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Case Report

Applications of Synthetic Hybrid-Scale Fiber Matrix in Head and Neck Reconstruction: A Case Series

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Head and neck reconstruction · Synthetic fiber matrix · Wound healing · Electrospun · Surgical

Abstract
Introduction: Patients with head and neck cancer often necessitate complex reconstructions, considering both functional and esthetic concerns. Reconstructions are further complicated by previous radiation therapy and patient co-morbidities, which impair wound healing. A recently introduced synthetic hybrid-scale fiber matrix has been shown to provide durable wound coverage and promote tissue healing as an alternative to traditional biologic allogenic and xenogenic skin substitutes. ***Case Presentation:*** Thirteen patients were treated at a single academic hospital between December 1, 2021, and May 1, 2023 with the synthetic matrix in head and neck reconstructions. Reconstructions included exposed muscle, scalp wounds, intra-oral defects, and radial forearm free flap donor sites. Wound sizes ranged from 2 × 2 cm to 18 × 10 cm. Serial photographs were taken to evaluate wound healing at 1, 4, 8, 12, and 16 weeks timepoints after application. Outcomes measured at each timepoint included wound size, presence of granulation tissue, and extent of epithelialization. No hematomas or wound complications were encountered. Complete wound healing was noted between 6 and 12 weeks, dependent on wound size. The synthetic matrix significantly promoted wound healing via early granulation tissue formation and epithelialization, or mucosalization, in all head and neck applications. Scar formation and contracture were acceptable in all cases. ***Conclusion:*** The use of synthetic hybrid-scale fiber matrix promotes wound healing and avoids patient morbidity associated with traditional allogenic and biogenic treatments, such as split-thickness skin grafts. This synthetic matrix has been demonstrated to be a valuable asset in the head and neck reconstructive armamentarium.

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Introduction

Head and neck reconstruction poses numerous challenges to surgeons worldwide. The resultant defects tend to impact not only patient esthetic concerns but also impair functions of daily living, including breathing, talking, and eating. Specifically, in the area of head and neck oncologic reconstruction, patients are predisposed to poor wound healing secondary to prior radiation therapy, malnutrition, and common co-morbidities such as smoking and alcohol consumption [1–3]. The reconstructive algorithm used in head and neck reconstruction continues to follow the traditionally taught reconstructive ladder, with an emphasis on loco-regional flap and free tissue transfer for larger defects. However, due to the diverse nature of head and neck wounds, many reconstructive surgeons continue to routinely use biologic xenogeneic or allogenic skin substitutes such as split-thickness skin grafts in their practice [2, 4–6]. The pitfalls of xenogeneic or allogenic skin substitutes lie in their poor durability, the inherent risk of disease transmission, and subsequent inflammatory response with biologic materials [4, 7]. Although effective for complex cutaneous wounds, split-thickness skin grafts also carry the burden of requiring a separate surgical procedure, anesthesia risks, creation of a potentially painful donor site, and the possibility of hypertrophic or keloid scarring [8].

An alternative to biologic and xenogeneic skin substitutes has emerged in the wound care armamentarium in the form of a synthetic hybrid-scale fiber matrix [9, 10]. The biocompatible matrix stimulates cellular ingrowth and granulation tissue through its synthetic fiber architecture, which mimics native human extracellular matrix. This aligned nanoscale arrangement allows cellular ingrowth on the fibers themselves, ultimately leading to neovascularization in the wound. This synthetic hybrid-scale fiber matrix has been previously shown to treat surgical wound beds in similar applications analogous to split-thickness skin grafts; however, its usage has not been studied in head and neck surgical reconstruction [10]. The objective of this case series was to evaluate the use of synthetic hybrid-scale fiber matrix in various applications in surgical head and neck oncology and reconstruction.

Materials and Methods

Patients with various head and neck wounds were treated with a synthetic hybrid-scale fiber matrix (Restrata, Acera Surgical, Inc., St. Louis, MO, USA) at an academic non-university based hospital between December 1, 2021, and May 1, 2023. Institutional Review Board approval was granted by HCA Healthcare PubClear 2023 MS #1174. Written informed consent was obtained from the participants and Case 1 patient's next of kin for publication of the details of their medical case and associated images.

