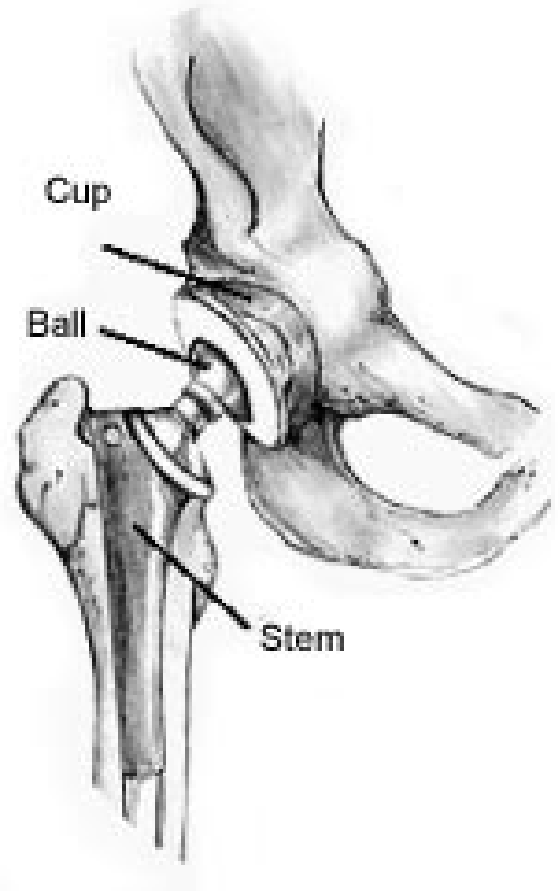
Femoral Component Installation Monitoring



Deena Abou-Trabi – University of Houston

Mike Guthrie – University of Wisconsin

Hunter Moore – Virginia Tech

Dr. Phillip Cornwell – Rose-Hulman

Dr. Michael Meneghini – St. Vincent Center for Joint Replacement, Indianapolis, IN

Dr. Aaron Rosenberg – Rush University Medical Center, Chicago, IL

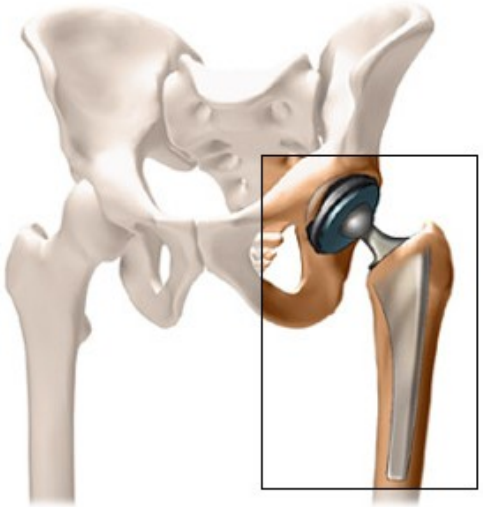
LADSS

www.toc-stl.com/ info/totalhip.htm

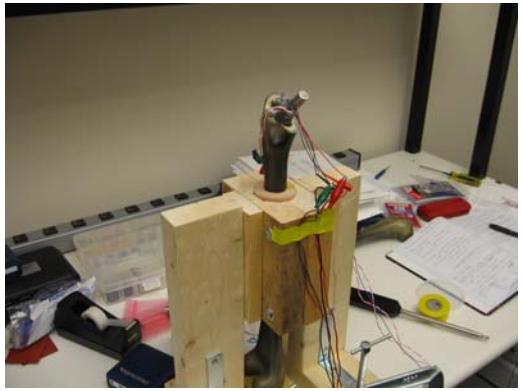
Los Alamos

This presentation provides a method of detection for a fully seated prosthesis within a femur

