



CENTER FOR DISRUPTIVE
MUSCULOSKELETAL INNOVATIONS

Development of Novel Impedance Sensor to Monitor Fracture Healing

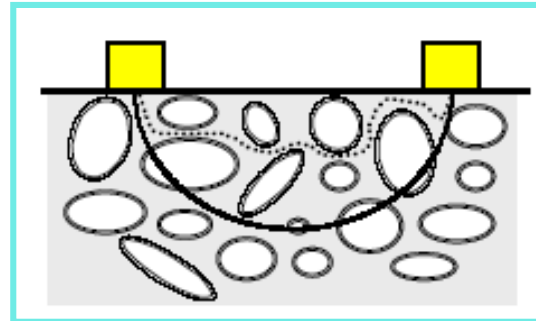
Meir Marmor, MD; Safa Herfat, PhD,
Chelsea Bahney, PhD; **Monica Lin, BS**

University of California – San Francisco,
University of California – Berkeley

WWW.NSFCDMI.ORG

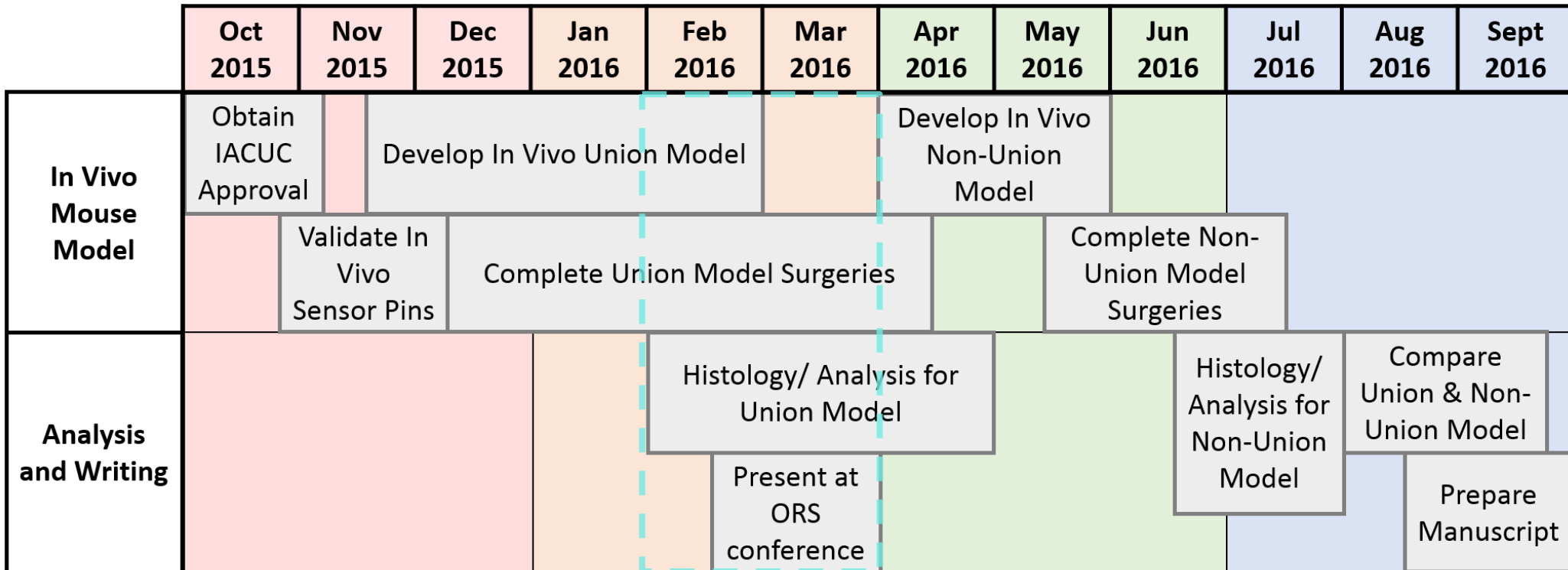
Project Summary

- 20% fractures → delayed or non-union
 - 46% when in conjunction with vascular injury
- Current radiographic methods inadequate
- Electrical impedance spectroscopy:
characterize
different tissues
- Feasibility & proof-
of-concept *ex vivo*
in 2015