Patients were enrolled retrospectively as well as prospectively via a review of patient charts. All patients received one application of the synthetic matrix, which was secured to the wound bed using dissolvable sutures and in some cases, a temporary bolster method. Coverage choice was based on application location and included Mepitel AG (Molnlycke Health Care US) with Xeroform (Covidien), or bolstering with Adaptic (3M) and a Xeroform pressure dressing with Kerlix (Covidien), or a negative pressure wound therapy device (V.A.C. ULTA Therapy System [3M]) at −100 mm Hg.

Each case was carefully monitored through the healing process, and photographs were taken to document progress at various time points. Time points included 1 week, 4 weeks, 8 weeks, 12 weeks, and 16 weeks after surgical application. Outcomes measured at each time point included wound size, presence of granulation tissue, and extent of epithelialization.

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Case Series

A total of 13 patients were included in this case series. All patients received one application of the synthetic hybrid-scale fiber matrix during head and neck reconstructive surgeries. Reconstructive applications included placement on exposed muscle following flap surgery, exposed scalp wounds, intra-oral full-thickness defects, and radial forearm free flap donor site wounds. Initial wound sizes ranged from 2 cm × 2 cm–18 cm × 10 cm.

Serial wound photographs were taken to evaluate wound healing at various time points, including 1 week, 4 weeks, 8 weeks, 12 weeks, and 16 weeks after surgical application. Outcomes measured at each time point included wound size, presence of granulation tissue, and extent of epithelialization. This section highlights four cases treated with the synthetic hybrid-scale fiber matrix, which resulted in significant healing. All cases were documented to be fully healed by 12 weeks after application of the synthetic hybrid-scale fiber matrix, with the vast majority of cases achieving full wound closure by 10 weeks. A complete list of patients treated in this case series can be found in Table 1. The CARE Checklist has been completed by the authors for this case series, attached as online supplementary material (for all online suppl. material, see https://doi.org/10.1159/000539200).

Case 1

A 59-year-old male, initially treated for T2N0M0 squamous cell carcinoma (SCC) of the larynx in the periphery with definitive radiotherapy, presented to clinic with a biopsy-proven recurrence 11 months after treatment. He was surgically treated with a salvage total laryngectomy, bilateral neck dissections, and an anterolateral thigh free flap reconstruction in an on-lay fashion. Final pathology was staged as a pT4aN1M0 SCC. Unfortunately, his post-operative course was complicated by a persistent right-sided pharyngeal pharyngocutaneous fistula that failed conservative measures, including daily packing and pressure dressings. The decision was made to perform a right pectoralis major muscular rotational flap to close the fistula definitively. A right muscle-only pectoralis major flap was raised in the standard fashion and reflected superiorly and inset in the right neck along the level of the fistula tract. In lieu of a split-thickness skin graft, a 5 cm × 7 cm sheet of synthetic hybrid-scale fiber matrix was placed on the exposed muscle. The synthetic matrix was sutured in place using 3-0 vicryl on an SH-1 needle and covered using Mepitel Burn, sutured down using 2-0 Silk on an SH-1 needle (Fig. 1a). A Xeroform dressing was placed overtop and changed daily (Fig. 1b). The Mepitel dressing was removed on post-operative day 14. The patient continued to follow up on a regular basis to monitor wound healing progress (Fig. 1c). Complete re-epithelialization was achieved 86 days after the initial application of the synthetic hybrid-scale fiber matrix (Fig. 1d).

Case 2

A 71-year-old male presented with a biopsy-proven squamous cell carcinoma in situ of the floor of mouth and ventral tongue. Physical examination demonstrated a 3 cm × 5 cm area of the ventral tongue extending to the vestibule and floor of mouth that is discolored with a central scar from recent biopsy. An oncologic ablative surgery was performed, which left a 5 cm × 4 cm area of exposed floor of mouth musculature and ventral tongue. A 5 cm × 7 cm sheet of synthetic hybrid-scale fiber matrix was placed on the wound bed and sutured in place using 3-0 vicryl on an SH-1 needle (Fig. 2a). This was covered with a Xeroform bolster, sutured to the surrounding intact mucosa using 2-0 silk on an SH-1 needle. The patient was discharged the same day as surgery on a soft diet. A bolster was left in place for 14 days and subsequently removed without difficulty in clinic (Fig. 2b). The patient was