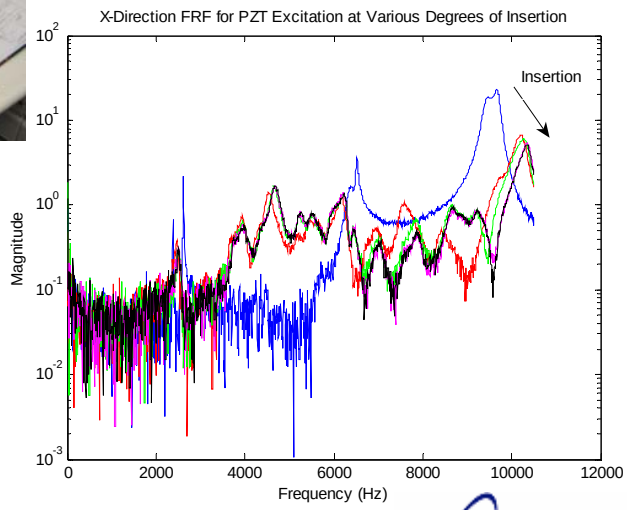
Background Information



Test Setup and Experimentation



Experimental Analysis



www.webmd.com/DW/arthritis/aa14678.asp

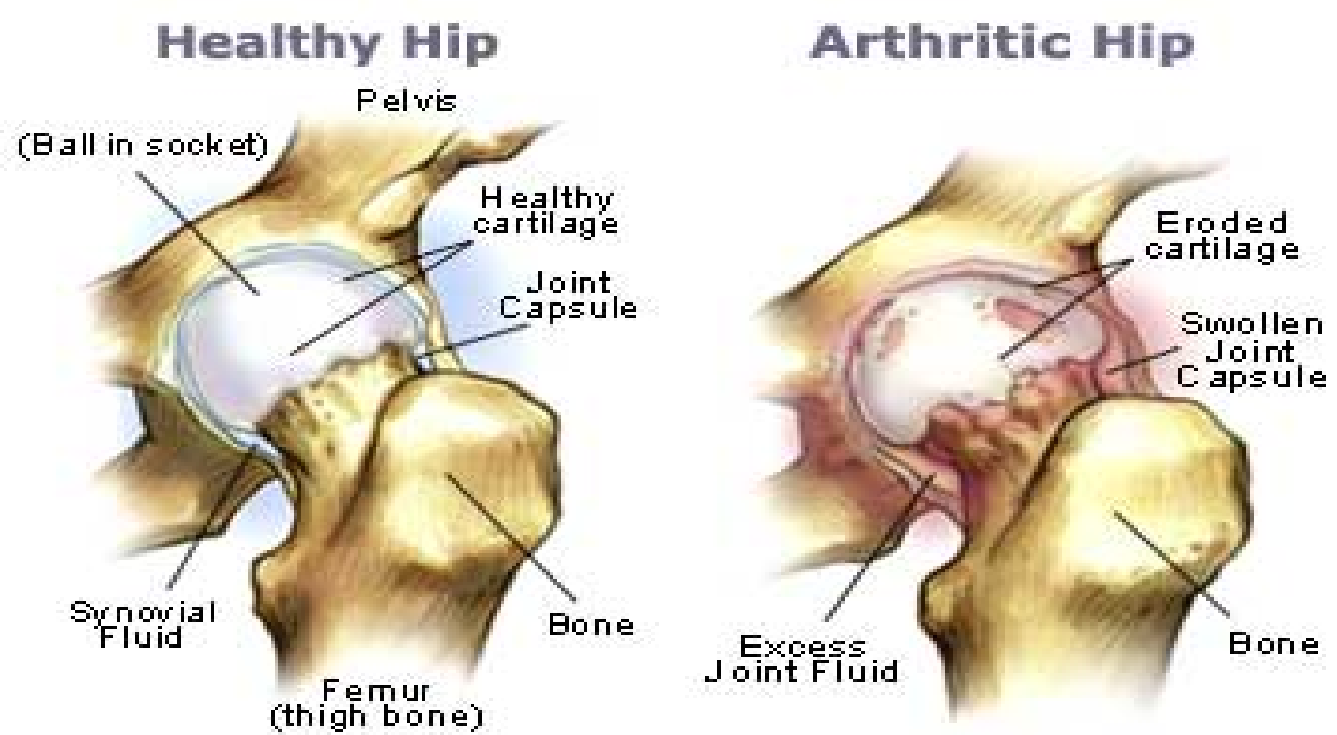
More than 172,000 people undergo total hip arthroplasty each year in the U.S.

