FINITE ELEMENT ANALYSIS MODELING AND PRECLINICAL STUDY TO ASSESS THE TISSUE STRAINS AND GRANULATION DURING NEGATIVE PRESSURE WOUND THERAPY WITH INSTILLATION USING A FELTED FOAM WITH 10 MM HOLES

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Background

Not all patients with wounds are able to undergo surgical debridement. Negative pressure wound therapy with instillation and dwell (NPWTi-d) using a felted, reticulated open cell foam with an array of 10 mm holes (VFCC*) has been used in clinic with NPWTi-d to eliminate non-viable material from the wound bed.[1]

Purpose

To evaluate the predicted finite element analysis (FEA) modeled tissue response of VFCC and VFC-NTH (no through holes) foams to the actual response in an *in vivo* porcine, derived-slough model (VFC†).

Methods

For this FEA model, skin was modeled as Neo-Hookean with a Young's Modulus of 0.05 MPa and Poisson's ratio of 0.15. Foam samples were compressed between steel platens to 70% compression to generate stress strain curves used in the model. For the preclinical study, 5 cm diameter, full-thickness wounds were created at day 0 in a swine model. This study complied with the Animal Welfare Act and followed recommendations in the Guide for the Care and Use of Laboratory Animals. *In vitro* derived-slough was applied to the wounds at day 0 and covered with a non-adherent dressing. NPWTi-d using VFCC was initiated using a repeating 10 min soak period and 3.5 h negative pressure period at -125 mmHg. Dressings were changed every 2 or 3 days.

Results

FEA Results:

Peak maximum principal strain imparted to tissue at -125 mmHg was 27.8% for VFCC and 0.8% for VFC-NTH. The frictional work around the holes in the VFCC was 0.18 mJ. When the modeled holes were removed (VFC-NTH), frictional work across the foam was negligible. The strain energy imparted to tissue with VFCC was approximately 0.89 mJ and 1.36 x 10-4 for VFC-NTH.

Table 1. FEA results for Max Principal Strain, Frictional Work and Strain Energy

Dressing	Max Principal Strain (%)	Frictional Work (mJ)	Tissue Strain Energy (mJ)
VFCC	27.8	0.18	0.89
VFC-NTH	0.8	0.00	1.36 x 10^4

Results (Cont'd)

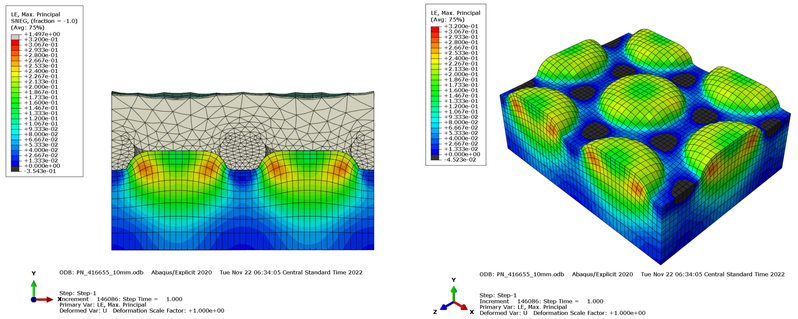

Figure 1A. FEA analysis of Maximum Principal Strain in the macrodomes of tissue during NPWTi-d with VFCC. Note the high areas of macrostrain at the sides of the tissue macrodomes as the tissue is pulled up into the 10 mm through holes.

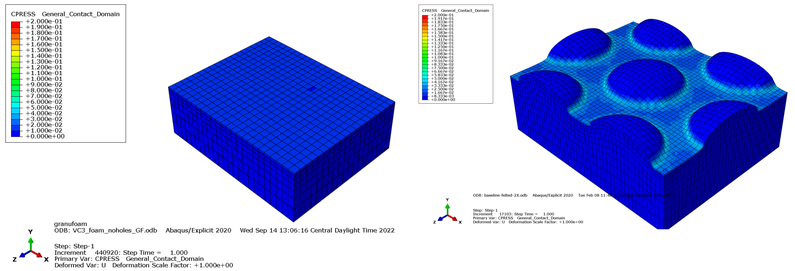

Figure 1B. FEA analysis of frictional work during NPWTi-d with VFCC. Note the areas of frictional work around the tissue macrodomes as the tissue is pulled up into the 10 mm through holes.

Results (Cont'd)

Preclinical Results:

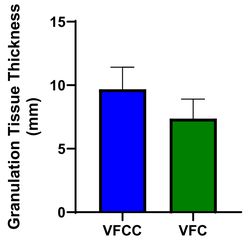

Figure 2. At study term, the granulation tissue thickness for wounds using VFCC was significantly thicker than for VFC (9.7 +/- 1.7 mm vs 7.4 +/- 1.5 mm).

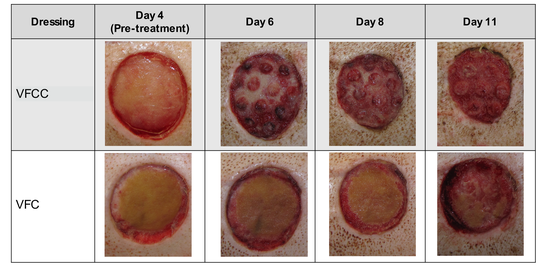

Figure 3. Visual representation of slough removal over the course of the study. Note the difference in appearance between VFCC and VFC wounds. Less slough was present in VFCC wounds at days 6 and 8.

Conclusions

The through holes in VFCC foam leads to higher forces imparted to the tissue than for VFC-NTH foam. Frictional work around the 10 mm holes may hold the tissue and or tissue covering in place under the holes leading to higher (macro) strain energy as the tissue is pulled up into the holes. This frictional work done by the dressing with NPWTi-d may allow for fracturing and removal of the tissue covering (devitalized tissue) following softening and solubilization during the instillation phase. The preclinical results using the VFCC foam demonstrated slough removal and an increased granulation response corresponding to the FEA results. The holes in the VFCC may allow for islands of macrostrain across the wound bed, which in turn assist with the hydromechanical removal of slough and devitalized tissue.

References

1. Matthews, M.R. Cureus, 2018. DOI: 10.7759/cureus.3632

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***VFCC - 3M™ V.A.C. Veraflo™ Cleanse Choice™ Dressing (3M, Maplewood, MN) †VFC- 3M™ V.A.C. Veraflo™ Cleanse™ Dressing (3M, Maplewood, MN)**

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