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Table 1. Head and neck applications of synthetic hybrid-scale fiber matrix

Patient No.	Indication	Anatomical location	Defect size	Wound Vac	Healing time, weeks	Total follow-up
1	Exposed muscle	Right neck following pectoralis major flap	5 × 7 cm	No	6	4 months
2	Exposed skull without pericranium	Posterior scalp, occiput	10 × 12 cm	Yes, 4 weeks total	10	12 months
3	Exposed muscle, neck contents	Submentum	4 × 2 cm	No	3	9 months
4	Exposed muscle, anterolateral thigh flap	Left lateral neck	4 × 4 cm	No	6	4 months
5	Exposed muscle	Right neck following pectoralis major flap	5 × 5 cm	No	6	10 months
6	Exposed skull, with pericranium	Vertex scalp	15 × 8 cm	No	12	12 months
7	Wound dehiscence following radiation therapy	Left posterior neck	2 × 2 cm	No	6	8 months
8	Left radial forearm free flap donor site	Left volar forearm	7.5 × 5 cm	Yes, 1 week total	12	11 months
9	Exposed tongue and floor of mouth musculature	Ventral tongue	5 × 4 cm	No	3	10 months
10	Inner lining of paramedian forehead flap	Right paramedian forehead flap, nasal recon	1 × 4 cm	No	4	4 months
11	Exposed muscle	Right neck following pectoralis major flap	4 × 4 cm	No	6	2 months
12	Exposed muscle	Left neck following pectoralis major flap	5 × 7 cm	No	6	3 months
13	Exposed skull, intact pericranium	Vertex scalp	3 × 5 cm	No	6	6 weeks

Healing time was defined as 100% epithelialization/mucosalization of the wound bed based on clinical photographs.

placed on Augmentin (Amoxicillin/Clavulanate Acid) antibiotics for the 14 days while bolster was in place. Complete resolution and mucosal healing was noted at 4 weeks post-operatively (Fig. 2c).

Case 3

An 87-year-old male presented to clinic with a biopsy-proven well differentiated squamous cell carcinoma of the vertex scalp. He had multiple prior surgeries, including Mohs resections of this area in the past. His past medical history was significant for a recent

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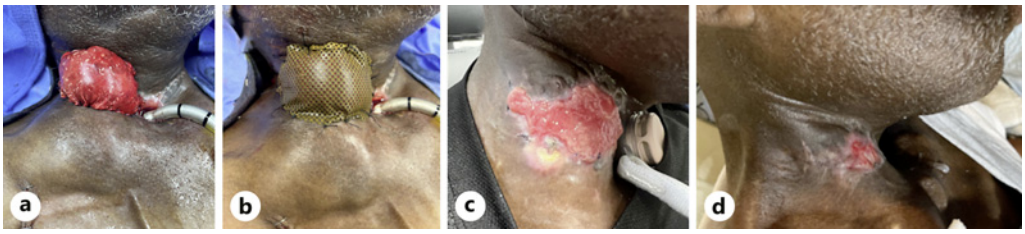

Fig. 1. Case 1. **a** Initial application of the synthetic hybrid-scale fiber matrix to pharyngeal pharyngocutaneous fistula. **b** Mepitel dressing sutured over the synthetic matrix. **c** 38 days after synthetic matrix application. **d** 86 days after synthetic matrix application.

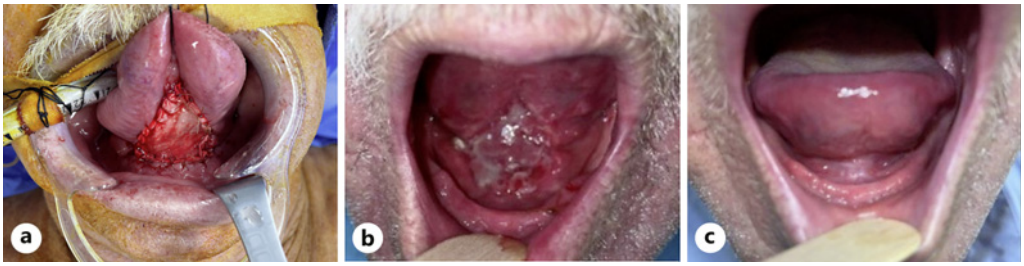

Fig. 2. Case 2. **a** Initial application of the synthetic hybrid-scale fiber matrix to defect of ventral tongue and floor of mouth. **b** After bolster removal and 2 weeks after synthetic matrix application. **c** Fully healed at 5 weeks after synthetic matrix application.

