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Role of ultrasound in diagnosis of Carpal Tunnel Syndrome in diabetic patients

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Abstract:
Objective: To detect the musculoskeletal disorders of diabetes affecting the hand by ultrasonography (US) and to study the relationship of these changes with the arterial Doppler blood flow pattern.
Materials & Methods: Both hands of 23 diabetic patients (age 53 ± 11.3 years) (10 female, 13 male) were examined by US and compared to age and sex matched control group (age 53 ± 11.1 years). Median nerve diameters, area and circumference measurements, flexor retinaculum thickness and tendinopathic changes as decrease in echogenicity, peritendinous fluid collection were studied. Arterial Doppler echo pattern of radial, ulnar and palmar arch arteries have also been studied. Clinical findings as arthralgia, numbness and limited joint mobility were recorded.
Results: Patients group showed a significant increase (P<0.01) in median nerve diameters (3.8 × 5.1 mm), area (15.5 ± 5.1 mm²), circumference (14.3 ± 2.4 mm) and flexor retinaculum (FR) thickness measurements (2.1 ± 0.3 mm), compared with the control group values (2.7 × 4.0 mm, 8.7 ± 1.9 mm², 11.1 ± 1.3 mm, 1.7 ± 0.1 mm, respectively). Monophasic arterial flow pattern was seen in 28 out of 46 hands and revealed a significant correlation with FR thickness, decreased tendon echogenicity, peritendinous fluid collection and HbA1c. Clinical findings were also significantly correlated with arterial monophasic flow pattern, FR thickness, peritendinous fluid, median nerve diameters, area, and circumference measurements.
Conclusion: We can evaluate the diabetic hand by US and the arterial flow pattern can be used as a predicting factor for the possible changes in the future.

Introduction

Diabetes mellitus (DM) is a chronic and progressive disease characterized by hyperglycemia and disorders of carbohydrate, protein, and lipid metabolisms. Long- term hyperglycemia has been demonstrated in various studies to cause negative changes in the vessels however glycosylation of skin collagen results in decreased skin elasticity, stiffness, and limitation of joint movements [1]. The most common complications of DM in the hand are flexor tenosynovitis, Dupuytren's contracture, diabetic stiff-hand, carpal tunnel syndrome (CTS), and infections. Carpal tunnel syndrome is the most frequently seen entrapment neuropathy developing as a result of obstruction of the median nerve of the wrist while passing through the carpal tunnel. It is characterized by pain in the hand and wrist, numbness in the distribution area of the median nerve and paresthesia. The aim of this study is to evaluate the contribution of sonography (US) to delineate musculoskeletal hand complications of diabetes mellitus as CTS, flexor retinaculum (FR) thicknening and tendinopathic changes. In addition, we aimed to study the arterial flow patterns in the hands caused by chronic vascular complications of diabetes by color Doppler US and to determine the associations between

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these flow patterns and musculoskeletal complications of the hand. To date, no studies performed in diabetic patients for early detection of the musculoskeletal involvement of the hand by US have been published in the literature.

Materials and Methods

Hands of a total of 100 cases, 50 with age and sex matched diabetes mellitus and 50 normal subjects, were evaluated between January 2012 and November 2013 in University Hospital. In the study group, both hands of 50 diabetic patients (22 females and 28 males) with a mean age of 53 ± 11.7 years were evaluated using US and Doppler US. The duration of both illness and treatment for diabetes was questioned, HbA1C levels were analyzed and clinical findings as arthralgia, numbness and joints stiffness were evaluated. Both hands were evaluated in neutral position by US while patients were in the supine position in all cases. US examinations were performed by an experienced musculoskeletal radiologist and a 7.5-12 MHz linear probe (Toshiba Nemio SSA-550A Otowara, Japan) was used. The cross-sectional areas of median nerve, transverse and anteroposterior diameters, were measured from the proximal carpal tunnel at the level of pisiform bone. Localization of median nerve was determined by asking the patient to flex and extend his fingers during US exam and was seen as a hypoechoic structure in the axial plane behind the flexor retinaculum between the flexor tendons of second and third fingers while neutral position. The diameter, circumference of median nerve and the thickness of flexor retinaculum were measured (Figure 1). Decreased echogenicity in the flexor tendons, peritendinous fluid collection, and loss of contour sharpness due to edema were evaluated by US (Figure 2). By Doppler US examination, flow patterns in radial, ulnar and palmar arc arteries were categorized as triphasic, biphasic, and monophasic. The local Institutional Review Board approved the study, and informed consent was obtained from each subject imaged under the research protocol.