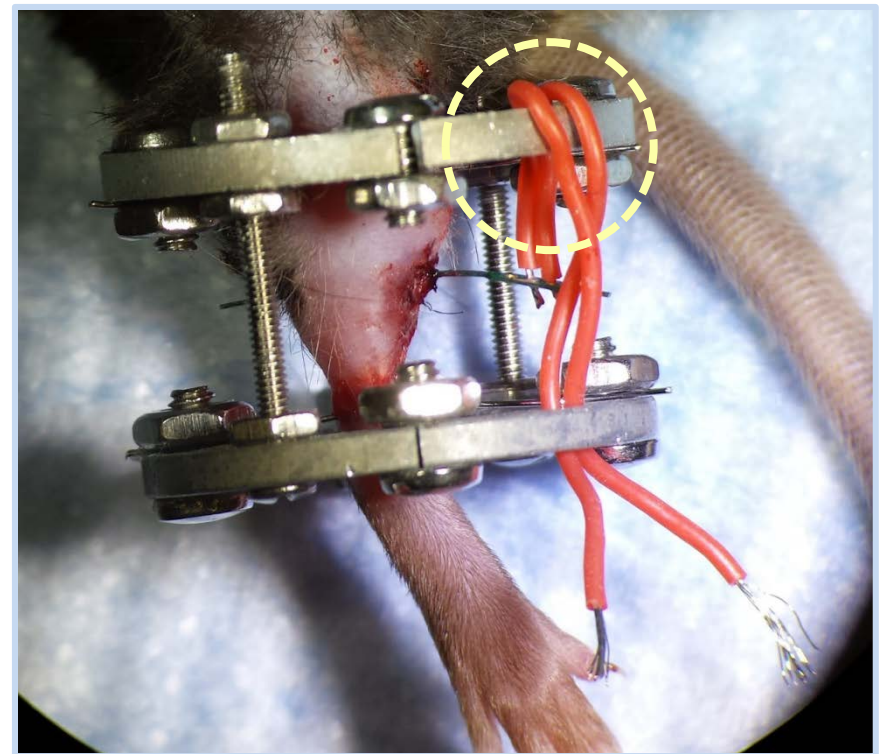
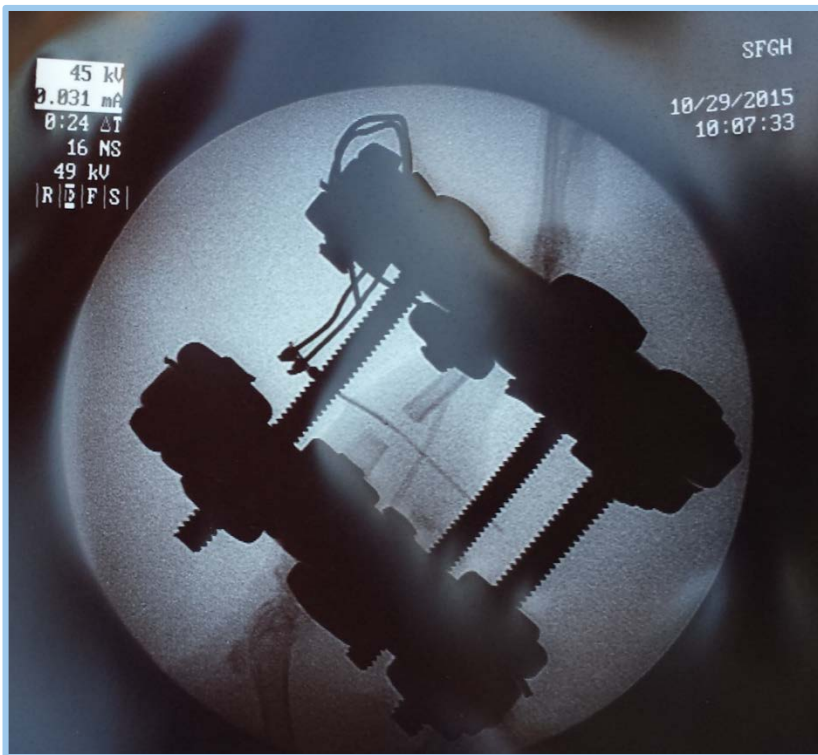
Develop an objective measurement tool that utilizes impedance spectroscopy to monitor fracture healing

