



Original Article

Range of motion of the ankle joint in male Japanese patients undergoing hemodialysis: influence of diabetes and hemodialysis

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Abstract. [Purpose] The purpose of this study was to analyze ankle range of motion in patients undergoing hemodialysis and those with diabetes. [Participants and Methods] Eight male kidney disease patients without diabetes undergoing hemodialysis and 10 male kidney disease patients with diabetes undergoing hemodialysis were enrolled in this study. For comparison, 27 patients with diabetes not undergoing hemodialysis and 10 healthy participants were included. All participants were divided into 4 groups: patients without diabetes undergoing hemodialysis, patients with diabetes undergoing hemodialysis, patients with diabetes not undergoing hemodialysis, and control group. The measured parameter was the passive range of motion of the ankle joint. [Results] Patients with diabetes not undergoing hemodialysis demonstrated the greatest joint restriction, followed by patients with diabetes undergoing hemodialysis. The main effect of diabetes was observed in ankle range of motion, rather than hemodialysis. There was a significant difference between both the diabetes undergoing hemodialysis and the diabetes not undergoing hemodialysis groups and the other groups. [Conclusion] Limited joint mobility of the ankle in patients undergoing hemodialysis may be affected by diabetes rather than hemodialysis.

Key words: Limited joint mobility, Hemodialysis, Diabetes mellitus

(This article was submitted Mar. 19, 2019, and was accepted May 5, 2019)

INTRODUCTION

The range of motion (ROM) of the ankle joint is important for smoothly moving the center of gravity forward when walking. Restriction of ROM of the ankle joint causes increased plantar pressure during walking^{1, 2)}. Limited joint mobility (LJM) of the ankle has been shown to occur more frequently in patients with diabetes mellitus (DM)¹⁻⁶⁾. Furthermore, LJM of ankle joints increases the plantar pressure after the mid-stance phase. Therefore, LJM of ankle joints is one of the risk factors for foot ulcers⁷⁾. However, only few studies have investigated LJM of the ankles in patients with kidney disease undergoing hemodialysis (HD).

In patients with kidney disease undergoing HD, arteriosclerosis progresses because of various factors such as secondary hyperparathyroidism; furthermore, the incidence of peripheral artery disease⁸⁾, risk of foot ulcers⁹⁾, and rate of lower limb amputation¹⁰⁾ are high. Changes in the ankle brachial pressure index¹¹⁾ and severe lower limb ischemia are associated with high mortality rate¹²⁾. Thus, it is necessary to prevent foot ulcers in patients with kidney disease undergoing HD who are at risk of developing peripheral artery disease. Additionally, elucidation of the current condition and cause of LJM of the

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ankle would be useful. A previous study on LJM in patients with kidney disease undergoing HD reported that the therapy resulted in the relaxation of tendon and ligament tissue¹³⁾ and that beta-2-microglobulin-associated amyloidosis influenced the restriction of ROM¹⁴⁾; however, no definitive conclusion has yet been made.

In contrast, these studies were not designed considering the influence of DM; thus, a study design based on both HD and DM is required to study the influence of HD and DM on ROM of the ankle joint for identification of patients with kidney disease undergoing HD who should focus on foot care for the prevention of foot ulcers. Currently, there is no conclusive evidence concerning the influence of HD on ROM of the ankle joint. However, with reference to the studies on LJM and DM, we hypothesized that patients with DM undergoing HD experience a comparatively greater ankle joint restriction than the patients without DM undergoing HD. To verify this hypothesis, this study aimed to analyze ROM of the ankle joint with regard to the factors HD and DM.

PARTICIPANTS AND METHODS

A total of 18 male patients (age range, 40–69 years) with kidney disease undergoing HD who visited the Hemodialysis Center of Japanese Red Cross Kanazawa Hospital were enrolled in this study. Primary diseases for which hemodialysis was performed are depicted in Table 1. Twenty-seven patients with DM not undergoing HD and 10 healthy participants without a history of chronic medical illness who were age- and gender-matched (the comparison object group) were enrolled. The participants were divided into four groups: patients without DM undergoing HD (HD group: HD without DM), patients with DM undergoing HD (HDDM group: HD with DM), patients with DM not undergoing HD (DM group: non-HD with DM), and control (C group: non-HD without DM). None of the participants had a history of severe motor unit or central nervous system diseases that affected their gait pattern, and all were able to walk without an assisting device. In addition to the patients' general information (such as age, height, and weight), HD implementation period and time since diabetes diagnosis were extracted for the DM and HDDM groups. Patient characteristics are summarized in Table 2. Examinations were performed according to the Declaration of Helsinki. All participants provided written informed consent for participation in the present study. This study was approved by the ethical committee of Japanese Red Cross Kanazawa Hospital (819).

