Tissue Dielectric Constant (TDC) as an Index of Skin Water in Women with and without Breast Cancer

Madeline Fasen1, OMS-II, DN Weingrad2, MD, FACS, Lidice Lopez2 P.A., HN Mayrovitz1, PhD

1 Nova Southeastern University, Ft. Lauderdale FL 2 Cancer Healthcare Associates, Aventura FL

Abstract

Background: Previous work showed tissue dielectric constant (TDC) measurements at 300 MHz useful to evaluate local skin water and showed a new hand-held compact version provided values similar to an original multi-probe system when assessed in healthy subjects.
Objectives: The goals of the study were to use the compact portable device to determine its utility in assessing age-related differences between younger healthy women vs. women with breast cancer, upper-arm site differences in women with breast cancer, and its utility and limitations of a single measurement vs. averaging triplicate measurements.
Methods: A total of 84 women were included: 42 were young (24.0±2.4 years) self-described healthy women (group A) and 42 were older (65.5±1.6 years) who were recently diagnosed breast cancer patients (group B). In both groups TDC values were assessed on the anterior forearm and in group B at the hand, forearm and biceps with all measurements bilateral and in triplicate.
Results: Results showed the following: 1) Forearm TDC values are similar for younger and older groups with no significant differences (NSD) between groups or between dominant and non-dominant sides or inter-arm ratios. 2) Hand TDC values are about 21% greater than forearm and biceps values but inter-arm ratios (at-risk/contralateral) are NSD among sites with values for hand, forearm and biceps of 1.027±0.180, 0.997±0.066 and 1.010±0.075 respectively. 3) Based on limits of agreement analyses, single TDC measurements are adequate for most forearm and biceps evaluations but multiple measurements likely needed for hand measurements. 4) Theoretical detection thresholds for unilateral tympanometry using a 350 limit of inter-arm ratios are 1.57, 1.20 and 1.24 for hand, forearm and biceps.
Conclusion: Forearm TDC values are similar for younger and older groups with no significant differences between groups or between dominant and non-dominant sides or inter-arm ratios, hand TDC values are 21% greater than forearm and biceps values but inter-arm ratios are not significantly different among sites, and single TDC measurements are likely adequate for most forearm and biceps evaluations but multiple measurements would be indicated for hand TDC evaluations.

Background

The goal of this study was to assess the applicability and potential limitations of a compact portable device that measures tissue dielectric constant (TDC) and to provide reference values for different age groups and anatomical locations. Prior work has shown TDC measurements made at 300 MHz, using either a multi-probe system or a compact device, accurately reflect local skin water values and their change. The specific aims of the present study were to use the compact hand-held version to 1) evaluate its utility in assessing age-related differences between younger healthy women vs. women with unilateral breast cancer (Group A) and 2) determine arm site differences in women with BC and 3) access the utility and limitations of single measurement vs averaging triplicate measurements.

Methods

TDC Measurement: The measurement is based on the principle that the TDC is directly related to the amount of free and bound water contained in the measuring volumes (Fig 3). The output used in this study was the hand-held compact device (MMDC) manufactured by Dolfino Technologies (Kupsil, Finland) as shown in Fig 2. The TDC of specific target areas was determined using a gentle skin contact for about 8 seconds. Prior work has indicated that effective penetration depth of the compact device is close to 2.5 mm. The measurement output is the TDC value that has a range of 1 to 80. For reference, water at a temperature of 34°C has a value of about 76.

Procedures: The 84 women in this study were evaluated and fulfilled entrance requirements as approved by the University IRB approved informed consent. Measurements were done on all subjects seated and began after a 10 minute acclimation rest interval. TDC values were measured bilaterally at three sites: Groups A and B were both measured on the anterior forearm, 6 cm distal to the antecubital crease (Fig 1b); Group B was also measured on the hand dorsum between thumb and index finger and on the anterior biceps 8 cm proximal to antecubital crease (Figs 1a and 1c).

Data Analysis: Age related differences (Group A and B) The average of triplicate TDC values at each site, denoted as TDC, was used to characterize each site's TDC value. TDCavg is calculated from the average dominant and non-dominant site TDC values. Variations among sites are calculated from the average dominant and non-dominant site TDC values. Differences among groups are calculated from the average dominant and non-dominant site TDC values. Variations among sites are calculated from the average dominant and non-dominant site TDC values. Variations among sites are calculated from the average dominant and non-dominant site TDC values. Variations among sites are calculated from the average dominant and non-dominant site TDC values. Variations among sites are calculated from the average dominant and non-dominant site TDC values. Variations among sites are calculated from the average dominant and non-dominant site TDC values.

Conclusions

Results Summary

Age related differences (Groups A and B) except for greater BMI of Group B (Table 1) all other measured forearm parameters were similar between groups with the average dominant and non-dominant TDC values (TDCavg) between groups being 2.4% with group B insignificantly greater. There were no group differences in the inter-arm ratios of either TDCavg, or Girnthcm. TDC values for dominant vs. non-dominant forearms were not significantly different between arms for group A (28.5±1.9 vs. 28.5±2.1, p<0.850) or for group B (29.0±3.5 vs 29.3±3.5, p<0.225). TDC values for corresponding arms were not significantly different between groups for the dominant arm (p = 0.579) or non-dominant arm (p = 0.300).

Variations among sites (Group B) Hand TDC values were found to be significantly greater (p<0.001) than forearm and biceps (Table 2) being about 20%-22% greater than each of the other sites. Hand and biceps were similar and not significantly different. Inter-arm TDC ratios (at-risk/contralateral arm) were similar among all three sites being 1.027±0.180 at the hand, 0.997±0.066 at the forearm and 1.010±0.075 at the biceps. Average TDC values vs Single TDC value (Group B) Triplicate averaged TDC values (TDC3) did not significantly differ from first TDC measurements (TDC1) on any site (Figure 5).

Conclusions

1) Forearm TDC values are similar for younger and older groups with no significant differences between groups or between dominant and non-dominant sides or inter-arm ratios.
2) Hand TDC values are about 21% greater than forearm and biceps values but inter-arm ratios are not significantly different among sites.
3) Single TDC measurements are likely adequate for most forearm and biceps evaluations but multiple measurements would be indicated for hand site TDC values.
4) The compact TDC device is well suited to the rapid assessment of skin tissue.

Acknowledgements

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