myocardial infarction, prior coronary artery bypass surgery, diabetes mellitus type 2, and he was on multiple medications, including Coumadin. His lesion measured approximately 15 cm × 8 cm and was resected down to the exposed skull, including pericranium. Under general anesthesia, his skull was drilled down to the diploic bleeding bone. A sheet of synthetic hybrid-scale fiber matrix was placed on the open wound, followed by Adaptic and a wound vac. Complete resolution and mucosal healing was noted at 12 weeks post-operatively.

Case 4

A 62-year-old male presented to clinic with a biopsy-proven moderately differentiated squamous cell carcinoma of the left retromolar trigone referred by a local oromaxillofacial surgeon. His past medical history was complicated by insulin-dependent diabetes mellitus, hypertension, pancreatitis, and a history of deep vein thrombosis. He underwent an extensive composite oromandibular resection, ipsilateral selective neck dissection, and a left osteocutaneous radial forearm flap reconstruction. A 7.5 cm × 5 cm perforated sheet of synthetic hybrid-scale fiber matrix was used on the forearm donor site, secured with 4-0 Chromic Gut suture, in addition to a negative pressure wound therapy device overtop for 7 days. Antibiotic prophylaxis in the form of Cefazolin 1 gm IV q8h and Metronidazole 500 mg IV q12h was given for 24 h following surgery. The wound was photographed at multiple time periods in the healing phase (Fig. 3a–c), and complete resolution of the wound was observed at 12 weeks post-operatively in clinic (Fig. 3d).

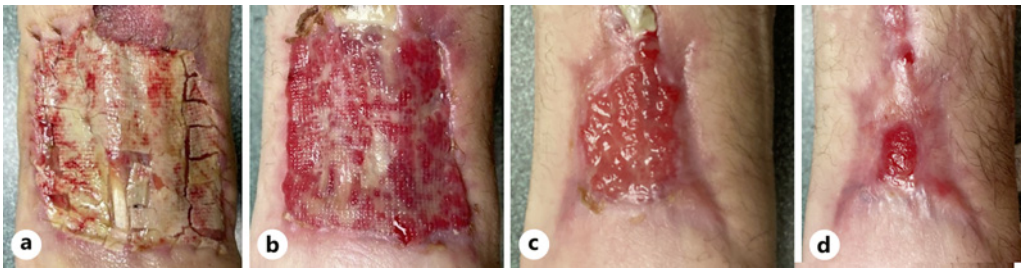

Fig. 3. Case 4. **a** 7 days after application of the synthetic hybrid-scale fiber matrix to radial forearm donor site. **b** Increased granulation tissue observed in wound bed 14 days after synthetic matrix application. **c** 6 weeks after synthetic matrix application. **d** 12 weeks after synthetic matrix application.

Discussion

Head and neck reconstruction requires thoughtful consideration from an esthetic and functional standpoint, which results in utilizing the entire reconstructive ladder. It is not uncommon for head and neck oncologic patients to have multiple risk factors for poor wound healing, such as advanced age, peripheral disease, ongoing smoking, or having previously radiated and/or operated vascular tissue in the area requiring reconstruction [1–3]. These patients are inherently poor candidates for complex surgical reconstructions, including free tissue transfer. The ability to quickly and efficiently treat complicated, co-morbid head and neck patients with a synthetic hybrid matrix under local anesthesia in the clinic, or a short general anesthetic in the operating room, is a valuable tool for head and neck oncologic and reconstructive surgeons. The above case series demonstrates the variety of uses of a synthetic hybrid matrix in the head and neck, with acceptable healing outcomes in various scenarios.

