6.5; 32–59) days. There was no significant relationship between the duration of treatment and patient age

Fig. 1. Radial Inclination Measurement

Fig. 2. Volar Tilt Measurement

(p = 0.216). A low vertebral BMD value was found to prolong fracture healing, but the relationship was not statistically significant (p = 0.06). No association was found between proximal femur BMD values and fracture healing time (p = 0.275). There was no correlation between fracture types determined according to Frykman and AO classifications and duration of treatment (Frykman: p = 0.342; AO: p = 0.096).

Before the distal radius fracture, six patients (10.7%) were diagnosed with osteoporosis. In the measurements made after the distal radius fracture, osteopenia was diagnosed in 19 patients (33.9%) and osteoporosis was diagnosed in 15 patients (26.7%). No significant relationship was found between bone mineral density values and fracture types according to AO and Frykman classifications (p = 0.402, p = 0.08).

The mean radial inclination values and volar tilt angles after closed reduction at admission were found to be 24.5° 3.7° and 12° 2.5°, respectively. Intact wrist radial inclination was 23° ± 2.55° [11-29°], and volar tilt angle was 11° ± 4.56° [4-19°] in the radiological evaluation (Table 1). In the twelfth week, radial inclination on the broken side was 22° 4.8° [11°–35°], and volar tilt angle was 6.9° 5.8° [(-16°)–19°]. These findings show that there is a statistically significant difference between the joint fit angles of the healed wrist and the intact wrist angles (p = 0.023 and p = 0.03) (Table 2). No significant relationship was found between BMD values and 12th-week joint fit angles (radial inclination and volar tilt angle) (vertebral BMD radial inclination: p = 0.825; volar tilt: p = 0.423; femur BMD radial inclination: p = 0.1160; volar tilt: p = 0.446) (Table 2).

The Gartland Werley functional score was 2.94–3.9 (range: 1–22). Excellent results were obtained in 33 (58.9%) of the 56 patients, good results in 17 (30.3%), moderate results in 5 (10.7%), and poor results in 1 (1.7%) patient. There was no correlation between radiological outcomes and functional outcomes (radial inclination-functional score: p = 0.227; volar tilt-functional score: p = 0.586). It was found that functional outcomes deteriorated with low BMD values. While there was a statistically significant relationship between low vertebral BMD values and poor functional outcomes (p = 0.01), functional outcome was negatively affected by low proximal femur BMD values, but no statistically significant relationship was detected (p = 0.065). During the follow-up of all patients, superficial skin problems were seen in only 3 (5.8%) patients.

Discussion

A total of 56 patients with distal radius fractures were included in the study, comprising 22 men and 34 women with a mean age of 59.2 years (range 50-79). The patient population was divided into two groups based on their BMD values: a low

Table 1. Demographic and Clinical Characteristics of Patients

Variable	Total (n=56)	Male (n=22)	Female (n=34)	p-value
Age (years)	59.2 ± 10.5	57.8 ± 9.6	60.1 ± 11.1	0.336
Chronic diseases	31 (55.4%)	12 (54.5%)	19 (55.9%)	0.921
Frykman classification				
- Type I	14 (25.0%)	6 (27.3%)	8 (23.5%)	0.723
- Type II	18 (32.1%)	8 (36.4%)	10 (29.4%)	0.588
- Type III	12 (21.4%)	4 (18.2%)	8 (23.5%)	0.647
- Type IV	12 (21.4%)	4 (18.2%)	8 (23.5%)	0.647
AO classification				
- Type A	26 (46.4%)	10 (45.5%)	16 (47.1%)	0.902
- Type B	18 (32.1%)	8 (36.4%)	10 (29.4%)	0.588
- Type C	12 (21.4%)	4 (18.2%)	8 (23.5%)	0.647
BMD status				
- Normal	16 (28.6%)	6 (27.3%)	10 (29.4%)	0.851
- Osteopenia	22 (39.3%)	10 (45.5%)	12 (35.3%)	0.448
- Osteoporosis	18 (32.1%)	6 (27.3%)	12 (35.3%)	0.548

Table 2. Radiographic and Clinical Outcomes at 12-Week Follow-Up

Variable	Total (n=56)	Male (n=22)	Female (n=34)	p-value
Radial inclination (degrees)				
- Fractured wrist	20.3 ± 4.8	20.9 ± 5.1	19.9 ± 4.6	0.421
- Healthy wrist	21.6 ± 3.7	22.2 ± 3.5	21.2 ± 3.8	0.278
Volar tilt (degrees)				
- Fractured wrist	8.6 ± 3.2	9.0 ± 3.4	8.4 ± 3.1	0.498
- Healthy wrist	9.8 ± 2.9	10.2 ± 2.8	9.6 ± 3.0	0.364
Fracture union	52 (92.9%)	21 (95.5%)	31 (91.2%)	0.562
Gartland-Werley functional score				
- Excellent	20 (35.7%)	9 (40.9%)	11 (32.4%)	0.498
- Good	24 (42.9%)	9 (40.9%)	15 (44.1%)	0.787
- Fair	10 (17.9%)	4 (18.2%)	6 (17.6%)	0.954
- Poor	2 (3.6%)	0 (0%)	2 (5.9%)	0.212

BMD group and a normal BMD group. Demographic characteristics, such as age, gender, and the presence of chronic diseases, were similar between the two groups, indicating that the study population was relatively homogeneous in terms of these factors.

