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Association between diabetes mellitus and disability in hand osteoarthritis

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ABSTRACT

Aims: Osteoarthritis (OA) and diabetes mellitus (DM) may coexist frequently. The increase in overall OA incidence is correlated with poor glycemic control and disease duration in patients with DM. However, the association between a DM diagnosis and specifically hand OA has not been explicitly determined. We assessed the association between DM and severity of disability in hand OA.

Methods: This single-center, case-control study prospectively enrolled outpatients with hand OA who visited a physical therapy and rehabilitation clinic. The patients were grouped according to the presence of DM diagnosis. Pain, hand function, grip strength, and quality of life were evaluated and compared between the two groups.

Results: The study included 100 participants [Age: 62.7±10.7 years (33-92); female: 78%]. The mean Australian/Canadian OA hand index of patients with OA with (n=50) and without DM (n=50) was 30.7±10.1 vs. 19.9±9.6, respectively (p<0.001). The mean lateral grip strength of the dominant hand of patients with and without DM was 4.5±2.1 vs. 5.9±2.1, respectively (p=0.002). Lateral grip strength of the non-dominant hand showed a negative correlation with DM duration among women (r=-0.387, p=0.018) and a positive correlation with hemoglobin A1c level among men (r=0.609, p=0.027).

Conclusions: This study showed an association between DM diagnosis and severity of hand disability in patients with hand OA, with different patterns among women and men. Nevertheless, the results were unadjusted for relevant confounders.

Introduction

A greater incidence of soft-tissue and musculoskeletal system pathologies is observed in patients with diabetes mellitus (DM) (1). Many pathological changes in soft tissues have been documented in DM, but the underlying mechanism of these musculoskeletal system disorders has not been understood (2). Bone, cartilage, and soft tissue diseases are commonly encountered in patients with DM (2), and it has been shown that DM is a risk factor for developing several rheumatic diseases (3). Besides, there is a high incidence of adhesive capsulitis, tendinitis, carpal tunnel syndrome, and Dupuytren's contracture in patients with DM (2). Connective tissue activating peptide (CTAP) is a CXC-type platelet chemokine with immunomodulatory and angiogenic activity with effects on the metabolism of connective tissue (4). CTAP is elevated in inflammatory diseases and can delay the completion of the repair phase of inflammatory damage, thereby decreasing collagen formation. CTAP-3 has been detected in diabetics (5).

The incidence of osteoarthritis (OA) was correlated with poor glycemic control and length of time since DM diagnosis (3). Moreover, it was reported that people with diabetic peripheral neuropathy might have a greater risk of the aggressive form of OA (6). However, the mechanism behind the association between DM and OA has not been determined (7).

Limited joint mobility (LJM) in DM is caused by the non-inflammatory thickening and increased stiffness in the peri-

articular structures (8). Although reported in the shoulder, LJM was first observed at hand (9). In the beginning, LJM may be painless and therefore unnoticed; however, LJM may precede severe upper extremity impairments associated with pain or disability. LJM and associated impairments at the hand may significantly impact functionality in patients with DM.

In this study, we compared patients with hand OA according to the presence of DM in terms of hand functionality, quality of life, pain level, and grip strength. We also determined any potential relationship between the DM duration, glycemic control, and hand OA, as well as the impact on the patient's ability to perform daily tasks.

Methods

Study design and participants

This observational and case-control study was conducted in Atatürk Training and Research Hospital after obtaining Ethics Committee Approval (approval number: 59, date: 22.03.2017). The data were collected from the Atatürk Training and Research Hospital Outpatient Clinic between March and June 2017 using a convenience sampling method. Informed consent was obtained from all patients. Inclusion criteria were; (i) patient age between 18 and 90 years, (ii) hand OA diagnosis based on the American Society of Rheumatology (10), and (iii) ability to cooperate and read and write in Turkish. Exclusion criteria were the presence of inflammatory, metabolic, and endocrine diseases other than DM that may lead to secondary OA and any neurological or rheumatological disorder in the hands or upper extremities. The participants were grouped with and without DM. The diagnosis of DM was self-reported and confirmed by the national health database.

