Automated Process to Manufacture Periosteum

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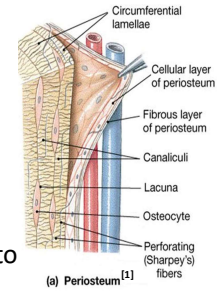
Background

The periosteum is a thin layer of fibrous tissue surrounding long bones in the human body and is a rich source of growth factor proteins and osteoprogenitor cells. Periosteal tissue plays a critical role in fracture repair and the prevention of non-union. AlloSource desires to incorporate periosteum fibers into their AlloFuse bone putty products to improve graft performance.[2] Current methods of removing the periosteum are limited and very manually exhaustive.



(a) Periosteum[1]

The aim of this project is to design an automated medical device that improves the efficiency of periosteum removal compared to current methods.

Objectives and Goals

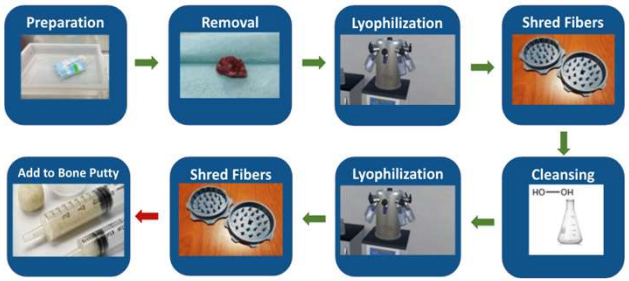
Design device to be adaptable:

- Adjustable center plate for different bone lengths
- Spring-loaded blade to allow for tissue removal regardless of bone geometry
- Wheel mechanism for 360° rotation of bone

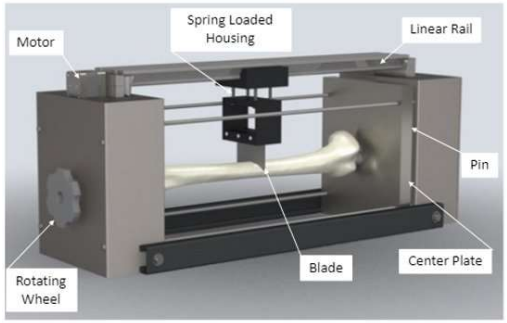
Safe and non-toxic process:

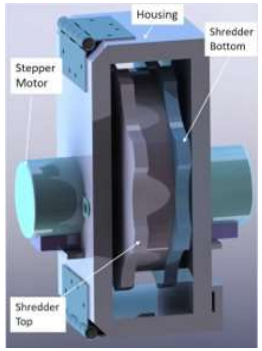
- Preservation of growth factors BMP-2 and TGF-β1
- Material selection for uncomplicated sterilization
- Reduce workload of technician

Established Procedure

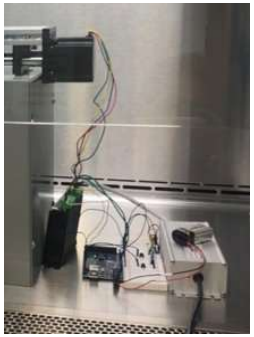


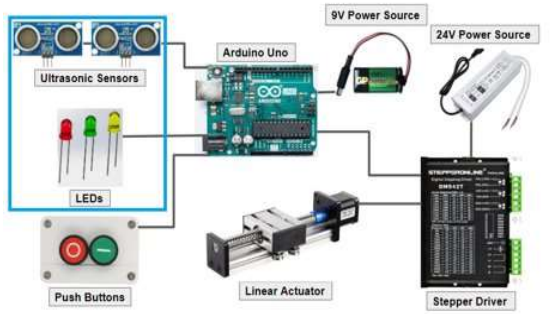
Geometric Modeling



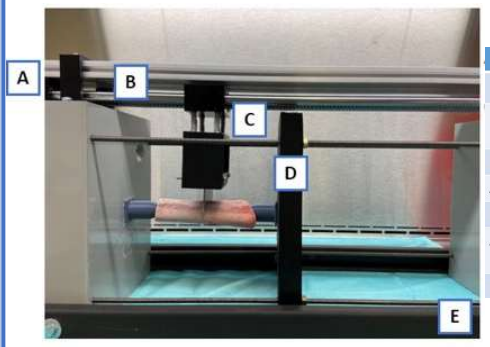


Functional Diagram





Prototype



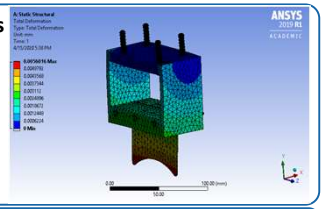
Comparison of Objectives versus Features	A	B	C	D	E
Efficiency of tissue removal	X	X			
Ergonomic safety	X	X			X
Amount of tissue removed			X		
Full rotation of bone					
Adjustable for different bone lengths		X	X	X	
Bone chips in sample		X	X		

A. Stepper motor B. Linear rail C. Spring loaded housing
D. Center Plate E. Frame

Validation

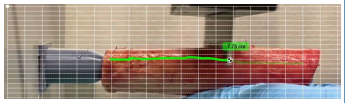
Finite Element Analysis

Minimal Max Deformation: 0.0056 mm



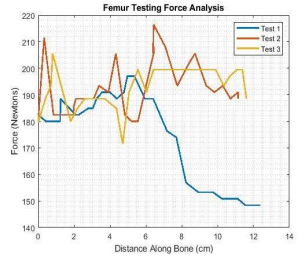
Kinovea Motion Capture Analysis

Average Vertical Displacement: 0.098cm



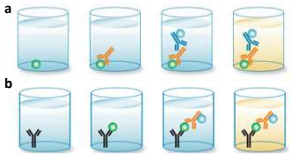
Average Force Range: 182.5 N to 212.9N

Average Force Applied: 194.4N



ELISA Tests

Enzyme-linked immunosorbent assays (ELISAs) used for growth factor quantification:[3]
(a) Indirect ELISA
(b) Sandwich ELISA



Conclusions and Future Work

(1) Blunt edge blades maximize periosteum removal
(2) Automating the removal device was proven to be the safest method for the tissue technician
(3) Further validation needed for the amount of tissue removed and length of removal process
(4) Complete automation of bone rotation during removal
(5) Update design for an adjustable pinning system

Acknowledgments

A special thanks to our AlloSource sponsors Arthur Joslyn, Kenneth Blood, and Marina Bull, faculty advisor Dr. Ellen Brennan-Pierce, and the School of Biomedical Engineering for their contributions to our project!

[1] "What Is the Periosteum? ." *Socratic Q&A*, Anatomy and Physiology, 15 Apr. 2020.
[2] Dwek, J. R. (2010). The periosteum: what is it, where is it, and what mimics it in its absence? *Skeletal Radiology*, 319-323.
[3] Types of ELISA: Bio-Rad." *Bio-Rad Laboratories*, 15 Apr. 2020.