Figure 1: Measurement of flexor tendon retinaculum (shown between two cursors).
Hypoechoic image of median nevre (marked wİth A)

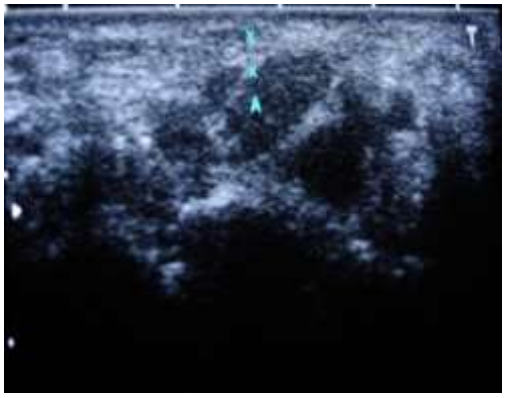

Figure-2: Fluid collection seen as hypoechoic focus around the tendon (black arrow)

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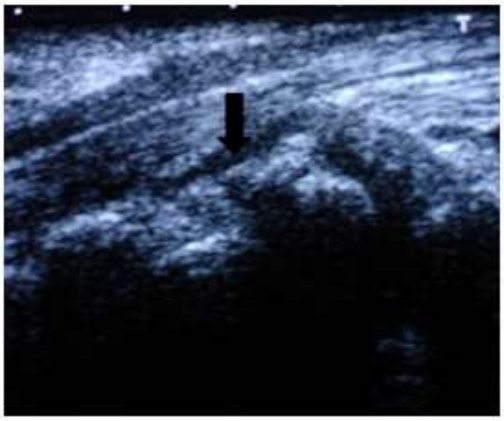

Statistical Analysis

Statistical analyses were performed using the SPSS package program (Version 11). Mean ages of patient and control groups were calculated. Age, duration of diabetes, HbA1c level, flexor retinaculum thickness, area, circumference, and diameter of median nerve of the patients were tested for correlations using Pearson's correlation test and flow patterns of radial, ulnar, and palmar arteries, tendon echogenicity, peritendinous fluid, and the presence of clinical findings were tested for correlations using Spearman's correlation test. Differences in the diameter, area, circumference of the median nerve, and FR thickness between patient and control groups were compared using the independent samples t-test. The differences in the tendon echogenicity, monophasic flow pattern, and presence of peritendinous fluid were compared between the patient and control groups using chi-square test. An association between the duration and diabetes and decreased tendon echogenicity was evaluated using the Mann-Whitney U-test. For the comparisons of area and circumference of the median nerve, FR thickness and tendon echogenicity and peritendinous fluid between the dominant and non-dominant hands of the patients, the Wilcoxon signed rank test was used.

Results

Table I reveals mean values ± SD for the US findings and HbA1c levels of both patient and control groups. The diameter, area and circumference of the median nerve, FR thickness, and HbA1c levels were increased significantly in the patient group ($p<0.05$). In the hands of the patient group, bilateral decrease in tendon echogenicity, peritendinous fluid, and monophasic flow pattern in the wrist and palmar arch were seen in 11 (22%), 21 (42%), and 10 (20%) patients, respectively.