Medical Conditions Requiring Surgery

Osteo-Arthritis

Bone Fractures

Rheumatoid Arthritis



Serious Consequences Occur from Not Having Surgery

Deep Vein Thrombosis

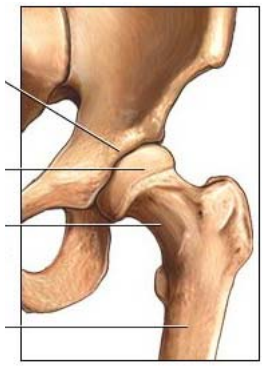
Pulmonary Embolism

The actual procedures involved in hip arthroplasty can be summarized in five steps

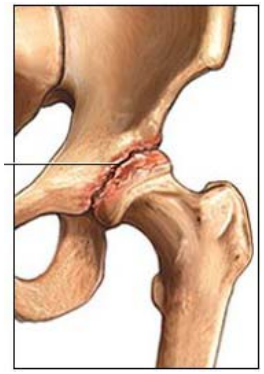
Hip Socket

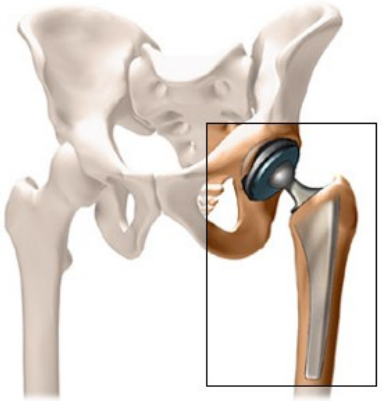
Femoral Head

Femur



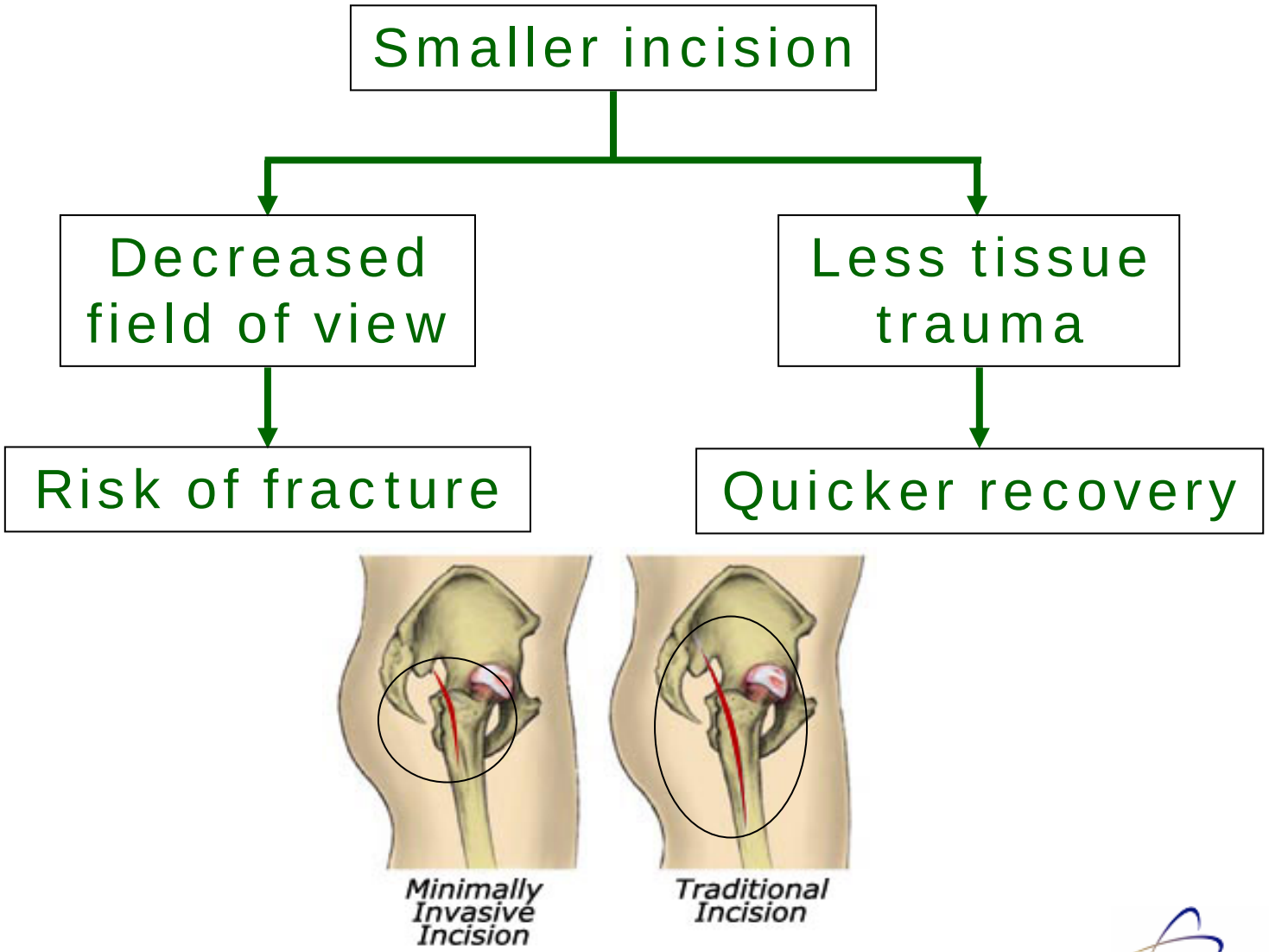
Osteo-arthritis





Source: www.webmd.com/DW/arthritis/aa14678.asp (Jul 2004)

