Comprehensive Assessment of Cutaneous Wound Healing by High-Frequency Ultrasound Image, Quantitative Parameters, and Contrast Agents Perfusion

Da-Ming Huang[1], Huang-Chen Lin[1], Shyh-Hau Wang[1, 2], [1]Department of Computer Science and Information Engineering; [2]International Center for Wound Repair and Regeneration, National Cheng Kung University, Tainan, Taiwan

Background, Motivation and Objective

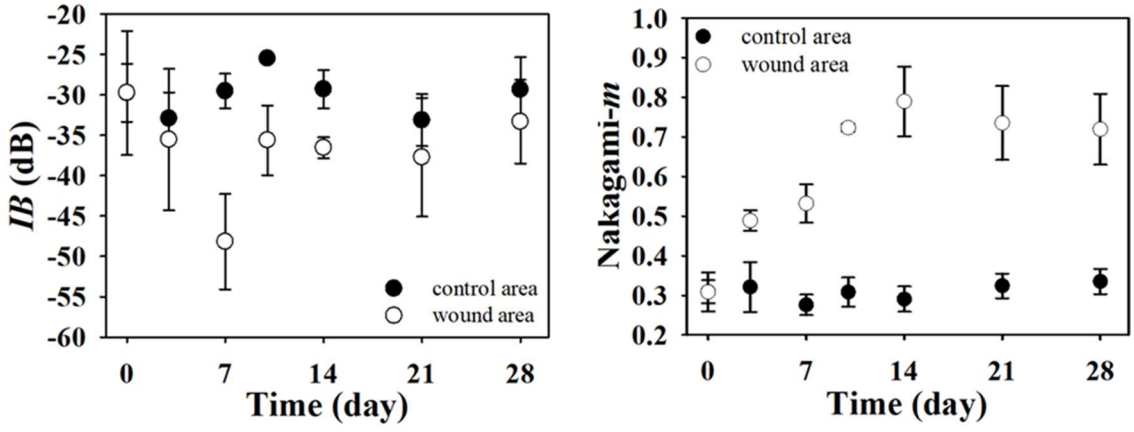
Assessment of cutaneous wound healing is crucial for oral and maxillofacial surgeons to diagnose the recovery of patient's facial lacerations and elective incisions and to provide better treatment for possible deformities in the wound tissue. A technique capable of in situ and noninvasively measuring the wound tissue properties covering the stages of wound repair is certainly essential. To meet this clinical demand, a high-frequency ultrasound system incorporated with measurements of backscattering tissue structure, shear-wave mechanical property, and blood perfusion by ultrasound contrast agents was developed and verified by animal experiments.

Statement of Contribution/Methods

The wound model of 1×1 cm^2 full-thickness incisions was made on the back of each experimental rat. A sequence of measurements with a 30 MHz ultrasound system was performed to acquire signals of healthy and wound skins lasted for four weeks. In addition to B-mode image, such ultrasound parameters as the integrated backscatter (IB), Nakagami-*m*, and shear-wave velocity (SWV) were estimated to better assess the wound tissue properties quantitatively. Furthermore, the perfusion of wound site was measured by the intravenous injection of microsphere contrast agents and in which the time-intensity curve (TIC) and associated parameters were calculated.

Results/Discussion

The IB, consistent with variation of B-mode images, tended to decrease immediately with that the skin incision was made and reach to a minimum at day 7 of wound healing. The decrease of echogenicity corresponded well the hemostasis and inflammation phases of wound healing. IB gradually increase with the proliferation and maturation phases of wound healing. The statistical Nakagami-*m* tended to increase gradually and then start to saturate at the day 14 of wound healing. The increase of Nakagami-m after day 14 was partially due to the formation of stronger and alignment echoes in the wound area verified by B-mode and Nakagami-m images. Moreover, both arrival time and area under curve of TIC in wound tissue tended to increase immediately after the surgery and that corresponded well to the hemostasis phase where the blood circulation was destroyed. The blood perfusion corresponding to neovasculature did not fully recover to value of normal skin. The SWV indicated similar tendency to reach to a maximum at day 7 of wound healing, and that could correspond to the formation of unstable tissue structures in the inflammation and proliferation phases. These results demonstrated that high-frequency image, quantitative parameters, and perfusion may be further applied to sensitively assess the cutaneous wound healing.



Ultrasound quantitative parameters as a function of cutaneous wound healing.