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CASE REPORT
Reconstructive

Full-thickness Skin Micro-columns within a Dermal Matrix: A Novel Method for "Donor-free" Skin Replacement

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Summary: Split-thickness skin graft has been the standard in the coverage of large full-thickness skin defects. However, donor sites can be associated with significant pain and scarring. Further, the recipient sites frequently lack some basic skin functions, such as temperature regulation, uniform texture, appropriate color, normal pliability, elasticity, and lubrication. Full-thickness skin grafts, while able to more adequately recapitulate skin function, have even greater donor site requirements. Implantation of full-thickness skin micro-columns is a relatively novel concept in which the skin is harvested orthogonally rather than tangentially. These micro-columns contain elements of full-thickness skin grafts, including reticular dermal fibroblasts, hair follicles, skin adnexa, and adipose tissue—all elements that contribute to skin function. Notably, it has been shown that the diameter of the skin micro-columns determine donor site morbidity; however, in most cases, full-thickness skin micro-column harvest results in a trivial donor site far less invasive or morbid than a traditional full-thickness skin graft or split-thickness skin graft harvest. Here, we present 2 cases in which full-thickness skin micro-columns were harvested and implanted into a bilayer dermal regeneration matrix (Integra) to achieve durable single-stage skin replacement with practically no donor site morbidity. *(Plast Reconstr Surg Glob Open 2020;8:e3304; doi: 10.1097/GOX.0000000000003304; Published online 18 December 2020.)*

INTRODUCTION

Large skin defects missing a significant portion of dermis are unlikely to heal on their own. Standard of care to treat these wounds often involves coverage with split-thickness skin grafts (STSG) made up of epidermis and upper dermis, harvested from intact skin, and often meshed to cover a larger surface area wound.[1,2] STSGs, however, have numerous disadvantages. First, procurement poses a challenge in cases where the area requiring coverage is extensive and patients lack enough intact, healthy skin to serve as a graft. Additionally, meshing can result in an aesthetically unappealing "fish-net" appearance once healed.[2] Because STSGs only include the upper dermis, they lack the skin appendages that afford much of its functionality such as hair follicles, sweat glands, and reticular dermal fibroblasts, resulting in dysfunctional scars upon healing.[3,4] Full-thickness skin grafts (FTSG) have an improved cosmetic outcome when compared with STSGs and can better recapitulate near-normal skin appearance and function. However, there are few sites that can serve as donors, and requirement for "take" is greater, resulting in higher failure rates for non-optimized wound beds.[2]

Full-thickness skin micro-column (FTSC) harvest is a novel technique that aims to capture the benefits of FTSG while mitigating the downsides. These micro-columns, which consist of all skin layers and components, are harvested using a skin biopsy punch and manually implanted into a bilayer dermal matrix to create a composite substrate (graft) to treat full-thickness wounds.

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CASE REPORTS

Case 1

Case 1 is a 90-year-old woman with a history of chronic bilateral lower extremity edema who developed bilateral hematomas after minor traumas. These wounds failed to heal and required debridement at the time of presentation. Following debridement, the wounds were full-thickness,

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necessitating coverage. However, both the patient and her daughter declined treatment with an STSG, given concerns regarding the morbidity associated with the donor site. A 2-mm biopsy punch was utilized to harvest 9 skin columns from her upper thigh and implanted into a 6-cm^2 Integra bilayer dermal matrix and secured using sutures. A soft dressing was applied and the donor site was covered with Tegaderm. By postoperative day 30, both the wound and donor site had healed with minimal scarring or pain.

Case 2

Case 2 is an 88-year-old woman with a history of multiple squamous cell carcinomas who presented with a mass on the volar aspect of her left arm. The mass was excised and allograft was placed as temporary coverage while awaiting pathology report. As the patient's skin was very thin and fragile, her family was concerned that an STSG would result in significant donor site morbidity, as the harvest would likely extend down to fat and thus heal very poorly. For this reason, FTSCs embedded within Integra was offered for coverage. A 1.5-mm biopsy punch was used to harvest 58 skin columns from her right lateral thigh (Fig. 1). The FTSCs were implanted into a 30-cm^2 Integra bilayer dermal matrix, applied to the wound, secured with suture, and covered with a negative pressure wound dressing (Fig. 2). By postoperative day 30, the donor site had completely re-epithelialized (Fig. 3), and by postoperative day 60, both the wound and donor site had healed with minimal scarring or pain (Fig. 4).

For both cases, a biopsy punch of the same size as that of the FTSCs was used to make a hole through the dermal matrix in its entirety but not through the silicone layer.

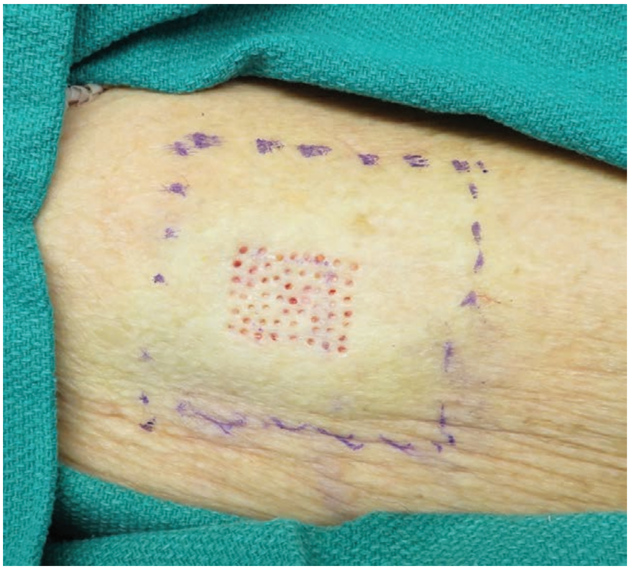

Fig. 1. Case 2, postoperative day 0. Donor site immediately following harvest of 58 skin columns from the right lateral thigh.

