DALHOUSIE UNIVERSITY
FACULTY OF ENGINEERING

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DeCell Technologies

DALHOUSIE UNIVERSITY
FACULTY OF MEDICINE
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School of Biomedical Engineering

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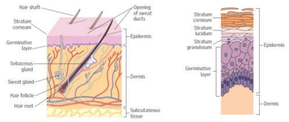
PIPEN: An Apparatus for Delivering Cell Culture used in Wound Healing Applications

RATIONALE

To design a device (PIPEN) that utilizes Aqueous Two-Phase Systems (ATPS) to deliver cells to a dermal matrix for wound healing application.

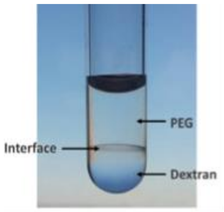


Skin consists of three layers:
1. Epidermis
2. Dermis
3. Subcutaneous tissue

PIPEN will aid in healing wounds by enhancing the formation of the epithelial (outer) layer of the skin.

Aqueous Two-Phase Systems (ATPS)

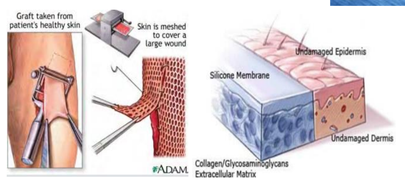
- Two immiscible polymer solutions
- Used to print cell in specific pattern
- Mimics the epidermis layer of skin



DermGEN™

- Sterile structural matrix
- Derived from human tissue
- Mimics dermal layer of skin

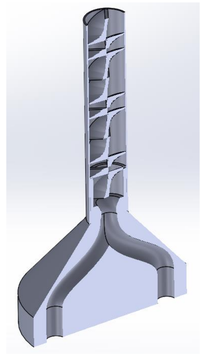
Current Treatment



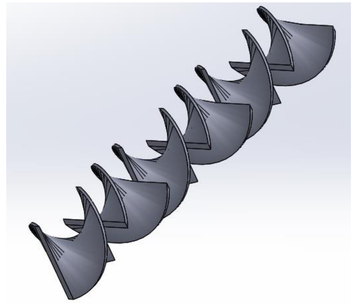
Currently two main methods of treatment are used: skin grafting from the patient and Integra™ artificial skin replacement

DESIGN OBJECTIVE

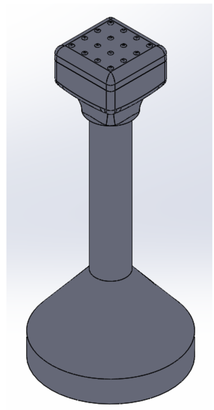
To create an engineered device that mixes cell culture media and dextran (DEX) solution, and dispenses the mixture onto the DermGEN™ dermal matrix coated with a layer of polyethylene glycol (PEG) solution.

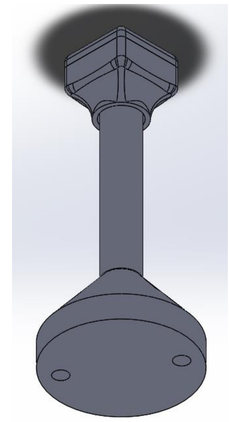


Holding Unit connected to Static Mixer

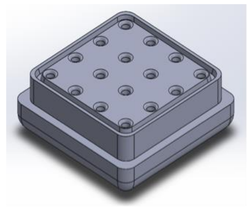


Static Mixer

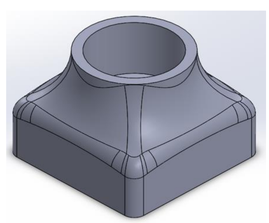




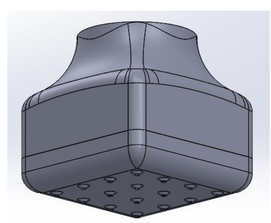
Assembly



Dispensing Head



Dispensing Head Connecter

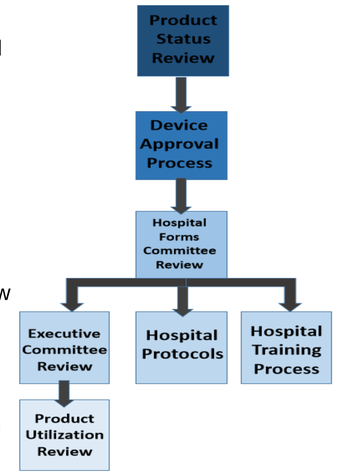


Assembly of Dispensing Head Elements

CONCLUSION AND IMPLEMENTATION

The PIPEN design met the required design criteria to dispense patterned cells shown previously to enhance wound healing.
For future work, fluid simulation of the entire device will verify fluid velocity, pressure and cell culture mixing.

