

Automated Stem Cell Separation

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INTRODUCTION

- Stem cells are able to replace unhealthy cells and can be used to treat spinal cord injury, heart disease, arthritis, burns, etc.
- Adult adipose tissue is a plentiful source of stem cells
- Current chemical processes break apart adipose tissue
- Chemical Processes are not approved by the FDA



Problem Statement: To create a device capable of mechanically breaking apart adipose tissue to release stem cells for regenerative medicine.

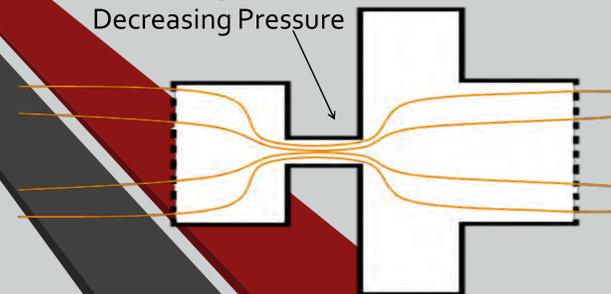
SOLUTION: CAVITATION

- Human fat tissue, obtained through liposuction, is run through the device
- Shock waves cause the tissue holding the cells together to burst
- The strength of the stem cells themselves is great enough to prevent their breakdown



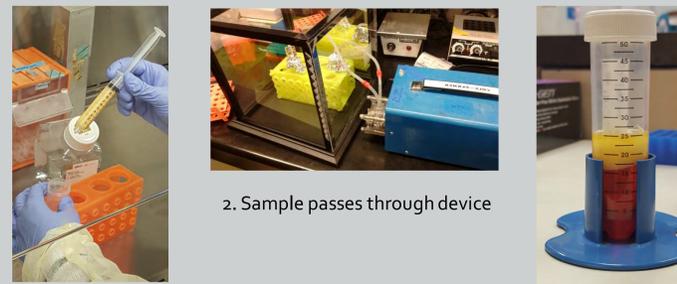
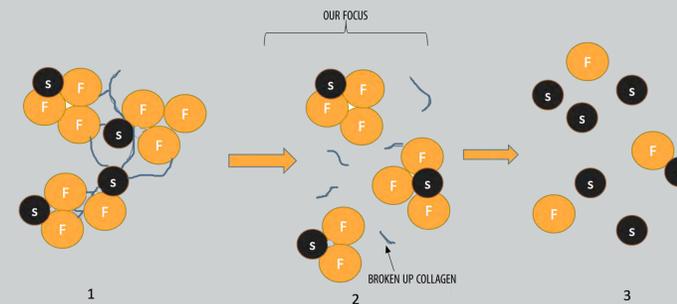
Image Courtesy: <http://s201.photobucket.com/user/kenuwfi/media/cavitation.jpg.html>

Increasing Velocity
Decreasing Pressure



Fluid velocity increases
↓
Fluid pressure drops with increased velocity
↓
Pressure drops low enough to initiate a phase change
↓
Bubbles of vapor form and subsequently collapse, releasing a shockwave

PROCESS



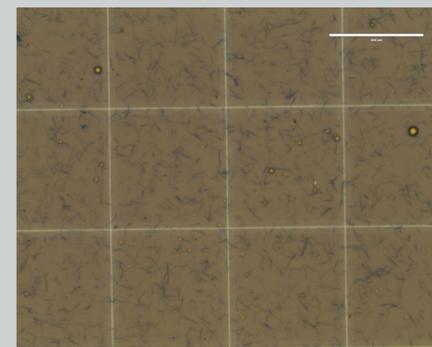
1. Untreated Fat Sample

3. Separation of cells into stromal vascular fraction

RESULTS



Cell counting using hemocytometer



Metric	Units	Marginal Value	Target Value	Actual Results: Single Orifice	Actual Results: Multiple Orifice
Adipose Breakdown	Ratio to input	3:1	10:1	6:1	10:1
Mechanical (Meets FDA Regulations)	Boolean	-	True	True	True
Viability of Stem Cells	% of collagenase	> 50%	> 70%	933%	2167%

DESIGN & MANUFACTURING

In order to determine the required orifice diameter the following equations were utilized:

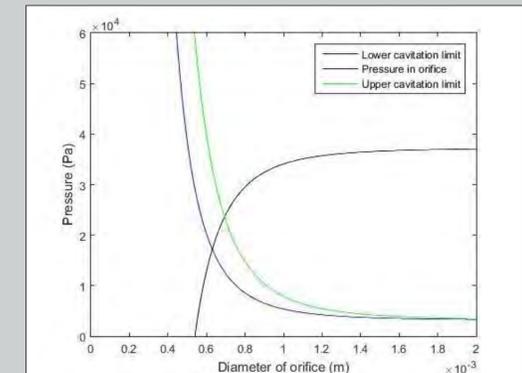
Bernoulli's:

$$P_1 + \frac{1}{2} \rho V_1^2 + \rho g h_1 = P_2 + \frac{1}{2} \rho V_2^2 + \rho g h_2$$

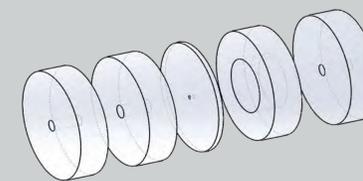
Cavitation number, K:

$$K = \frac{2(P - P_v)}{\rho V^2}$$

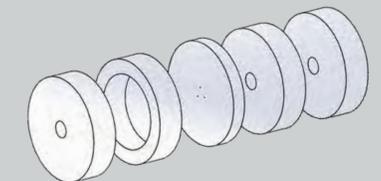
P = static pressure of fluid at the cross section
 ρ = density of the flowing fluid
 g = acceleration due to gravity
 v = mean velocity of fluid flow at the cross section
 h = elevation head of the center of the cross section with respect to a datum.



Orifice diameter vs. pressure at a fixed flow rate of 150 mL/min



CAD design of single orifice device



CAD design of multiple orifice device



Laser cutting disks out of acrylic prepped with adhesive



Disks ready for assembly



Cavitation device fully assembled, cleaned, and cured



Device during testing of human fat

CONCLUSIONS

- Due to the fact that too few tests were run, these results are inconclusive regarding comparison to chemical methods, but valuable regarding which mechanical design is more effective
- This device is only one step in what could be a larger system used to harvest stem cells to be reimplanted into a patient
- This step is critical, as the process needs to break the tissue into isolated cells while maintaining viability
- Later researchers can use what was learned here, and use the harvested stem cells after isolating them from non-stem cells

ACKNOWLEDGEMENTS

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