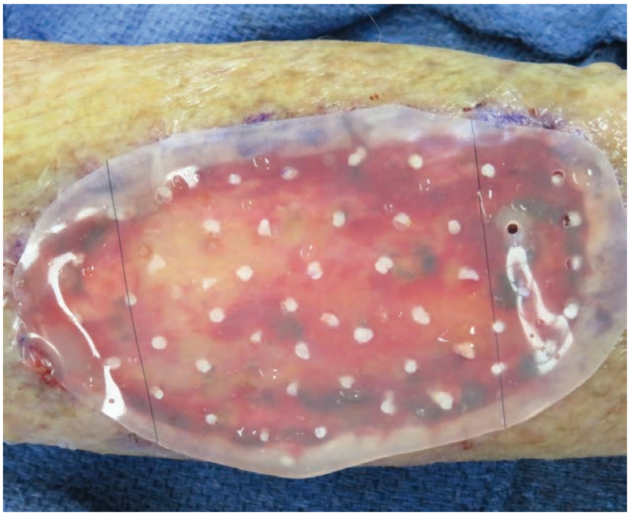

Fig. 2. Case 2, postoperative day 0. Placement of FTSC within bilayer dermal matrix onto clean, open wound.

Fig. 3. Case 2, postoperative day 30. Donor site free of hyperpigmentation and scarring and entirely re-epithelialized.

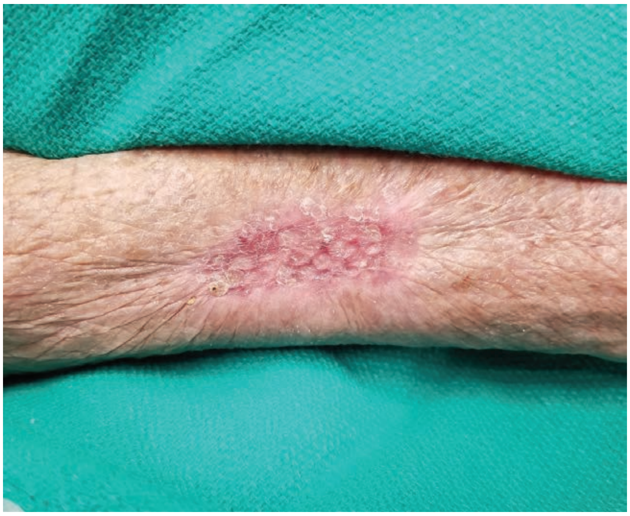

Fig. 4. Case 2, postoperative day 60. Upper extremity wound completely re-epithelialized.

FTSCs were then placed within the holes with the epidermal portion toward the silicone layer. As the epidermis was visualized proliferating under the silicone layer, the silicone layer became loose and started separating from the dermal matrix, at which time the entire silicone layer was removed.

DISCUSSION

Emerging research has revealed the benefits of FTSC in the recapitulation of skin appendages and minimal scarring and pain at donor sites, when compared with STSG.[2,3,5] Combining various forms of tissue digestions (including vascular fragments with dermal matrices) has also previously been found to improve re-epithelialization and revascularization.[6,7] The concept behind this improvement can be applied to the FTSC seeding of dermal matrices; the dermal matrix serves as a necessary scaffold into which the FTSCs can expand, and provides a temporary wound covering before re-epithelialization. The punch specimen placed into the dermal matrix retains an intact microvascular network within its basal end, providing multiple pre-formed vascularized networks from which neovasculature can proliferate the matrix and vascularization can be improved. This is likely due to not only the presence of the vessels themselves but secretion of various vascular growth factors as well.

Utilizing FTSCs to cover full-thickness wounds has many advantages. First and foremost, the procedure itself is not difficult. It can be performed in most facilities and is cost effective, as widely available punch biopsies are used to harvest the skin columns. As biopsies of this size are often taken under local anesthesia, it could be theorized that this procedure could be performed at the bedside. Shortcomings of FTSC harvesting include that the process of punching and then implanting the skin columns into the dermal matrix template is time-consuming and tedious. Although the process of FTSC harvest itself is not costly, if implanting the FTSCs into a dermal matrix template, as performed in these cases, the cost could dramatically increase. Additionally, one could argue that the small wound described in Case 1 could have closed on its own via secondary intention. The wound in Case 2, however, was large enough to require intervention—a fact supported by evidence of epithelialization occurring centripetally from around the skin columns, instead of solely from the wound periphery. Although we have seen similar healing taking place with wounds treated with Integra alone, the healing process often takes longer and more contraction occurs. However, more research is needed regarding the healing of wounds covered by Integra alone by secondary intention. Additional research must also be carried out to determine whether skin columns need to be oriented properly when applied, to conclude the optimal ratio of skin column harvest and implantation, and to establish whether or not FTSCs are in fact able to reliably reproduce skin appendages important to retaining the skin's numerous functions. These case reports indicate that FTSC harvest is an effective method for skin harvesting to successfully heal full-thickness wounds while minimizing scarring and pain at the donor sites.

CONCLUSIONS

Here we have described, to our knowledge, the first clinical usage of FTSCs embedded in bilayer dermal matrices for successful durable coverage of full-thickness defects in 2 patients without any perceivable donor site morbidity. Further developments are needed to achieve a wide clinical adoption of this technique as an alternative to conventional skin replacement therapy.

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