had failed the clinical standard of care or complex wounds where modalities beyond skin grafting would have been required.

METHODS: Biomedical manufacturing of a small full-thickness skin harvest into the AHSC cell-tissue product followed by application into a clean wound bed. Wound closure, AHSC % take, volume restoration, hair-follicle presence, 2-point discrimination, bioimpedance, pigment propagation, Raman spectroscopy, and histomorphologic assessment of regenerated skin were conducted on regenerated skin specimen when possible.

RESULTS: The entire cohort of 15 patients had successful wound preparation and application of AHSC following full-thickness skin harvest. No repeat treatment with AHSC or STSG was required for AHSC-treated wounds. No donor site complications were reported. All patients had complete AHSC take and wound coverage at the time of follow-up (average, 4.0 ± 2.9 months). Two-point discrimination, bioimpedance, Raman spectroscopy, and histomorphologic analyses showed that AHSC-regenerated skin was analogous to native skin. Hair follicles were present in healed AHSC-treated wounds and were similar to native skin hair follicles on histomorphologic and Raman spectroscopy analysis.

CONCLUSIONS: This novel treatment method demonstrated regeneration of full-thickness skin with minimal donor site morbidity and was able to cover exposed underlying structures in complex wounds. Due to the observed results, utilization of AHSC can be considered as a therapeutic option for patients suffering from burns, complex wound reconstruction, chronic wounds, and traumatic defects. Therapy utilizing AHSC can be performed by surgical and nonsurgical trained clinicians and midlevel providers across a variety of care settings, including resource-poor areas. AHSC demonstrated safe and efficacious treatment for the complete closure of complex cutaneous wounds refractory to conventional therapies and cases involving open deep structures not amenable to reconstruction with STSGs alone.

A Novel Suture Training Device to Innovate the Surgical Curriculum in Medical School

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PURPOSE: Suture training is a critical component of the medical school curriculum because it serves as the first opportunity to learn proper technique. For those students who enter surgical specialties such as plastic surgery, early and repetitious practice is crucial in developing competence for residency. Currently, the majority of medical schools in the United States utilize suture training tools such as porcine feet or sponges to simulate human tissue. At our institution, satisfaction survey data have indicated dissatisfaction with the accessibility, quality, and longevity of these materials. Herein, the purpose of this project is to devise a novel tool for suture training using medical grade silicone and a 3-dimensional (3D)–printed stencil to create life-like, standardized tissue defects.

METHODS: Our plastic surgery department’s 3D printing laboratory developed a 10 × 5 × 2 cm mold. Using Blender software, tissue defects of varying depths, shapes, and sizes were included in the design. Different textures of silicone were poured into the mold and dyed with pigment to simulate the layers of skin, fat, and muscle. Plastic surgeons were consulted on material textures and layer depths. Study outcomes included a 30-question survey given to fourth year medical students following a 30-minute practice session with the silicone device. Questions measured texture characteristics and similarity of suture material to human tissue on a scale from 1 to 5 (5 being identical to human tissue). Additionally, the survey assessed limitations with current suture training models and impression of this novel device’s educational utility.

RESULTS: Twenty-five fourth year medical students participated in the study. All (n = 25) had sutured on human tissue an average of 46.0 (SD: 66.0) times. Additionally, all participants had sutured on porcine feet and sponges. The most common barriers to self-directed suturing practice were accessibility to material (n = 23) and material longevity (n = 20). The mean score for the silicone pad’s tissue layers (4.20, SD: 0.5) and “feel” (4.36, SD: 0.64) was significantly higher (P < 0.0001) than those for porcine feet (2.52, SD: 1.00; and 2.48, SD: 0.87, respectively) and sponges (1.21, SD: 0.51; and 1.38, SD: 0.65, respectively). Upon assessment of varying suturing techniques on each material, the mean scores for the silicone pad’s interrupted sutures (4.56, SD: 1.411), running sutures (4.30, SD: 0.62), and knot tying (4.44, SD: 0.711) were significantly higher (P < 0.0001) than those for porcine feet (3.08, SD: 1.04; 2.16, SD: 0.85; and 3.36, SD: 0.95, respectively) and sponges (1.75, SD: 0.85; 1.66, SD: 0.816; and 2.04, SD: 0.99, respectively). All (n = 25) participants stated that the silicone suture pad was the best tool to practice suturing, and 92% (n = 23) stated that their suturing skills would be better or much better if the silicone pads replaced porcine feet and sponges during medical school.