Timeline



Initial *In Vivo* Tests - Conclusions

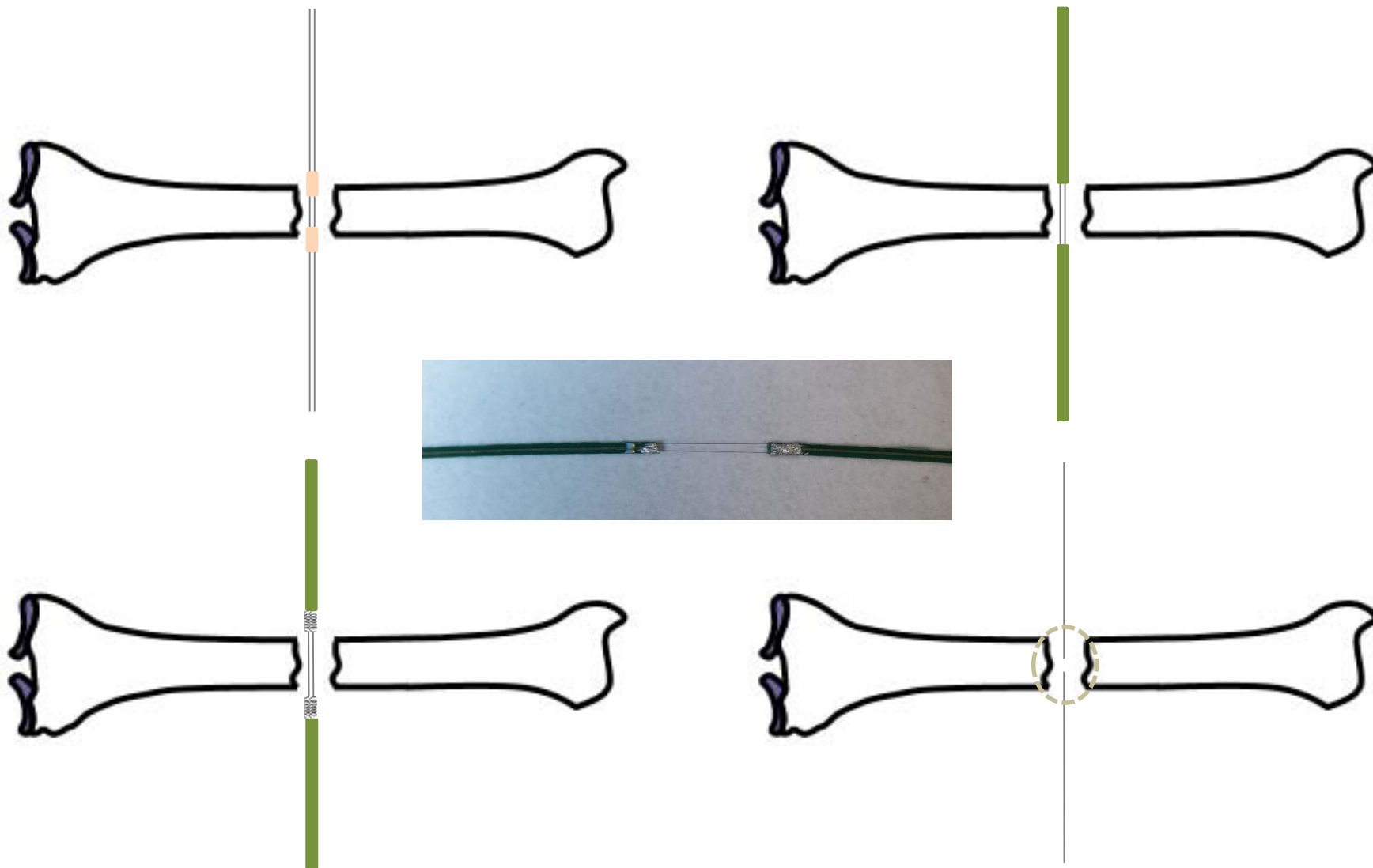
- Weak signs of healing even at ~14 days