Assessment of participants

The demographic characteristics, including gender, age, co-morbidity, and body mass index (BMI) were collected. The duration of DM and hemoglobin A1c (HbA1c) levels were noted.

A hydraulic hand dynamometer (Baseline Hydraulic, Irvington, NY, USA) was used to determine the grip strength. Three measurements were done for each hand while the elbow was at a 90-degree flexion and the forearm and wrist were neutral. The results are reported as means in kg (11). A pinch gauge (Baseline Hydraulic, Irvington, NY, USA) was used to determine finger grip strength, and measurements were done in three different positions-lateral, fingertip, and palmar. For measuring lateral grip, the pinch gauge was pressed by the mid-distal phalanx of the thumb and supported from below by the lateral side of the second phalanx of the index finger. The fingertip grip was determined by squeezing the pinch gauge between the tip of the thumb and the index finger. Palmar measurements were carried out by supporting the pinch gauge laterally with the fingers while pressing on it with the inside of the thumb. Patients were instructed to squeeze the gauge with maximum strength, and each measurement was conducted bilaterally in triplicate, and the means were calculated.

Disability in hand functions was evaluated using three different scales. The Australian/Canadian OA hand index (AUSCAN) evaluates pain, stiffness, and difficulty performing daily activities (12). The validity and reliability of this index have been established, and it has been translated into various languages (12,13). The Duruoz hand index (DHI) measures hand and wrist functionality and consists of eighteen tests with scores ranging from 0-90. The higher the score, the greater the activity limit (14). The grip ability test (GAT) comprises three components: filling a glass with water, putting a paper clip on an envelope, and putting a sock over one hand. A high score indicates impaired hand function (15).

A visual analog scale (VAS) was used to quantify pain levels. A straight line was divided into ten 1-cm sections from 0 to 10, where 0 meant no pain and 10 meant the most severe pain, and patients were asked to indicate the number corresponding to their pain on the scale (16).

The Quality of Life (QoL) was evaluated by the short form-36 (SF-36) questionnaire, which consists of eight sub-groups: vitality, physical function, general health, pain, social function, physical-emotional role limitation, and mental health. It is scored from 0 to 100, with 0 being the worst health status, while 100 indicates the best health. The validity and reliability of the SF-36 have been adequately demonstrated in Türkiye (17).

Outcomes

The primary endpoints were hand grip strength and hand function in diabetic and non-diabetic patients with OA. The secondary endpoint was pain and QoL.

Statistical Analysis

The Statistical Package for the Social Sciences for Windows (version 20.0, IBM.Corp., Armonk, NY, 2011) was used for data analysis, and normal distribution was determined using the Kolmogorov-Smirnov test. Data are expressed as mean ± standard deviation or percentage values. Where appropriate, case-control comparisons were performed by Student's t-test, Mann-Whitney U test, or chi-square test. Pearson's and Spearman's coefficients determined the correlation. Statistical significance was set at $p<0.05$.

Results

The mean age of the study population was 62.7±10.7 (33-92) years, and 78 patients (78%) were female. The mean age of patients with DM (n=50) was 62.2±11.2 years, and those without DM (n=50) were 63.3±10.3 years. The frequency of females in the patients with DM and without the group with diabetes was

74% and 82%. No significant difference was found between the groups regarding sex, age, BMI, and dominant hand (p>0.05). The mean duration of DM was 12.1±7.8 years, and HbA1c averaged 7.7±1.9 in patients with DM. Only two patients had type 1 DM.

The VAS pain scores of the group with DM in motion were significantly higher than those without DM (p=0.045). The VAS pain score measured at rest was numerically higher in the group with DM (p=0.057), but this was insignificant (Table 1).

AUSCAN, DHI, and GAT evaluated hand functionality and severity of the disability, and all were significantly higher in patients with DM than in those without DM. Two components of SF-36, pain, and function, were significantly lower in the group with DM (p<0.05) (Table 2). The dominant hand's lateral grip strength, fingertip grip strength, and palmar grip strength were significantly lower in the group with DM than in those without DM (p<0.05). However, in terms of power grip and palmar grip strength in the non-dominant hand, the groups were not statistically different (p>0.05) (Table 3).