The LJM measurement was performed on the right foot. Passive ROM of the plantar flexion and dorsiflexion of the ankle joint was measured. For ankle joint measurements, patients were placed in supine position with a roll placed under the right knee to produce slight flexion. The anatomical position of the subtalar joint was maintained. The stationary arm was the longitudinal axis of the fibula, and the movable arm was the sole of the heel. Measurements were performed by a physiotherapist, who was not the primary investigator in the study, using a double-armed digital goniometer (GM-180, Nippon Medical & Chemical Instruments, Co., Ltd., Japan) calibrated in 1° increments based on established methods¹⁵⁾. The maximum ROM of the ankle joint was measured thrice, and the mean value was calculated.

Characteristic data of participants such as age, body weight, and BMI were determined using one-way analysis of variance. They were compared between the four groups (HD, HDDM, DM, and C groups), with the Bonferroni test used for post hoc analysis. Other characteristic data such as hemodialysis duration and time since diabetes diagnosis were compared between the two groups using non-paired t-test. The influence of HD and DM on ROM of the ankle joint was determined using two-way analysis of variance. ROMs were compared between the four groups (HD, HDDM, DM, and C groups), with the Bonferroni test used for post hoc analysis. The significance level was set at $p < 0.05$. Statistical analyses were performed using SPSS for Windows version 10.4 software (SPSS, Inc., Chicago, IL, USA).

Table 1. Primary disease for which hemodialysis was performed

	n
Diabetes nephropathy	10
Glomerulonephritis	3
Chronical nephritis	2
IgA nephropathy	1
Nephrosclerosis	1
Polycystic kidney	1

Table 2. Characteristics of participants

	C	HD	DM	HDDM	p
Participants	10	8	27	10	
Age (years)	59.5 ± 6.6	56.8 ± 11.0	59.4 ± 5.7	62.3 ± 5.2	0.364
Body weight (kg)	67.8 ± 12.2	$60.1 \pm 11.5^*$	74.6 ± 11.4	$59.0 \pm 5.0^*$	0.001
BMI (kg/m ²)	23.4 ± 4.1	$21.1 \pm 3.5^*$	25.4 ± 3.5	$21.4 \pm 1.6^*$	0.003
Hemodialysis duration (years)		8.0 ± 4.8		4.1 ± 2.8	0.047
Time since diabetes diagnosis (years)			8.9 ± 7.7	21.9 ± 6.2	<0.001

Date are n or mean \pm SD.

C: control group; HD: hemodialysis without diabetes mellitus group; DM: non-hemodialysis with diabetes mellitus group; HDDM: hemodialysis with diabetes mellitus group. * $p < 0.05$ vs. DM.

RESULTS

Body weight, and BMI were significantly higher in the DM group compared with the HD and HDDM groups. Hemodialysis duration was significantly longer in the HD group compared with the HDDM group. Time since diabetes diagnosis was significantly longer in the HDDM group compared with the DM group (Table 2). ROM of the ankle joint for the HD, HDDM, DM, and C groups was $69.1^\circ \pm 14.2^\circ$, $56.0^\circ \pm 8.1^\circ$, $55.3^\circ \pm 8.5^\circ$, and $69.1^\circ \pm 9.2^\circ$, respectively; the DM group showed the most restriction, followed by the HDDM group. Based on the two-way analysis of variance, the main effect of DM was observed in ankle ROM, and the main effect of HD was not observed. There was no interaction between DM and HD (Table 3). Significant differences in ROM between the C and DM groups, C and HDDM groups, DM and HD groups, and HD and HDDM groups were noted, whereas no significant differences were found between the C and HD groups and DM and HDDM groups (Table 4).