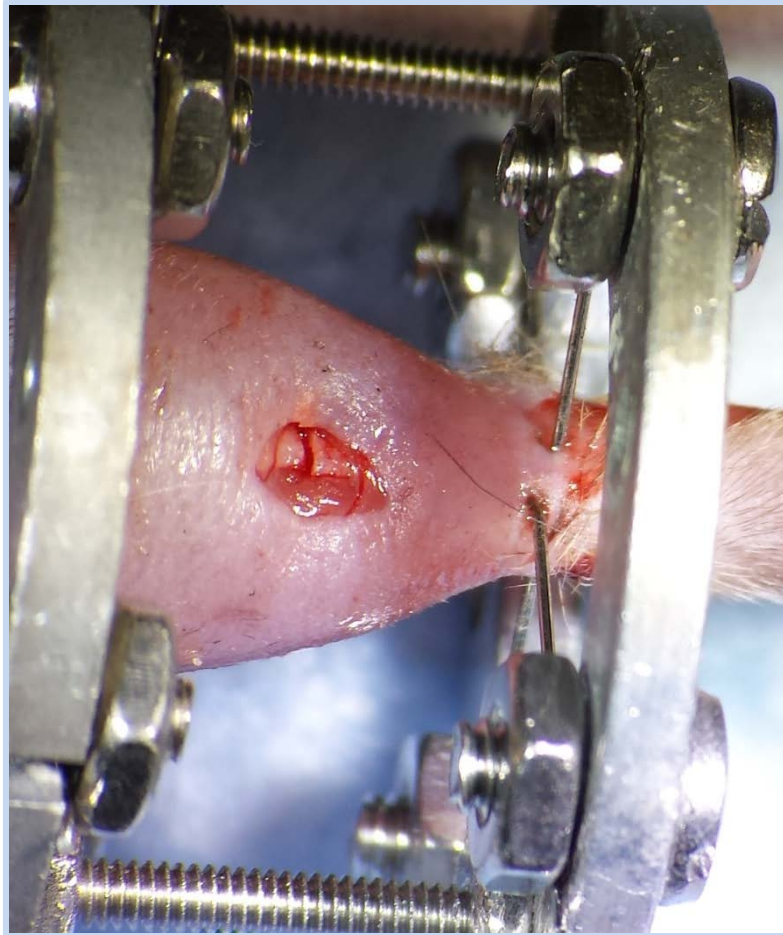
Possible Issues

Problems		
Biocompatibility	Size	Rigidity

Alternative Designs



In Vivo Test – Round 4



- Do not remove bone
- Distract just enough to get sensor in gap



- Parylene-coat original PCB sensor

Presented at 2016 ORS Annual Meeting

CENTER FOR DISRUPTIVE
MUSCULOSKELETAL
INNOVATIONS



Novel Impedance Spectroscopy Device Detects Fracture Progression in Mice

Monica C. Lin^{1,2}, Frank Yang¹, Safa T. Herfat¹, Chelsea S. Bahney¹, Michel M. Maharbiz², Meir Marmor¹

¹ University of California – San Francisco ² University of California – Berkeley

ORS Annual Meeting
March 8, 2016

Orthopaedic Trauma Institute
UCSF + SAN FRANCISCO GENERAL HOSPITAL

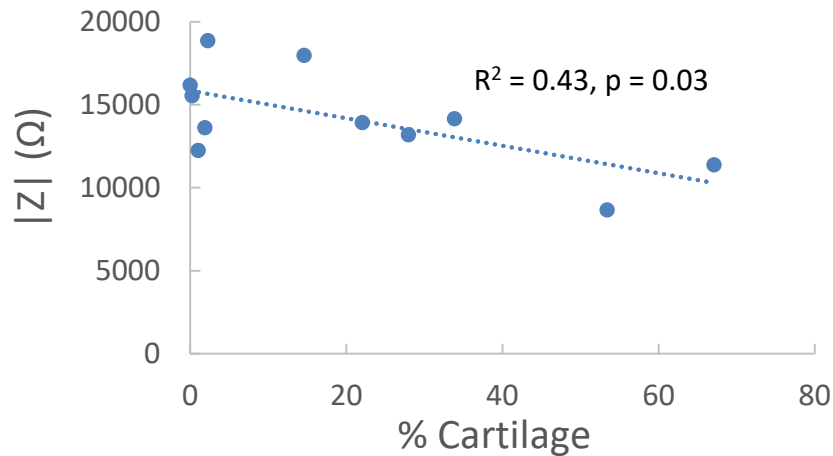
Graduate Program in
Bioengineering
UC Berkeley

Impedance Correlates to Cartilage and Bone Fractions

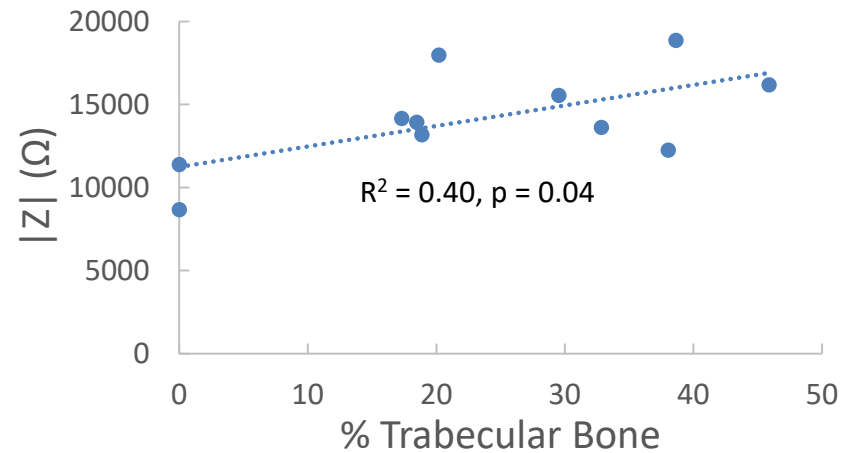
Mouse	% Cartilage	% Trab Bone	% Cort Bone	% Fibrous	% Muscle	% Mar. Space
7-4	53.41	0.00	3.17	39.51	4.15	0.00
8-5	67.07	0.00	0.00	25.75	5.99	0.00
14-1	14.58	20.19	12.71	17.01	1.50	34.58
14-2	27.94	18.86	11.03	18.33	1.42	22.95
14-3	22.05	18.46	10.77	24.36	0.77	23.72
14-4	33.83	17.29	6.51	22.09	1.07	19.21
21-1	0.24	29.53	11.88	6.00	2.12	50.35
21-2	2.27	38.64	14.77	3.64	0.00	40.91
21-3	1.90	32.83	4.74	0.00	0.00	60.34
21-4	1.02	38.03	3.71	1.28	0.00	55.57
21-5	0.00	45.89	4.24	7.16	0.53	41.91

