Skin Water in Persons with Diabetes Mellitus (DM) Assessed by Tissue Dielectric Constant (TDC) Measured at 300 MHz

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Background: Skin changes of various types occur in about 30-35% of persons with DM. Persons with type I are more likely to have autoimmune related skin lesions whereas persons with type II are more prone to cutaneous infections. In both types there appears to be a tendency for thinner skin and less than normal amounts of subcutaneous fat. The presence of such skin changes may indicate changes that alter skin water content that may precipitate further changes depending on the degree of glucose control since excess glucose leads to non-enzymatic chemical reactions between the carbonyl group of glucose and amino acids. This glycation of structural and regulatory proteins plays a role in the pathogenesis of diabetic skin complications such as diabetic ulcer or diabetic foot syndrome. But, it is not clear how changes in tissue water content that may be associated with differing HbA1c values affect this process.

Objective: We hypothesized that skin water as measured by TDC is inversely related to HbA1c in persons with DM and our main objective was to test this hypothesis.

Methods: Skin-to-fat tissue water was determined by measuring TDC at 300 MHz at anterior forearm, lateral calf and foot dorsum in DM patients who presented for a routine clinic visit. TDC measurements were made by touching the target skin site with a sensor for about 10 seconds. TDC values largely depend on the amount of free and bound water within the interrogation region. In this study four different sensors were used that allowed quantification to 0.5, 1.5, 2.5 and 5.0 mm below the epidermis. In addition, body composition parameters were determined using a bioimpedance scale (50 KHz). Parameters measured included percentages of total body water (TBW) and fat (TBF) and also fat percentages of arm (AFP) and leg (LFP). A total of 42 persons (28 female) participated in this study after signing an IRB approved consent form. Group age (mean ± SD) was 64.4 ± 15.2 yrs, 38 had type II, BMI was 27.3 ± 5.2 Kg/m², HbA1c was 8.2 ± 2.0 (5.5-13.9), TBF was 32.3 ± 7.9% and TBW was 48.6 ± 5.6%, AFP was 31.2 ± 9.6% and LFP was 34.9 ± 9.1%.

Results: TDC values monotonically decreased with increasing measurement depth at all sites (forearm, leg and foot) with TDC values at 0.5, 1.5, 2.5 and 5.0 mm depths being significantly different from each other (p<0.001). At all depths except 0.5 mm there were significant differences in TDC values among sites (p<0.001) with TDC values of foot greater than leg and leg greater than forearm. Analyses also showed that TDC values were significantly negatively correlated with HbA1c only for foot and then only at a 1.5 mm depth (r = -0.332, p=0.034). There was also a small positive correlation between HbA1c and AFP (r = 0.331, p=0.048).

Conclusions: The initial hypothesis, that there is an inverse correlation between TDC values and HbA1c, is weakly supported by the present findings. At most, the correlation of foot TDC values with HbA1c would explain only about 11% of the observed variation. We thus conclude that over the range of HbA1c values herein evaluated there is little effect of HbA1c on skin water as judged by TDC measurements. This finding suggests that persons with DM may be evaluated with TDC methods without fear of possible confounding effects related to variations in HbA1c. Further, the TDC values herein obtained provide a DM-related TDC reference data set.