DISCUSSION

This study is the first to investigate the influence of HD and DM on ROM of the ankle joint in patients undergoing HD who are at a high risk of developing foot ulcers. The most important finding in this study is that DM affects LJM of the ankle and that the DM and HDDM groups demonstrated greater ankle joint restriction than the other two groups without DM. Till date, many previous studies have shown that LJM of the ankle occurs in middle-aged and elderly participants^{1, 4, 6}. It has been reported that young patients with insulin-dependent DM tend to experience restricted ROM of the ankle joint¹⁶. The results of the present study support the results of these previous studies. One cause of LJM by DM is deposition of advanced glycation end products as a result of glycosylation stress on tendon and ligament tissue with low turnover¹⁷. Furthermore, advanced glycation end products reduce the sliding of collagen fibers, leading to loss of viscoelasticity of the entire soft tissue¹⁸. Therefore, the results of this study suggest that ROM of the ankle joint in patients with DM undergoing and not undergoing HD is restricted by the same mechanism. Further study may be necessary for the fact that ROM in the HDDM group was more affected by glycation stress than that in the DM group, as the HDDM group had a longer time since diabetes diagnosis than the DM group.

The second important finding of this study is that HD did not affect the ROM of the ankle joint. Rillo et al.¹³ reported the hypermobility of cervical vertebrae due to hyperlaxity of the ligament tissue as a side effect of HD, whereas Hurst et al.¹⁴ reported that LJM frequently occurs as a result of joint surface destruction in major joints, such as the shoulder and hip joints of patients undergoing HD. In these reports, ankle joints were not investigated, and to the best of our knowledge, there are no reports regarding ROM of the ankle joint in patients undergoing HD. Therefore, the novelty of this study is that it provides data suggesting that hemodialysis does not affect LJM (in particular, derived from the joint surface destruction of the ankle) in the ROM of male patients undergoing HD.

The finding of no interaction between HD and DM is also important. The importance of smoking cessation, exercise, and foot care for the prevention of foot ulcers in patients with or without DM undergoing HD has been reported⁸. Since there was no interaction between these two factors, LJM of the ankle of patients with DM undergoing HD should be treated to prevent foot ulcer without any concern for joint surface destruction. In patients with DM not undergoing HD, physiotherapy interventions aimed at improving muscle strength and ROM of the ankle joint by exercise¹⁹ and improving ROM of the ankle joint by manual therapy⁵ are valid. These interventions are important for patients with DM undergoing and not undergoing HD.

There are several limitations of this study. First, the enrollment criteria included only males aged 40–69 years. It is unclear if the findings are applicable to female patients as muscle flexibility²⁰ and ROM of the ankle joint²¹ is less restricted in females than in males. Furthermore, ROM of the ankle joint decreases with age^{16, 21}; therefore, older people experience greater joint restrictions, whereas younger people have greater joint motilities. Second, this study was conducted at a single hospital and the study cohort was small. Especially, the HD group were few. Thus, it will be difficult to apply these findings to all

Table 3. Results of analysis of variance

	F	p
Hemodialysis	0.018	0.894
Diabetes	21.946	<0.001
Hemodialysis × Diabetes	0.017	0.897

Table 4. Results of post hoc test for the ankle joint

Group	Compared group	Difference	p
C	DM	13.8	0.002
C	HD	-0.0125	1.000
C	HDDM	13.07	0.021
DM	HD	-13.8	0.004
DM	HDDM	-0.759	1.000
HD	HDDM	13.1	0.034

C: control group; HD: hemodialysis without diabetes mellitus group; DM: non-hemodialysis with diabetes mellitus group; HDDM: hemodialysis with diabetes mellitus group.

patients undergoing HD. Third, physical activity levels were not considered. Previous research has shown that low levels of physical activity can cause LJM in patients with DM⁶⁾. Therefore, future studies may benefit by including measurements and analysis of physical activity levels considering that patients undergoing HD have decreased physical activity^{22, 23)}. Another limitation is that body weight and BMI were significantly higher in the DM group compared with the HD and HDDM groups. Because Park et al. reported that ROM is limited by the effect of obesity²⁴⁾. Furthermore, future global research encompassing factors such as gender and race is essential.

Conflict of interest

None.

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