Table 1. Clinical, demographic, and pain characteristics of hand osteoarthritis patients with and without DM

	DM (n=50)	Without DM (n=50)	p
Age, years, mean±SD	62.2±11.2	63.3±10.3	0.717
Female sex, n (%)	37 (74)	41 (82)	0.334
Right hand dominancy, n (%)	48 (96)	48 (96)	0.691
BMI, mean±SD	30.0±4.7	28.4±4.7	0.091
HbA1c, mean±SD	7.7±1.9	-	-
Diagnosis duration, years, mean±SD	12.1±7.8	-	-
VAS at rest, mean±SD	2.1±1.1	1.8±1.2	0.057
VAS in motion, mean±SD	5.4±1.6	4.7±1.6	**0.045**

Chi-square test, Mann-Whitney U test, Fisher's exact test and Student's t-test were used in comparisons according to the distribution characteristics of data. Statistically significant variables are shown in bold.
DM: Diabetes mellitus, SD: Standard deviation, BMI: Body mass index, HbA1c: Hemoglobin A1c, VAS: Visual analog scale

Table 2. Functional level and quality of life in OA patients with DM and those without DM

	DM (n=50)	Without DM (n=50)	p
AUSCAN	30.7±10.1	19.9±9.6	**<0.001**
DHI	45.1±17.5	24.8±17.0	**<0.001**
GAT	70.2±39.3	52.5±35.6	**<0.001**
SF-36	-	-	**-**
1. Pain	33.4±21.1	47.9±24.1	**0.015**
2. Function	21.8±29.7	33.6±29.8	**0.002**

Data are shown as mean±standard deviation. Mann-Whitney U test or Student's t-test were used in comparisons. Statistically significant variables are shown in bold.
OA: Osteoarthritis, DM: Diabetes mellitus, AUSCAN: Australian/Canadian osteoarthritis hand index, GAT: Grip ability test, SF-36: Short form-36, DHI: Duruoz hand index

Table 3. Grip ability comparison between OA patients with and without DM

	DM (n=50)	Without DM (n=50)	p
Dominant hand			
Power grip	18.0±11.0	18.4±8.0	0.301
Lateral grip	4.5±2.1	5.9±2.1	**0.002**
Fingertip grip	3.0±1.7	3.7±1.7	**0.012**
Palmar grip	3.7±1.7	4.4±1.6	**0.007**
Non-dominant hand			
Power grip	17.9±11.2	17.9±7.5	0.406
Lateral grip	4.2±1.9	5.2±1.8	**0.007**
Fingertip grip	2.7±1.6	3.3±1.4	**0.016**
Palmar grip	3.4±1.5	3.9±1.3	0.053

Data are shown as mean±standard deviation. Mann-Whitney U test was used in comparisons. Statistically significant variables are shown in bold.
OA: Osteoarthritis, DM: Diabetes mellitus

The association and correlation of the AUSCAN, DHI, GAT, and two components of the QoL with the different types of grip strength were also evaluated. The functionality component of SF-36 was positively correlated with all indices of grip strength (Table 4).

Among women with DM, disease duration was inversely correlated with all non-dominant hand index strength measures except for the power grip. However, among men with DM, HbA1c levels were positively correlated with lateral grip strength in both dominant and non-dominant hands (Table 5).

Discussion

This study was conducted on patients with hand OA and found that AUSCAN, DHI, VAS pain in motion, and GAT were

Table 4. Correlation of AUSCAN, DHI, GAT, SF-36 with handgrip strength

	AUSCAN		DHI		GAT		SF-36 (pain)		SF-36 (function)	
Grip types	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**
Dominant hand										
Power grip	**<0.001**	-0.446	**<0.001**	-0.336	**0.001**	-0.338	0.232	0.121	**0.001**	0.333
Lateral grip	**<0.001**	-0.577	**<0.001**	-0.500	**<0.001**	-0.362	0.070	0.209	**<0.001**	0.412
Fingertip	**<0.001**	-0.523	**<0.001**	-0.406	**0.001**	-0.330	0.247	0.117	**0.003**	0.297
Palmar grip	**<0.001**	-0.551	**<0.001**	-0.443	**<0.001**	-0.393	0.253	0.115	**<0.001**	0.435
Non-dominant hand)										
Power grip	**<0.001**	-0.460	**<0.001**	-0.374	**0.021**	-0.230	0.168	0.139	**<0.001**	0.364
Lateral grip	**<0.001**	-0.602	**<0.001**	-0.516	**<0.001**	-0.405	0.122	0.156	**<0.001**	0.357
Fingertip	**<0.001**	-0.448	**<0.001**	-0.345	**0.004**	-0.285	0.546	0.061	**0.006**	0.275
Palmar grip	**<0.001**	-0.515	**<0.001**	-0.432	**0.001**	-0.331	0.231	0.121	**<0.001**	0.467