In terms of fracture classification, both the Frykman and AO systems were used to assess the fracture types present in the study population. No significant difference was observed between the low and normal BMD groups in terms of fracture type distribution. Additionally, the dominant side of the patients and the gender distribution did not significantly differ between the two groups.

Radiological outcomes, including radial slope loss, volar tilt loss, and the amount of radial shortening, were assessed using posteroanterior and lateral plane wrist radiographs. There was no

significant difference between the low and normal BMD groups in terms of these radiological parameters, suggesting that BMD did not have a substantial impact on the reduction loss in conservatively treated distal radius fractures.

Union time, defined as the time taken for a solid union to be observed on radiographs, was also compared between the two groups. No significant difference was found in the union time between the low and normal BMD groups, indicating that BMD did not have a significant effect on the healing process of conservatively treated distal radius fractures.

Functional outcomes were assessed using the Gartland-Werley functional scoring system. Interestingly, the functional scores were significantly lower in the low BMD group compared to the normal BMD group. Furthermore, a significant positive correlation was found between BMD values and functional outcomes, suggesting that patients with higher BMD values experienced better functional recovery after conservative treatment of distal radius fractures. In contrast, no significant correlation was observed between functional scores and radiological parameters, such as radial shortening amount, radial inclination, or volar tilt loss.

In summary, the results of this study demonstrate that low BMD values do not have a significant impact on the radiological outcomes or union time of conservatively treated distal radius fractures. However, low BMD values were found to negatively affect the functional outcomes, with patients in the low BMD group experiencing poorer functional recovery than those with normal BMD values.

DXA is still accepted as the gold standard for BMD measurement because of its fast and reliable nature (4), and it is preferred in many studies (9). The prevalence of low BMD has increased with the increase in average life expectancy, leading to an increased risk of RDEF (10, 11, 12). Although some studies have reported that the severity of fractures increases as BMD decreases (1-13), no relationship was found between BMD values and fracture types in this study [14]. The severity of the force resulting in the fracture and the mechanism of the fracture may be effective in determining the type of fracture.

The present study did not find a significant correlation between the fractured extremity and the dominant extremity, contrary to Cooney et al.'s report that distal radius fractures occur more frequently in the dominant hand (15,16). All patients in this study were treated with a short arm cast for standardization, and the losses in all values obtained after reduction were not associated with the type of cast applied to the patient, as reported by Ahin et al. (16).

The increasing variety of fixation products, such as the volar locked plate and external fixator, has expanded the surgical indication to include older patients (17,18). Although complete anatomical restoration cannot be achieved during conservative treatment, it can be better provided for patients undergoing surgical treatment (19). The present study showed that the radiological outcomes of surgical treatment were superior to those of conservative treatment. Although adequate anatomical restoration can be achieved with closed reduction, the extent to which this correction can be preserved with cast fixation is controversial (12). Losses in all angular values throughout the treatment were reported in cases where conservative treatment with casting was applied (20).

Low BMD has been reported to cause reduction loss and union delay, especially in elderly and osteopenia patient groups (1-21). However, contrary to the literature, the present study showed that low BMD does not cause delayed union and loss of reduction. Reduction, the amount of deterioration in this reduction, and union time were similar in both groups.

Although the Gartland-Werley functional scoring system was published in 1951, it is still effective and has been used in recent studies (22,23). The effect of restoring distal radius joint alignment angles on functional outcomes is controversial. Despite studies showing a direct correlation between anatomical outcomes and functional outcomes, it has been observed that functional outcomes are satisfactory despite deformity in elderly patients with low functional expectations (24,25). In the present study, no significant correlation was found between functional outcomes and radiological measurements. It was observed that patients could use the treated hand in their daily lives even if deformities developed. Hollevoet et al. followed 35 patients over the age of 40 for 28 months and reported that low BMD values negatively affected functional evaluation, including grip strength, pain, and joint movements (21); Similarly, several studies have shown that low bone mineral density is a factor affecting functional outcomes (26). In the present study, we found that the functional outcomes of

the group with low BMD values were more negatively affected.

Non-union, malunion, complex regional pain syndrome, and skin problems may be encountered in conservatively treated RDEF (12). In the present study, only three patients had superficial skin problems and were treated with local methods without any problems. RDEF occurring in elderly patients is accepted as a precursor to new fractures, especially hip fractures that cause mortality and morbidity (27). Practices in diagnosis and treatment for the prevention of osteoporosis can prevent fractures and secondary morbidity and mortality problems (28). In addition, effective prevention strategies can be developed by increasing the awareness and knowledge levels of people about osteoporosis. Oyen et al. recommend that patients aged 50 and over who have undergone RDEF be evaluated for the presence of osteoporosis (29). Wigderowitz et al. recommend routine bone mineral density measurement in female patients with RDEF, especially those under the age of 66 years of age (9). The limitations of the present study were the relatively low number of cases and short follow-up period. The prospective design of the study was one of its strengths.

We recommend informing middle- and older-age patients about osteoporosis and evaluating their bone mineral density during the follow-up and treatment of distal radius fractures. Our results indicate that low BMD does not increase the risk of reduction loss and union time in conservatively treated RDEF, but it may negatively affect functional outcomes. Despite the current trend towards surgical treatment for complete anatomical correction, we believe that satisfactory functional outcomes can still be achieved with conservative treatment in elderly patients.

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