CONCLUSION: Preliminary survey data demonstrate that the silicone suture pad generated with a 3D-printed stencil
serves as a portable and realistic training tool. Additional evaluation with a greater sample size of medical students is needed to further compare the device’s ability to enhance the medical school suturing curriculum.

**Effect of Keratinocytes on Myofibroblasts in Hypertrophic Scars**

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**PURPOSE:** Scars instigate cosmetic problems and, importantly, lead to various complications including pain, itchiness, and motor impairment, caused by mismatch at the interface of the scar and normal tissues, and recurrence of the wound. Abnormal scarring, such as that in fibrosis, and keloid and hypertrophic scars, is a pathologic process, distinctive from the normal physiologic process of wound healing. During wound healing, myofibroblasts play a central role in matrix formation and wound contraction and, at the end of the healing, undergo apoptosis. Hypertrophic scarring is a pathologic condition in which myofibroblasts persist in the tissue. It has been hypothesized that abnormalities in epidermal-dermal crosstalk cause this pathology. Therefore, in this study, we investigated whether myofibroblasts are affected by keratinocytes.

**METHODS:** The present study was a prospective, single-center study. In this study, transforming growth factor-β1 treatment was used to establish experimental myofibroblast model, termed Imyo, from the patient-derived dermal fibroblasts. The Hmyo (hypertrophic myofibroblasts) cells are the myofibroblasts isolated from the existing hypertrophic scars from patients. Although both the Imyo and the Hmyo should represent characteristics of myofibroblasts, their physiologic state would be different. Transforming growth factor-β-induced myofibroblasts (Imyo) and myofibroblasts from hypertrophic scar tissue (Hmyo) were characterized by microarray. The analysis of microarray data using the fold change criteria revealed >600 upregulated genes in Imyo and Hmyo compared to control group among the 5,761 genes, from which 83 genes of significant increase were selected for further analysis. The changes in the genes expressed in Imyo, Hmyo, and normal fibroblast upon coculture with keratinocytes were quantitatively analyzed by quantitative polymerase chain reaction.

**RESULTS:** Based on the microarray data, among the selected pool of 83 genes with upregulated genes, 21 genes showed similar expression levels, which may indicate the genes of the stage-independent myofibroblasts. On the other hand, 62 genes whose expression levels with >2-fold difference between the Imyo and Hmyo may reflect the stage-specific difference in myofibroblasts. We found that many extracellular matrix- and smooth muscle cell–associated genes were upregulated in Imyo and Hmyo, respectively, suggesting that Hmyo are fully differentiated myofibroblasts and Imyo are less differentiated compared to Hmyo. Decreased collagen type 1 gene expression was shown in keratinocytes cocultured Imyo and Hmyo and a smooth muscle actin expression in Imyo increased in the presence of keratinocytes.

**CONCLUSION:** These observations strongly suggest that keratinocytes play a role in the development of pathologic fibrosis in hypertrophic scar by influencing the behavior of dermal fibroblasts and myofibroblasts. We speculate that keratinocytes inhibit abnormal scarring in the early stages of scarring, when fibroblasts differentiate into protomyofibroblasts, by reducing the expression of COL1A1 and α-SMA, and contribute to improving scars in the hypertrophic stage, when fibroblasts have already been differentiated, by reducing α-SMA expression. We believe that this study provides the basis for understanding the pathophysiology of hypertrophic scarring and uncover new therapeutic approaches for this dysfunction.

**A Tissue Expander–like Scaffold With Photothermal Tumor Ablation Property for Breast Tissue Engineering**

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**BACKGROUND:** Tissue engineering–based breast reconstruction after mastectomy is a promising alternative to traditional treatments. Nevertheless, it could so far neither prevent the potential breast cancer recurrence nor solve the problem of covered skin shortage.

**PURPOSE:** Here we reported the construction of a novel breast tissue engineering scaffold. Benefiting from the photothermal effect of graphene, it can ablate breast cancer cells and recover its shape in a tissue expander-like manner.