Table 1: Comparison of US findings and HbA1c levels in patient and control groups
*p< 0.05

	Diameter of MN (mm)	Area of MN mm²	Circumference of MN (Mm)	FR thickness (mm)	DTC	PF (%)	H	MF (%)
Patient group (100)	(3.8x5.1) *	(15.5±5.1) *	(14.3±2.4) *	(2.1±0.3) *	11 (22%) *	21 (42%) *	12.8%*	10 (20%) *
Control group (100)	(2.7x4)	(8.7± 1.9)	(11.1±1.3)	(1.7±0.1)	0 (0%)	0 (0%)	7.1%	0 (0%)

Median Nerve (MN), Decreased Tendon Echogeenicity (DTC), Peritendinous fluid (PF), HbA1c (H), Monophasic flow (MF)

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These findings showed a significant stastistical difference in relation to the control group ($p< 0.05$). Pain, numbness, and limited range of motion were noted in 43 patients. Table II shows that there was significant correlations between clinical and US findings, median nerve diameter ($r=0.571$, $p=0.000$), median nerve area ($r=0.549$, $p=0.000$), median nerve circumference ($r=0.550$, $p=0.000$), monophasic flow pattern ($r=0.338$, $p=0.022$), flexor retinaculum thickness ($r=0.367$, $p=0.012$) and peritendinous fluid ($r=0.388$, $p=0.008$). The cross section area (CSA) of the median nerve at the outlet and wrist crease were significantly larger in CTS DM patients compared to control group. The cut-off value of cross-sectional area of the median nerve CTS confirmation was more than 13 mm^2 in DM patients compared to control hands. In the patients group, a monophasic flow pattern was seen in radial, ulnar, and palmar arch arteries of both hands by Doppler examination in ten patients (20%).

Table- II: Corelations between clinical and ultrasonographic findings

Clinical findings (pain, numbness, limited range of motion)	Monophasic flow pattern seen(r= 0.338, p=0.022)
	Flexor retinaculum thickness increase (r= 0.367, p=0.012)
	Prescence of peritendinous Fluid (r= 0.388 , p=0.008)
	Median nerve diameter increase (r= 0.571, p=0.000)
	Median nerve area increase (r= 0.549, p=0.000)
	Median nerve circumference increase (r= 0.550, p=0.000)

Significant correlations were found between monophasic flow pattern and flexor retinaculum thickness ($r=0.508$, $p=0.000$), decreased tendon echogenicity ($r=0.507$, $p=0.000$), peritendinous fluid ($r=0.498$, $p=0.000$), and HbA1c ($r= 0.528$, $p=0.000$) (Table III).

Table- III: Findings correlated with monophasic flow pattern

Monophasic flow pattern	Flexor retinaculum thickness increase (r= 0.508, p=0.000)
	Decreased tendon echogenicity (r= 0.507, p=0.000)
	Presence of peritendinous fluid (r= 0.498, p=0.000)
	HbA1c increase (r= 0.528, p=0.000)

Flow pattern was seen as triphasic in 14 (28%), biphasic in 26 (52%), and monophasic in 10 patients (20%). In the control group only triphasic 26 (52%), and biphasic 24 (48%) flow patterns were present. A significant difference was present between patient and control groups in regarding to the monophasic flow patterns observed in the radial ($p=0.0001$), ulnar ($p=0.0001$), and palmar arch ($p=0.0001$). The duration of diabetes and decreased tendon echogenicity ($p=0.087$), median nerve area ($p=0.184$), median nerve circumference ($p=0.111$), and FR thickness ($p=0.121$) were not stastistically significant. Clinical findings and decreased tendon echogenicity were not stastistically significant ($p=0.174$). There was a stastistically significant difference in US findings between male and female patients in both study and control groups ($p<0.05$). We found significant correlations between clinical findings and increased median nerve diameter, median nerve area, median nerve circumference, flexor retinaculum, and monophasic flow pattern and peritendinous fluid ($p<0.05$) Measurements of median nerve and FR thicknesses were found to be increased

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in patients with clinical findings compared to the control group and peritendinous fluid was also observed in those patients. Median nerve measurements and FR thicknesses were increased compared to the control group in 50 patients. The mean median nerve area was 15.5±5.1 mm^2 in the diabetic patient group. This value was 8.7±1.9 mm^2 in the control group. FR thickness measurements 2.1 ± 0.3 mm in the diabetic patient group. This value was 1.7 ± 0.1 mm in the control group. (Table IV).

