Surface Modification of Metal Implants for Ease of Surgical Removal

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Background

- Removing bone fracture implants can become difficult when the outer layer of the bone recovers such that it engulfs the implants
- Fracture implants are infrequently removed after recovery. Leaving hardware inside patients can lead to adverse consequences (inflammation, loss of joint function), especially in adolescents[1]
- Designing implants so that they are easier to remove may encourage more frequent fracture implant removal

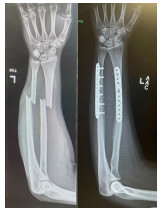

Fig 1. Example fracture repair

Preventing the submersion of fracture implant hardware in recovering bone will increase the efficiency of hardware removal surgery.

Design Criteria

Design Requirements	Justification
Maintain key design characteristics of current orthopedic hardware	Hardware must function as originally and primarily intended, to guide bone fracture healing by fragment stabilization.
Zero rate of normal growth inhibition	Fractures should heal at a normal rate such that the patient can be indisposed for the least possible amount of time.
100% interference with bone *overgrowth* at hardware removal interfaces	Bone cells should not spread to or over the locales utilized for removal to increase procedure efficiency.
Total cost of modified implant product ≤ $9,000	$9,000 is the breakeven point of current hardware removal surgeries and the coated implant.
Zero impact to other bodily processes and regions	Patient health is the first priority; negative off target effects are to be avoided.

Prototype

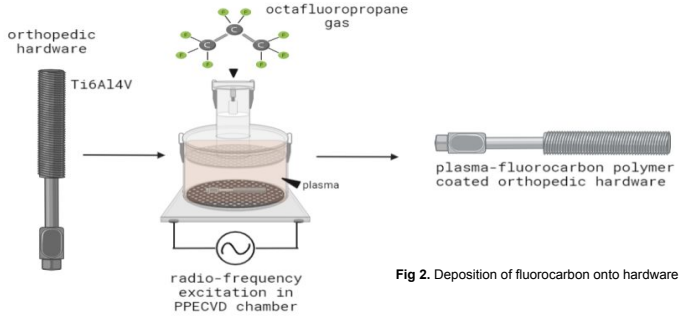

Fig 2. Deposition of fluorocarbon onto hardware

Testing

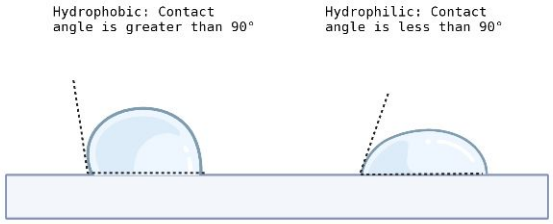

Fig 3. Water droplet test to measure hydrophobicity

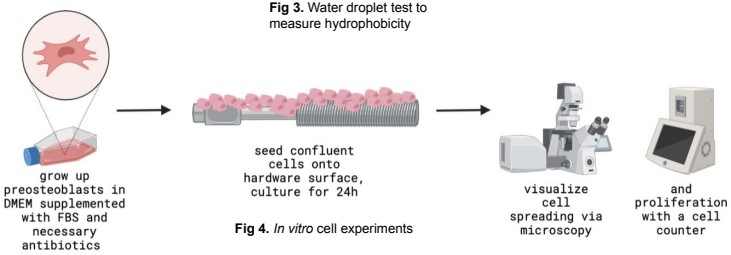

Fig 4. *In vitro* cell experiments

Engineering Standards

ASTM F981-04: Standard Practice for Assessment of Compatibility of Biomaterials for Surgical Implants with Respect to Effect of Materials on Muscle and Bone

ASTM F2885: Standard Specification for Metal Injection Molded Titanium-6Aluminum-4Vanadium Components for Surgical Implant Applications

ISO 10993-5:2009: Biological evaluation of medical devices — Part 5: Tests for in vitro cytotoxicity

The Biomedical Engineering Society *Code of Ethics:* "regard the rights of the patient and the responsibility towards the patient as the utmost concern" as well as "cost, availability, and delivery of health care".

Future Plans

- Begin osteoblast cell culture
- Under guidance of Dr. Mensing, coat multiple metal pieces to determine optimal PECVD settings
- Perform water droplet tests to measure hydrophobicity
- Test and establish a control measurement for *in vitro* cell testing of titanium alloy sheet
- Test and experimental groups with *in vitro* cell testing of a coated titanium alloy sheet and compare with the control

Acknowledgments

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References

[1] Metal implant removal: benefits and drawbacks – a patient survey, 2015.
[2] Anti-Adhesive Finishing of Temporary Implant Surfaces by a Plasma-Fluorocarbon-Polymer, 2014.
[3] Kay, E., and A. Dilks. "Metal-Containing Plasma Polymerized Fluorocarbon Films-Their Synthesis, Structure, and Polymerization Mechanism." *AVS*, American Vacuum SocietyAVS, 1 Mar. 1979.
[4]"Plasma Enhanced Chemical Vapour Deposition (PECVD)." *Oxford Instruments*, https://plasma.oxinst.com/technology/pecvd.