Statistically significant variables are shown in bold.
AUSCAN: Australian/Canadian osteoarthritis hand index, DHI: Duruoz hand index, GAT: Grip ability test, SF-36: Short form-36

Table 5. Correlation of length of DM and hemoglobin A1c level with AUSCAN, DHI, GAT, SF-36, and handgrip strength

	Female (n=37)				Male (n=13)			
	Length of DM		Hemoglobin A1c		Length of DM		Hemoglobin A1c	
	r	p	r	p	r	p	r	p
AUSCAN	0.141	0.404	0.006	0.971	-0.208	0.495	-0.347	0.245
DHI	0.278	0.096	0.167	0.322	-0.094	0.761	-0.533	0.061
GAT	0.086	0.611	-0.036	0.833	0.055	0.858	0.005	0.986
SF-36-function	-0.050	0.767	-0.087	0.607	-0.007	0.982	0.296	0.326
SF-36-pain	0.143	0.399	0.004	0.980	-0.218	0.474	0.078	0.799
Morning stiffness	0.337	**0.041**	0.213	0.205	-0.261	0.390	0.218	0.474
VAS in motion	0.094	0.581	0.125	0.460	-0.297	0.324	-0.273	0.367
VAS in rest	-0.053	0.754	-0.141	0.405	0.019	0.950	-0.140	0.647
Dominant hand								
Power grip	-0.098	0.563	-0.192	0.255	0.129	0.674	0.467	0.108
Lateral grip	-0.127	0.452	-0.076	0.656	0.192	0.529	0.571	**0.041**
Fingertip grip	-0.064	0.705	0.129	0.447	0.017	0.956	0.407	0.167
Palmar grip	-0.280	0.094	-0.100	0.556	0.053	0.864	0.238	0.434
Non-dominant hand								
Power grip	-0.270	0.106	-0.341	**0.039**	0.121	0.694	0.418	0.156
Lateral grip	-0.387	**0.018**	-0.175	0.301	0.376	0.205	0.609	**0.027**
Fingertip grip	-0.392	**0.016**	-0.211	0.211	0.182	0.552	0.464	0.110
Palmar grip	-0.395	**0.016**	-0.305	0.067	0.182	0.552	0.276	0.362

Statistically significant variables are shown in bold.
DM: Diabetes mellitus, AUSCAN: Australian/Canadian osteoarthritis hand index, DHI: Duruoz hand index, GAT: Grip ability test, SF-36: Short form-36, VAS: Visual analog scale

significantly higher, and SF-36 and grip strength were significantly lower in patients with DM compared with the patients without. Grip strength was inversely correlated with AUSCAN, DHI, and GAT. In parallel with the increase in the prevalence of DM and the life expectancy of the patients, DM-related musculoskeletal abnormalities are more commonly observed (18). However, no association between OA and DM has been definitively shown. In this study, we investigated whether DM was linked to impaired hand function and found that the hand function indices were worse, and the two components of the QoL and grip strength were lower in patients with DM.

