Purpose: Normal-tissue toxicity is a limiting factor in cancer radiotherapy that has yet to be objectively measured. Recently, quantitative ultrasound has shown promise in accurate diagnosis of normal-tissue toxicity in breast-cancer radiotherapy. However, current ultrasound evaluation entails the physician's manual delineation of the skin layers, which is time consuming and subjective. The purpose of this study is to develop a skin segmentation algorithm to automate ultrasound-based normal-tissue toxicity in breast-cancer radiotherapy.

Methods: We developed a skin segmentation algorithm based on the active contour method. We incorporated the skin segmentation algorithm into our ultrasound technique reported previously and developed an automated-tissue-toxicity-assessment (ATTA) program that computed the radiation-induced skin and subcutaneous tissue toxicity. Twenty-three breast-cancer patients previously treated with radiation were recruited, and a total of 720 ultrasound images from 72 ultrasound studies were used. To assess the performance of the ATTA program, two physicians manually contoured the skin layers of all the images and the toxicity level computation was performed based on their results. In this study, the three sets of results (two from physicians and one from the proposed ATTA method) were compared using two statistical methods: (1) the difference of skin thickness value was computed; and (2) an intra-class correlation coefficient (ICC) was calculated to evaluate inter-observer reliability.

Results: For the skin thickness measurements, the average percent differences between ATTA and two experts were 4.86% ± 17.8%, and -3.81% ± 21.1%, respectively. The ICC between ATTA and two experts ranged between 0.70 to 0.93, indicating ATTA's high accuracy and reliability.

Conclusions: We have developed a non-invasive ultrasound-based technology, which guarantees an objective documentation of the tissue toxicity in breast-cancer radiation therapy. Our ultrasound technology offers a unique opportunity to quantify tissue injury in a more meaningful and reproducible manner than the subjective scales currently employed in the clinic.

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