Minimally invasive techniques have both positive and negative aspects



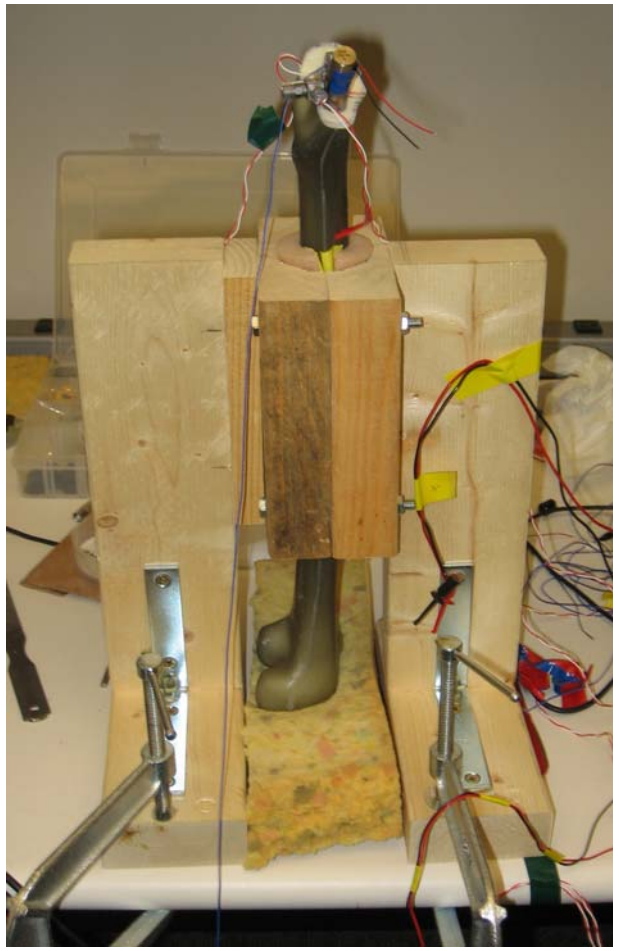
www.centerorthopedic.com/rapid_hip.html

The surgeon impacts the prosthesis in a similar manner to our testing

A test structure was constructed for the sawbones

The bolts and C-clamps were used to provide repeatability

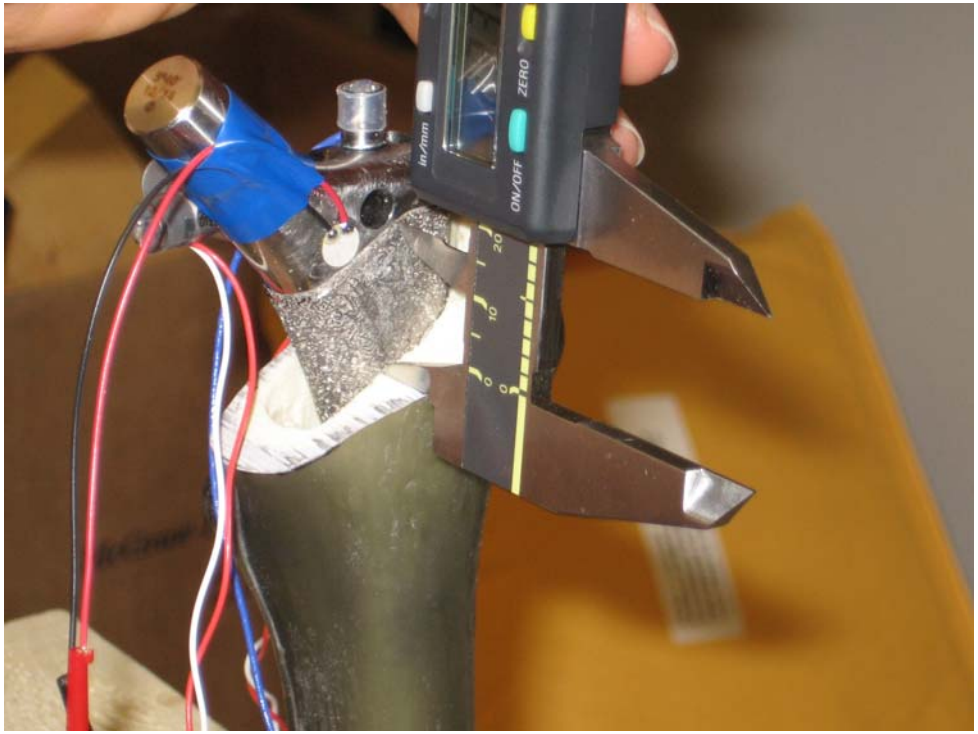