Impedance Correlates to Cartilage and Bone Fractions

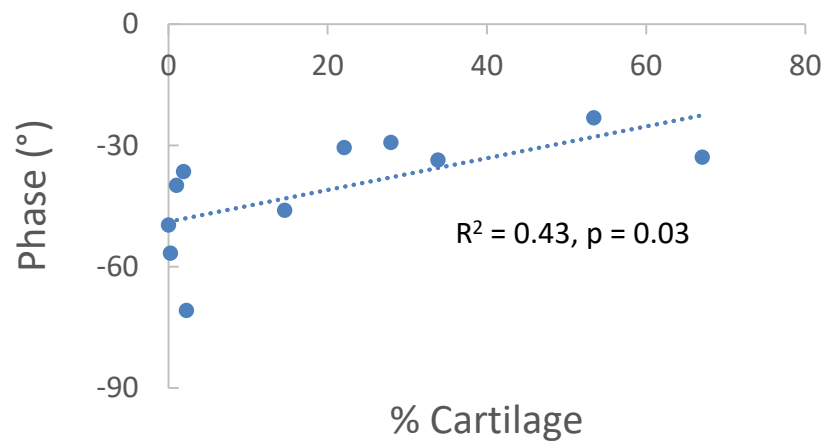
(500 kHz) $|Z|$ vs % Cartilage



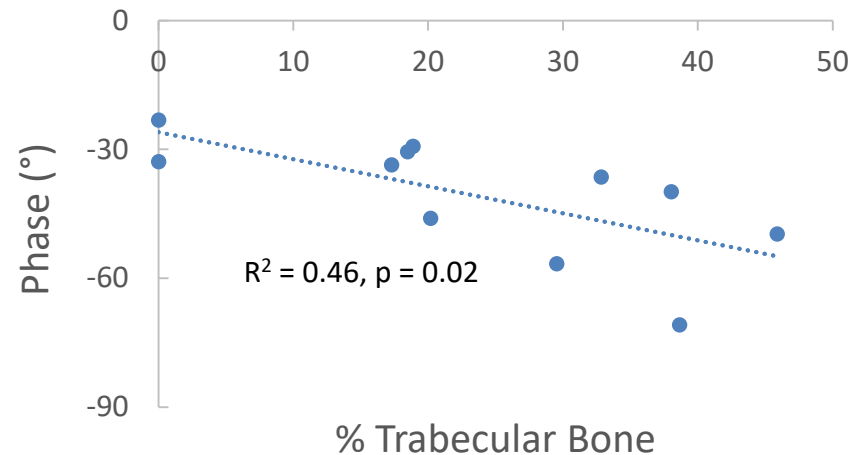
(500 kHz) $|Z|$ vs % Trabecular Bone



(500 kHz) Phase vs % Cartilage



(500 kHz) Phase vs % Trabecular Bone



Timeline

	Oct 2015	Nov 2015	Dec 2015	Jan 2016	Feb 2016	Mar 2016	Apr 2016	May 2016	Jun 2016	Jul 2016	Aug 2016	Sept 2016	
In Vivo Mouse Model	Obtain IACUC Approval		Develop In Vivo Union Model						Develop In Vivo Non-Union Model				
		Validate In Vivo Sensor Pins	Complete Union Model Surgeries							Complete Non-Union Model Surgeries			
Analysis and Writing					Histology/ Analysis for Union Model					Histology/ Analysis for Non-Union Model		Compare Union & Non-Union Model	
						Present at ORS meeting	Prepare Manuscript						

Acknowledgements

- Frank Yang
- Diane Hu
- Michel Maharbiz

Research supported by:



IIP-1361975



EFRI-1240380

