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Bovine fetal collagen reinforcement in a small animal model of hernia with component repair

Kevin G. Cornwell, PhD,[a,*] *Feng Zhang, MD, PhD,*[b] *and William Lineaweaver, MD*[c]

[a] *TEI Biosciences Inc., Waltham, Massachusetts*
[b] *Division of Plastic Surgery, University of Mississippi Medical Center, Jackson, Mississippi*
[c] *Joseph M. Still Burn and Reconstruction Center, Jackson, Mississippi*

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ABSTRACT

Background: Component separation is a surgical strategy used to achieve abdominal wall reconstruction for patients with significant ventral hernias. With an increasing number of variations in procedural techniques and materials, the development of a small animal model of this surgery would allow for the controlled evaluation of variables with analytics not available in human clinical studies. To test this model, we investigated the reinforcement of these component repairs in rats with a bovine fetal collagen (BFC) scaffold.
Methods: Fifty Sprague Dawley rats were randomized into either component repair alone or BFC reinforced component repair. At time points up to 1 y, these groups were evaluated for hernia formation, strength of repair, strength of mesh-muscle interface, and histology of the repair site.
Results: Anterior component separation was achievable and reproducible in this small animal model. Significantly fewer hernias were found in BFC reinforced repairs. The change in transverse abdominal length was lower for reinforced repairs indicating less external oblique retraction, and reinforced repairs were consistently stronger than controls through 1 y. BFC was revascularized and repopulated with host cells but not rapidly degraded.
Conclusions: This small animal model of hernia repair with anterior component separation was effective in evaluating the reinforcement of a hernia repair with mesh. It may be useful in future work for the controlled, comparative investigation of different repair techniques and mesh materials in anterior component separation hernia repairs. Additionally, bovine fetal collagen was found to effectively reinforce component repairs and undergo an assimilation process including rapid revascularization and repopulation with host cells followed by gradual extracellular matrix remodeling.

1. Introduction

Strategies for ventral hernia repair and abdominal wall reconstruction include a great number of varying surgical repair techniques [1] and materials [2]. These procedures are reported to have high rates of complications including recurrence. Since described by Ramirez *et al.* [3], component separations have become more common for achieving midline closure of the disrupted abdominal wall [4,5]. However, component repair techniques and reinforcement methodologies can vary significantly and lack prospective randomized data on effectiveness.

* *Corresponding author*. TEI Biosciences Inc., Boston, MA. Tel.: 617-268-1616; fax: 617-268-3282.
E-mail address: kcornwell@teibio.com (K.G. Cornwell).
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The problem of abdominal wall reconstruction, therefore, would benefit from a more detailed understanding of the specific effect of technical variables and different materials used supplementary. To this end, the first goal of this research was to develop a reproducible small animal model of ventral hernia repair with component separation that could be studied with analytics not possible in human clinical studies.

A recently published clinical series of standardized component repairs found that reinforcement with a bovine fetal collagen (BFC) dermal matrix resulted in a reduction of hernia recurrence compared to other materials [6]. Selective CT imaging of these intact repairs found evidence that the BFC matrix assimilated in the reconstructed abdominal muscle layer, with a thick tissue remaining for lasting reinforcement [6]. Therefore, another goal of this study was to use the model to investigate the effects of bovine fetal collagen onlay reinforcement on hernia recurrence, strength of repair, and assimilation with the host over time.

2. Methods

2.1. Study design

Fifty male Sprague Dawley rats (Charles River Labs, Wilmington, MA) weighing 275–300g each were randomized into two treatment groups in this TEI Institutional Animal Care and Use Committee approved study conducted in the TEI Surgical Research Labs. The component repair only control group consisted of a surgically created ventral incisional hernia repaired with an anterior component separation and midline fascial closure. The experiment group had the same repair, with a bovine fetal collagen (SurgiMend, TEI Biosciences, Boston, MA) onlay reinforcement. Five animals per variable were then assigned to five time points including 2, 4, 12, 26, or 52 wk. After surgery, animals were housed in individual cages, monitored daily, and fed *ad libitum*.