Furthermore, improvements to the apparatus should include a controlled dispensing system to allow consistent application of cells.
A finalized implementation strategy should include considerations for mass production of the product and an associated economic analysis. In addition, the design must ensure sterility for patient safety.



Implementation Strategy Flow Diagram

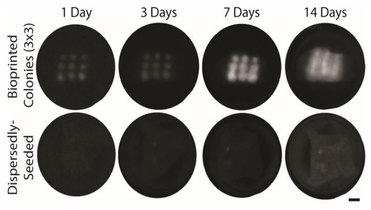
ACKNOWLEDGMENTS

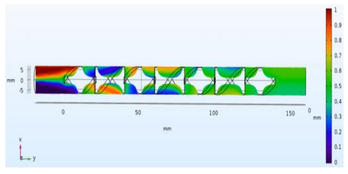
The Chemical Engineering Senior Design Team would like to express their gratitude and appreciation to Associate biomedical engineering Professors Dr. John Frampton and Dr. Paul Gratzer (Co-Founder of DeCell Technologies Inc.), Chemical Engineers Michele Hastie, Jonathan Totten, and Dr. Jan Haelssig for their collaboration to make this project a success. We would also like to thank Dr. Jack Rasmussen from the Department of Critical Care in the Queen Elizabeth II Hospital.

TARGET OF DESIGN

Three design specifications were identified for the use of the device and the application of the cell culture colonies.

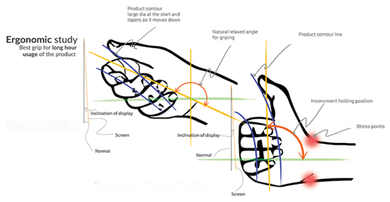
(1) 4x4 Grid Pattern for Cell Culture Printing enhances epidermal cell growth and viability





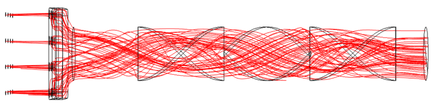
(2) Mixing within the device leads to even volume distribution and a homogenous mixture

(3) An ergonomic design for easy hand-held application by clinicians

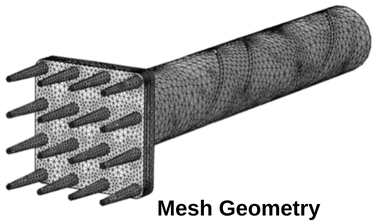


VERIFICATION OF THE PIPEN: Mixing, Velocity, Pressure

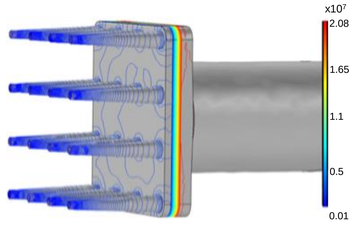
COMSOL Simulations



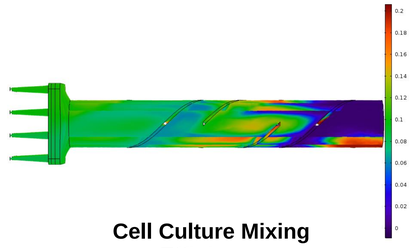
Fluid Velocity Streamlines at 3.25 m/s



Mesh Geometry

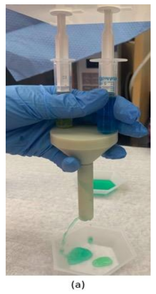


Pressure Contours with Induced Pressure Gradient

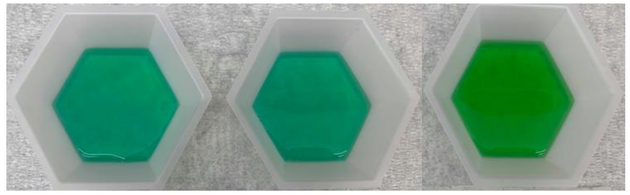


Cell Culture Mixing Efficiency

Experimental Evaluations



(a)



(b) (c) (d)

(a) coloured dyes were used to observe mixing efficiency (DYE1 – Yellow, DYE2 – Blue)

(b) mixing water (DYE1 & DYE2) ***without*** the static mixer

(c) mixing DYE1 and DYE2 ***with*** the static mixer

(d) mixing 5% DEX (DYE1) and water (DYE2) with the static mixer (lost 0.38mL ± 0.1mL)