Age-related differences in tissue dielectric constant values of female forearm skin measured noninvasively at 300 MHz

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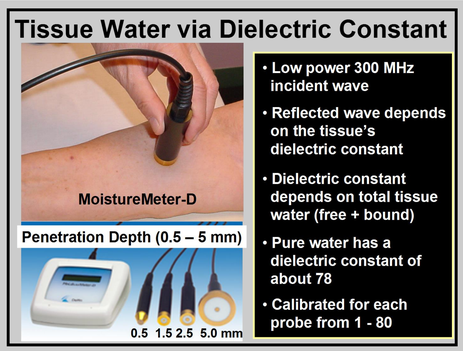
Background

Prior measurements[1] of stratum Corneum (SC) hydration at the volar forearm was shown to be greater in an older female group (60–80 years) compared to a younger group (18–39 years). This was found to be true with no apparent age-related difference in transepidermal water loss (TEWL). We believe an involved aspect is that SC and skin water are largely present as bound water[2] either tightly or loosely bound to macromolecules[3-4] but shift toward increased percentages of more mobile water with skin aging[5]. Since bound water[6] has a lower dielectric constant than mobile water[7–9] such a shift would be associated with an increase in measured capacitance. This could be interpreted as an increase in age-related water content.

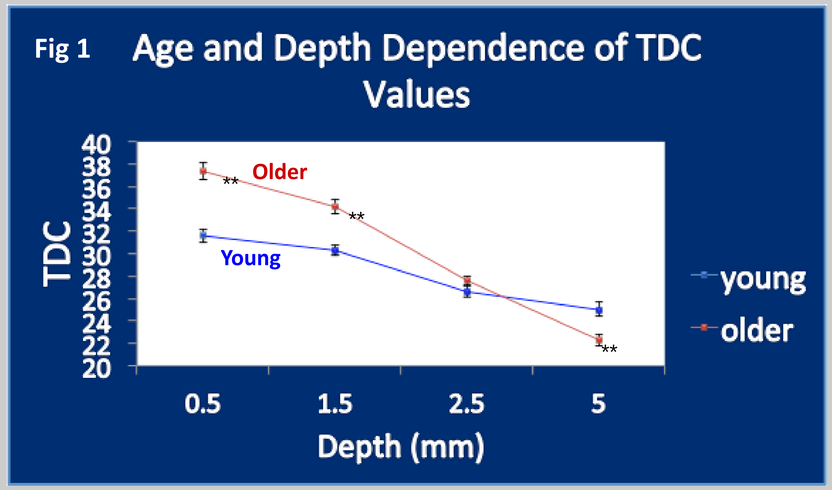
We hypothesized that a further manifestation of such changes in water state should cause an age-dependent increase in skin tissue dielectric constant (TDC) that is detectible at depths below the SC in and deeper to the dermis. Thus, one aim of this study was to test this hypothesis by measuring skin TDC values to several skin depths in groups of younger and older women. Further, because skin-to-fat TDC values show promise as a way to characterize skin water changes in a variety of circumstances and as a tool for lymphedema assessment[10–11] a secondary aim was to establish reference ranges suitable for use with young and older women.

Methods

Females (N = 270) in two age groups, young (20–40 years, N = 165) and older (≥60 years, N = 105) with Fitzpatrick's skin types II–IV were separated into four measurement groups (I, II, III, IV). TDC measurements were made with the MoistureMeterD. This device measures skin and skin-to-fat TDC at a 300 MHz by touching skin with the probe for about 10 s. All probes were used allowing TDC measurements to depths of 0.5, 1.5, 2.5, and 5.0 mm. Measurements were done with subjects supine on a padded table with arms resting palms up and started after being supine for a minimum of 5 min. Measured sites were both volar forearms 6 cm distal to the antecubital fossa with each site measured in triplicate. Measurements between right and left arms were alternated until three values per arm were obtained. The average was used to characterize TDC values and reported as the average of the two arms. This was done for each of the four effective measurement depths.



Results (TDC values are bilateral averages)



TDC values for young and older groups decrease with increasing depth ($P < 0.001$) with the older group having greater TDC values at the two shallower depths (0.5 and 1.5 mm) but a lesser value at the deepest depth; **$P < 0.001$ older vs young groups with no significant difference at 2.5 mm. Error bars are one SEM.

Results (Fig 1) show that within each age group TDC values monotonically decrease with increasing depth ($P < 0.001$).

For the older group, TDC values at all depths differed from all other depths ($P < 0.001$).

Comparisons of TDC values between age groups at each depth showed a pattern in which TDC values for the older group at 0.5 and 1.5 mm depths were both significantly greater than the younger group TDC values at corresponding depths ($P < 0.001$).

At a depth of 2.5 mm there was no significant difference between age groups ($P = 0.108$), and at a depth of 5.0 mm the direction of the difference reversed with the older group now having TDC values that were less than the younger group ($P < 0.001$).

References

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Conclusions

To our knowledge the present is the first systematic investigation and report of age-related differences in skin-to-fat TDC values between young and older females.

A major new finding based on these TDC measurements of volar forearm skin in a large number of females is that the magnitude and direction of differences between age groups depends on the depth of the tissue included in the measurement.

The greater TDC values of the older females measured at the shallower depths is consistent with the previously noted age-related shift in water state from mostly bound water to more mobile water with increasing age.

The reversal of the TDC difference at the deepest depth (5.0 mm) is not fully explainable based on a shift in water state.

Lastly, The present data provide a set of non-edematous forearm skin reference values that could be used to aid in detecting edema or lymphedema presenting in forearms.

This could be done by determining the departure of measured values from the reference set herein contained specific to the age- range group of the patient being evaluated and the depth of the measurement.