Traditional treatment for complex head and neck wounds has been the use of allogenic split-thickness skin grafts, often taken via a dermatome at a secondary surgical site such as the outer thigh [11]. Allogenic split-thickness skin grafts are a popular reconstructive technique among head and neck surgeons based on their immediate availability and versatility. However, split-thickness skin grafts require the creation of a secondary wound, which can result in possible donor site pain and morbidity [5, 8, 11]. It is our experience that patients often complain of more pain at their split-thickness skin graft donor site than their free tissue transfer donor site or their head and neck wounds themselves. Other disadvantages of split-thickness skin grafts include keloid scarring, hypo and hyperpigmentation, and superficial infections [8].

Another well studied agent in complex wound coverage of the head and neck is acellular dermal matrix (ADM), which is a biologic product composed of a basement membrane and a dermal collagen layer. With the ability to strip cellular contents of the product, ADMs have been shown to be able to evade the host immune response [2, 4, 5, 7, 12]. In addition, they have been shown to promote neovascularization of the head and neck in endoscopic skull base surgery [13]. The most widely used dermal matrices in head and neck applications are AlloDerm and Integra. Sinha et al. [5] published results on ADM coverage of radial forearm free flap donor sites in 2002, which resulted in minimal wound complications and acceptable patient cosmesis. However, the main disadvantage of ADM lies in its susceptibility of infection and lack of an epidermal layer leading to prolonged wound healing time of up to 12 weeks [5].

Prior groups have published the utility of the synthetic hybrid-scale fiber matrix in wound settings, including diabetic foot ulcers, traumatic wounds, enteroatmospheric abdominal fistula, and exposed hand tendons [10]. In addition, in a recent cost analysis, Fernandez et al. [10] demonstrated that the use of a synthetic hybrid-scale fiber matrix resulted in both less operating room time and lower total cost of case when compared to traditional treatments,

including split-thickness skin grafts. This case series is the first study to examine the various applications of the fiber matrix in head and neck reconstruction.

This case series is not without limitations, which include a relatively small sample size of 13 patients. The retrospective nature of case series, in general, depends on a careful review of the available medical records, which can lead to accuracy concerns. We did not utilize a standardized wound healing metric for time to healing; however, accurate photographs at various time points were collected. In addition, the timing of follow-up clinic visits depended on oncologic care and was influenced by scheduling appointments around adjuvant treatment, such as radiation therapy. Therefore, the exact time in which a wound closed may not have been recorded until the next clinic visit. No control arm was used with our preliminary case series. Other wound care products were used in conjunction with the synthetic hybrid-scale fiber matrix, including Adaptic, Xeroform, Kerlix, and VAC therapy, which could have impacted or influenced the rate of healing in combination.

Conclusion

The above case series demonstrates the successful application of a synthetic hybrid matrix in various head and neck reconstructive scenarios, including exposed skull, exposed muscle, and donor sites of free tissue transfers. This product can be used as a low risk, low morbidity alternative to split-thickness skin grafts and other allogeneic and xenogeneic skin substitutes. These results warrant further investigation in the form of prospective non-inferiority or randomized control study compared to split-thickness skin grafts in head and neck reconstruction moving forward.

Statement of Ethics

This research was supported (in whole or in part) by HCA Healthcare and/or an HCA Healthcare affiliated entity (Institutional Research Board PubClear 2023), approval reference: (MS #1174 July 6, 2023). The views expressed in this publication represent those of the author(s) and do not necessarily represent the official views of HCA Healthcare or any of its affiliated entities. Written informed consent was obtained from the participants and Case 1 patient's next of kin for publication of the details of their medical case and associated images.

Conflict of Interest Statement

The first author, P.H., is a consultant for Acera Surgical.

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P.H. serves as a consultant for Acera Surgical, Inc. The funder had no role in manuscript writing, nor the design, data collection, data analysis, or execution of this study.

Author Contributions

P.H.: writing – original draft, review, editing, study conceptualization, investigation, and data collection. S.S.: review. D.N. and J.H.: investigation and review. All authors reviewed and approved the final version of this manuscript.

Data Availability Statement

All data generated or analyzed during this series can be found within this manuscript. Further inquiries can be directed to the corresponding author.

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