The foam around and under the sawbone was used to simulate a human leg



Seating measurements were taken after each impact

A digital caliper was used to measure the distance the prosthesis had been seated

The first two seating measurements were free-free and non-impacted seated

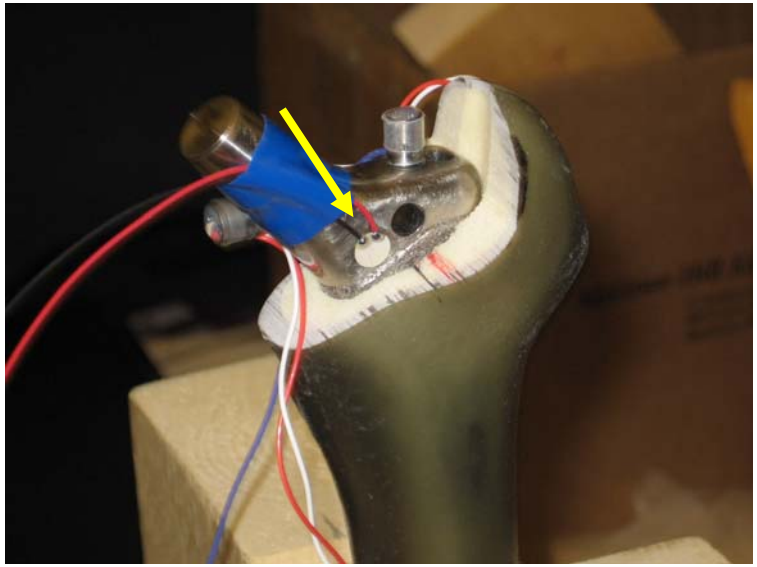


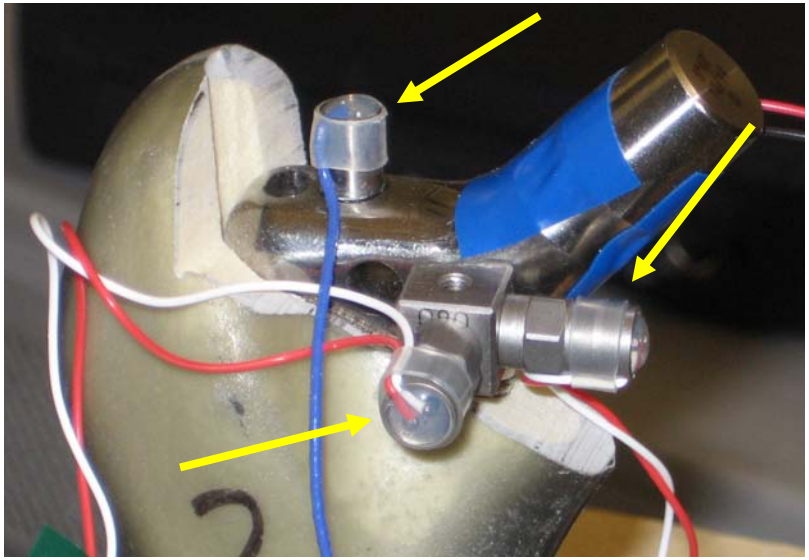
The first test run at each measurement was an impact test