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Table IV: Measurements of median nerve and FR thicknesses in the patient and control groups according to gender

Patient group(n)	Median nerve Area	Median nerve circumference	FR thickness
Female (22)	(18.1± 2.7 mm²)*	(15.4 ± 1.1 mm)*	(2.2 ± 0.4 mm)*
Male (28)	(13.1 ± 5.4 mm²)*	(13.3 ± 2.8 mm) *	(1.9 ± 0.3 mm) *
Control group			
Female (21)	(7.3 ± 1.2mm²)	(10.1 ± 1.0 mm)	(1.6 ± 0.1 mm)
Male (29)	(9.4 ± 1.4mm²)	(11.5 ± 0.8 mm)	(1.7 ± 0.1 mm)

* $p < 0.05$

Monophasic flow pattern was observed in each of the radial, ulnar and palmar arch arteries of both hands of 10 patients (20%) in Doppler examination. We found significant correlations between monophasic flow pattern and flexor retinaculum thickness, decreased tendon echogenicity, peritendinous fluid, and increased HbA1c levels ($p<0.05$) The mean duration of diabetes was 12.6± 9.1 years in patients with clinical findings of pain, numbness, limited range of motion. No statistically significance was found between the duration and diabetes and decreased tendon echogenicity, area, and circumference of the median nerve and increased flexor retinaculum thickness. Statistically significant differences were found between females and males in the patient group in the median nerve area, median nerve circumference, and FR thickness. Although the median nerve measurements and FR thicknesses were higher in the males in the control group compared to the females, median nerve area, circumference, and FR thickness were increased in women in the patient group.

Discussion

Accurate detection of median nerve entrapment in patients with a clinical suspicion of CTS is essential. US has been advocated as noninvasive diagnostic technique for the detection of median nerve entrapment. US provide direct visualization of the median nerve within and proximal to the flexor retinaculum, enabling morphologic assessment of the median nerve, including nerve swelling, edema, flattening, and bowing of the flexor retinaculum. A number of authors have reported the accuracy of sonography criteria of median nevre entrapment, and several studies have addressed the quantification of the nerve cross sectional area and its role in diagnosing carpal tunnel syndrome Review of studies reveals a number of discrepancies in the accuracy of various sonography criteria in diagnosing carpal tunnel syndrome [2]. To date literature states that nerve swelling is the main sonography criteria indicating CTS, the swelling position (i.e., proximal to the carpal tunnel or at the tunnel inlet or outlet) and the critical threshold for nerve cross-sectional area are changed in diseased patients. The sensitivity of nerve swelling was 57% to 89% (3-6, 7, 8, 9), and the nerve cross-sectional area indicating carpal tunnel syndrome was 9 to 15 mm² (4, 10). In our study we found nevre cross-sectional area as 15. 5 ± 5. 1 mm², slightly higher than literature. The role of retinaculum bowing and nerve flattening also varied among studies, with sensitivities of 45–81% (3, 8) and 38–65% [3,4], respectively. Buchberger et al. and Sarria et al. examined bowing of retinaculum and accepted that as a useful criteria in the diagnosis of CTS, but there are differences in the values that they chose as critical; Buchberger et al. accepted a significance value of > 4 mm, whereas Sarria accepted >2.5 mm. [3,8]. In this

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study our finding was 2.1 ± 0.3 mm in the diabetic patient group as seen in the literature. In current literature there is no data about comparing monophasic flow pattern and CTS US findings. In addition, a significant correlation was found between the monophasic flow pattern and US findings (median nerve measurements, flexor retinaculum thickness, and tendinopathic changes). There are some limitations of this study, the number of patient and control groups can be increased to have more accurate data to represent whole population. In conclusion, in the hands of the diabetic patients, the frequency of diabetic complications, primarily CTS, increases compared to the control group; therefore, high resolution US with its low cost and easy access should be the preferred method in early diagnosis of this condition. The presence of a monophasic flow pattern in the hands may be beneficial in the early diagnosis of ischemic complications that might develop in diabetic patients.

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