Turan et al. (19) reported a significant correlation between DHI and dominant handgrip strength in patients with DM, which is consistent with the results of the present study. Also, in agreement with the current study, Savaş et al. (20) determined higher DHI scores in people with diabetes than in healthy controls. The reasons behind these observations may involve the pathological changes including Dupuytren's contracture, trigger finger, and cheiroarthropathy, attributed to DM itself and its duration. These are thought to be associated with microvascular complications (21). Besides, Sayer et al. (22) showed that dysregulation of blood glucose could decrease grip strength in type 2 patients with DM. Thus, these diabetic complications may increase DHI scores. Magnusson et al. (23) found that diabetic patients with OA suffered more severe pain in their hands and showed higher AUSCAN index scores. In another study by this group, long-term type 1 DM (>45 y) was strongly associated with increased pain (high AUSCAN index) and stiffness in the hands and more significant overall disability consistent with a diagnosis of erosive OA (24). Higher AUSCAN index and pain VAS scores than the control group support the findings of our study. Five components of SF-36 were found lower in patients diagnosed with type 2 DM compared to a group of healthy controls (25), which is consistent with our results that the pain and functional components of SF-36 were significantly lower among patients with DM.

Autonomic disorders and sensory neuropathy are common in DM, however, only a few studies have been published on the effect of DM on motor functions. Two studies reported that patients with DM had severe distal muscle weakness (26,27). Also, patients with DM have lower physical functional capacity and hand strength than healthy controls of the same age (28). Li et al. (29) found that although the grip strength of patients with type 2 DM was lower than age-matched controls, their muscle mass was comparable. Thus, handgrip strength can be considered a good indicator of DM that one group has proposed using it as a diagnostic tool in developing countries, along with BMI, age, blood pressure, and other factors to identify patients with DM (30). Additionally, Loprinzi and Loenneke (31) showed that grip strength was a good indicator of the prevalence and severity of type 2 DM in both men and women and that reduced grip strength was associated with higher HbA1c. In another study, de Carvalho e Silva et al. (32) reported that compared to healthy controls, hand function and grip strength were poorer in patients with DM but better than in the subjects diagnosed with hand OA. The current study showed that, compared with the non-diabetic group, hand function and grip strength were reduced in patients with OA with DM.

The mechanisms proposed to explain muscle weakness in the presence of DM is complex. Uncontrolled hyperglycemia can lead to muscle protein breakdown and inadequate energy availability, resulting in poor muscle function (33). Uncontrolled glycemia is also associated with increased production of systemic inflammatory cytokines, C-reactive protein, and fibrinogen, which adversely affect muscle function (34). In addition to the direct cytokine effect on muscle breakdown, neuropathy can be involved in poor muscle function in patients with DM. In an animal study, the relative loss of torque was greater via nerve stimulation (43%) than the force lost indirectly through stimulated muscle (24%), indicating a neural deficit in DM (35). In humans, the severity of diabetic neuropathy is associated with decreased muscle strength (36). Electrophysiological studies also support the findings that the functional neuronal deficit in DM is due to disrupted re-innervation after axonal loss (37).

Type 2 DM and type 1 DM patients have different features of hand OA. Although no relationship was found between type 2 DM severity or duration and hand OA (7), long-term type 1 DM was associated with increased hand pain, disability, and stiffness (24). However, none of the studies examined gender-wide differences. Our results showed that the length of DM duration in women, and HbA1c level in men positively correlated with disability and the severity of hand OA. This novel finding needs to be further evaluated in future studies.

The limitations of our study include the small sample size, which did not allow adjusted analyses, and the lack of information about several comorbid conditions related to hand pain and dysfunction, such as polyneuropathy and carpal tunnel syndrome that are common in patients with DM (21). The lack of radiography evaluations is another limitation.

Conclusion

In conclusion, we showed reduced grip strength, and worse hand function and QoL in patients with hand OA having DM. These findings suggest that OA and type 2 DM have a complex relationship beyond age and BMI. DM may be considered an additional risk factor for OA. More studies are needed to fill in the gaps in our knowledge about how the prevention and control of DM can affect OA progression in humans.

Ethics

Ethics Committee Approval: This observational and case-control study was conducted in Atatürk Training and Research

Hospital after obtaining Ethics Committee Approval (approval number: 59, date: 22.03.2017). The study was conducted under the principles of the Declaration of Helsinki.

Informed Consent: Informed consent was obtained from all patients.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: S.A.A., S.K., Design: S.K., Data Collection or Processing: S.A.A., S.K., Analysis or Interpretation: S.A.A., Literature Search: S.A.A., S.K., Writing: S.A.A., S.K.

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