The impact was implemented using an instrumented hammer and a surgical punch

The response was measured using three accelerometers

The second test run at each measurement was a PZT actuation test





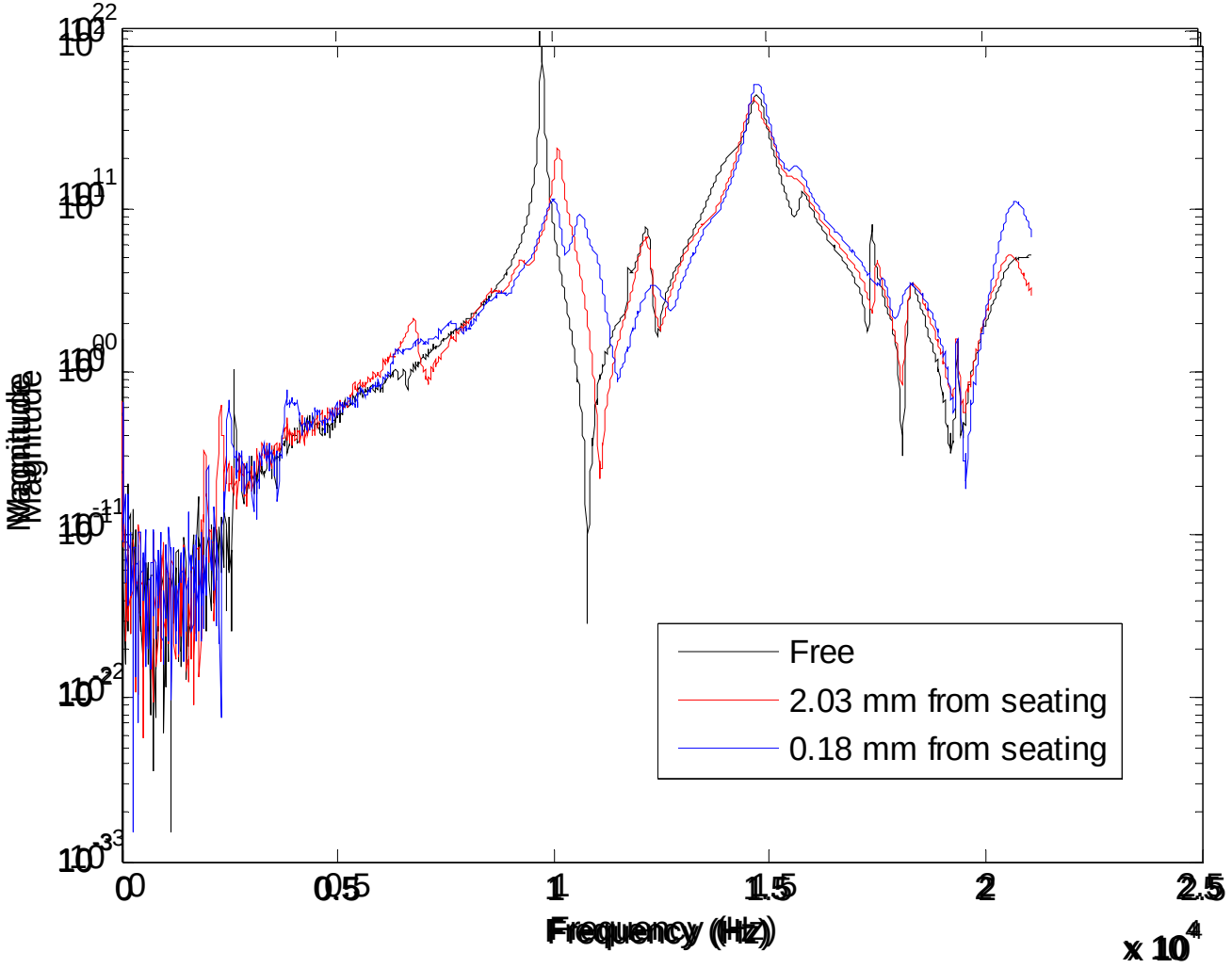
A Dactron system was used to actuate the PZT at 15 V and then collect data from the three accelerometers