2.2. Surgical methods

Animals were anesthetized by isoflurane, shaved, and the skin prepped with povidone iodine. A 5-cm skin incision was made at the midline, and extensive lateral skin flaps were raised distally. A midline incision was made through the linea alba beginning 1 cm below the xyphoid process and extending 4 cm in length to simulate a midline ventral hernia. Anterior component separation was achieved by incision through the external oblique muscles just distal to the semilunar line from the costal margin superior to the inguinal ligament inferiorly. The abdominal wall was sutured closed primarily at the midline with a loose running 4-0 polypropylene suture (Fig. 1). In the experimental animals, the same procedure was followed with the addition of BFC matrix. The 1-mm thick BFC matrix (SurgiMend 1.0, Boston, MA) was hydrated in sterile room temperature saline and stitched to one lateral cut edge of the external oblique muscle with degradable suture (4-0 Polyglactin 910). The BFC matrix was then laid across the abdomen and trimmed to coincide with the lateral cut edge of the external oblique muscle on the opposing side. This side was then sutured to external oblique muscle with 4-0 degradable suture completing the reinforcement (Fig. 1). In both control and experimental animals, marking sutures (4-0 polypropylene) were placed superior and inferior to the midline incision to allow measurement of the change in abdominal length with time. Marking sutures were also placed in the external oblique muscles just distal to the relaxing incisions to measure changes in abdominal width including external oblique retraction with time (Fig. 1). Measurements of the vertical and horizontal distances between marking sutures were recorded. The skin was then closed with stainless steel wound clips.

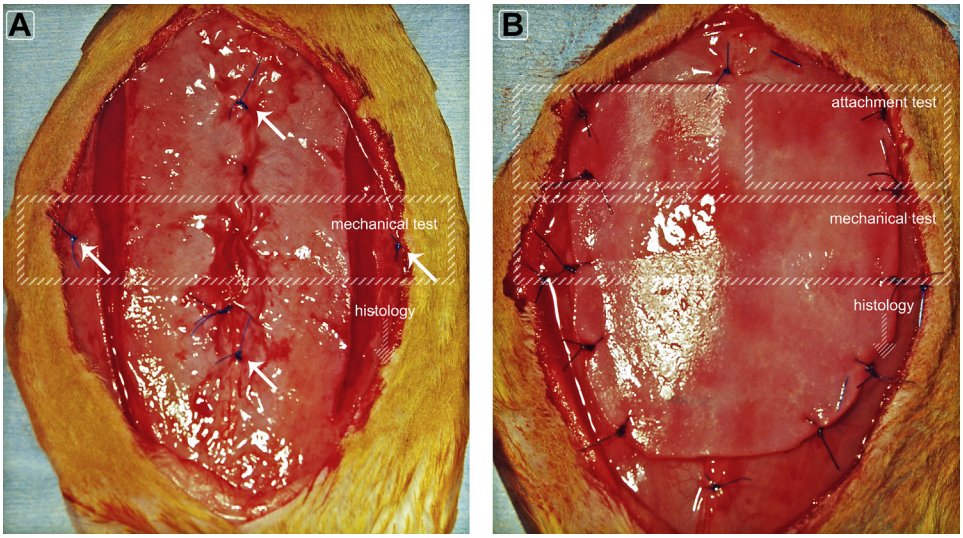

Fig. 1 – Surgical technique and methods. After anterior release of the external oblique muscles, midline incisions were closed with running permanent suture (A). In half, the animals BFC was placed as an onlay reinforcement and secured with interrupted degradable suture to the lateral cut edge of the external obliques (B). Areas later used for mechanical testing, histology, and attachment testing on explants are noted in white. Permanent marking sutures are noted with white arrows. (Color version of figure is available online.)