The final test run at each measurement was an impedance analysis

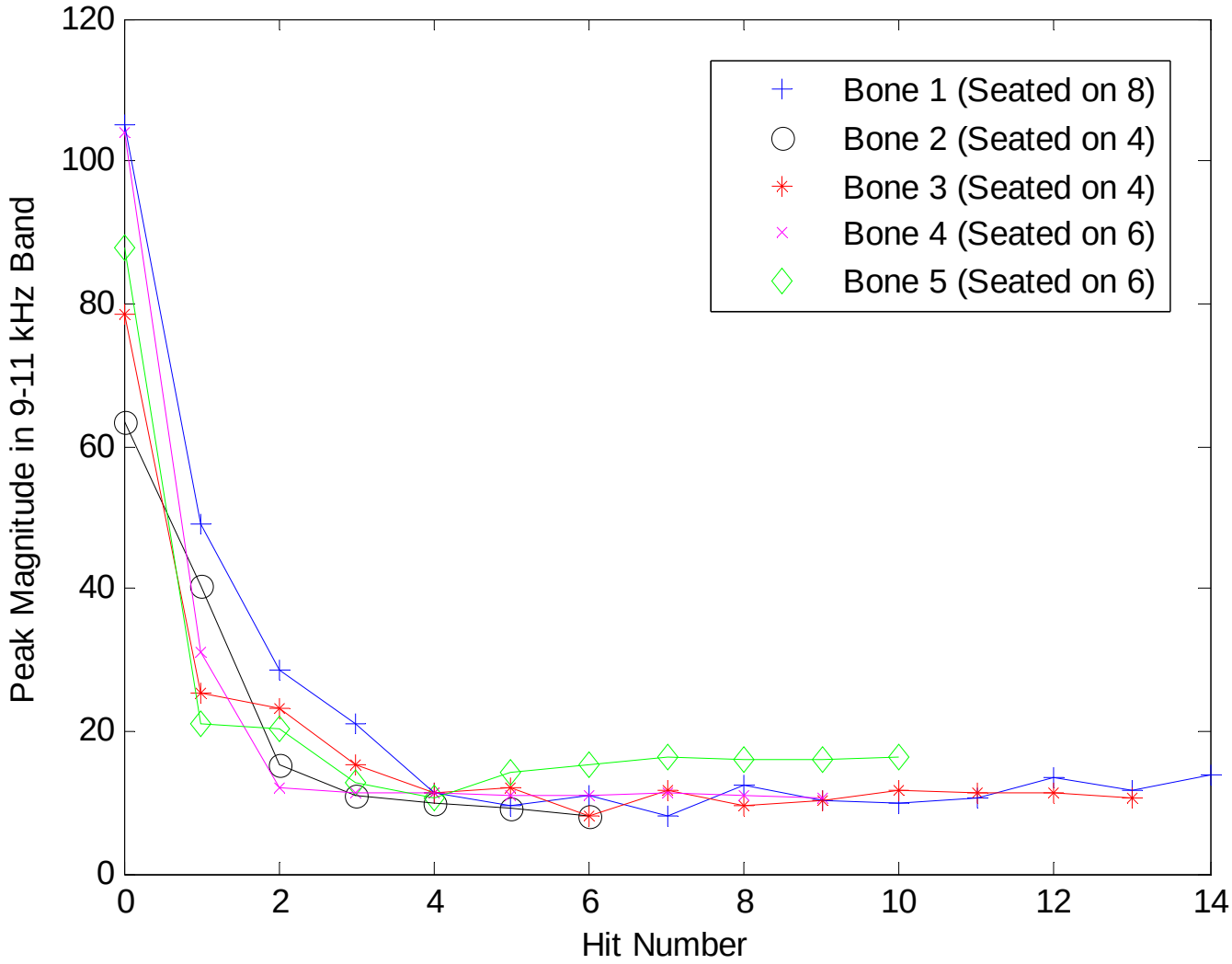
A Gaussian White excitation was used for excitation

300 averages were taken in order to extrapolate the most important data

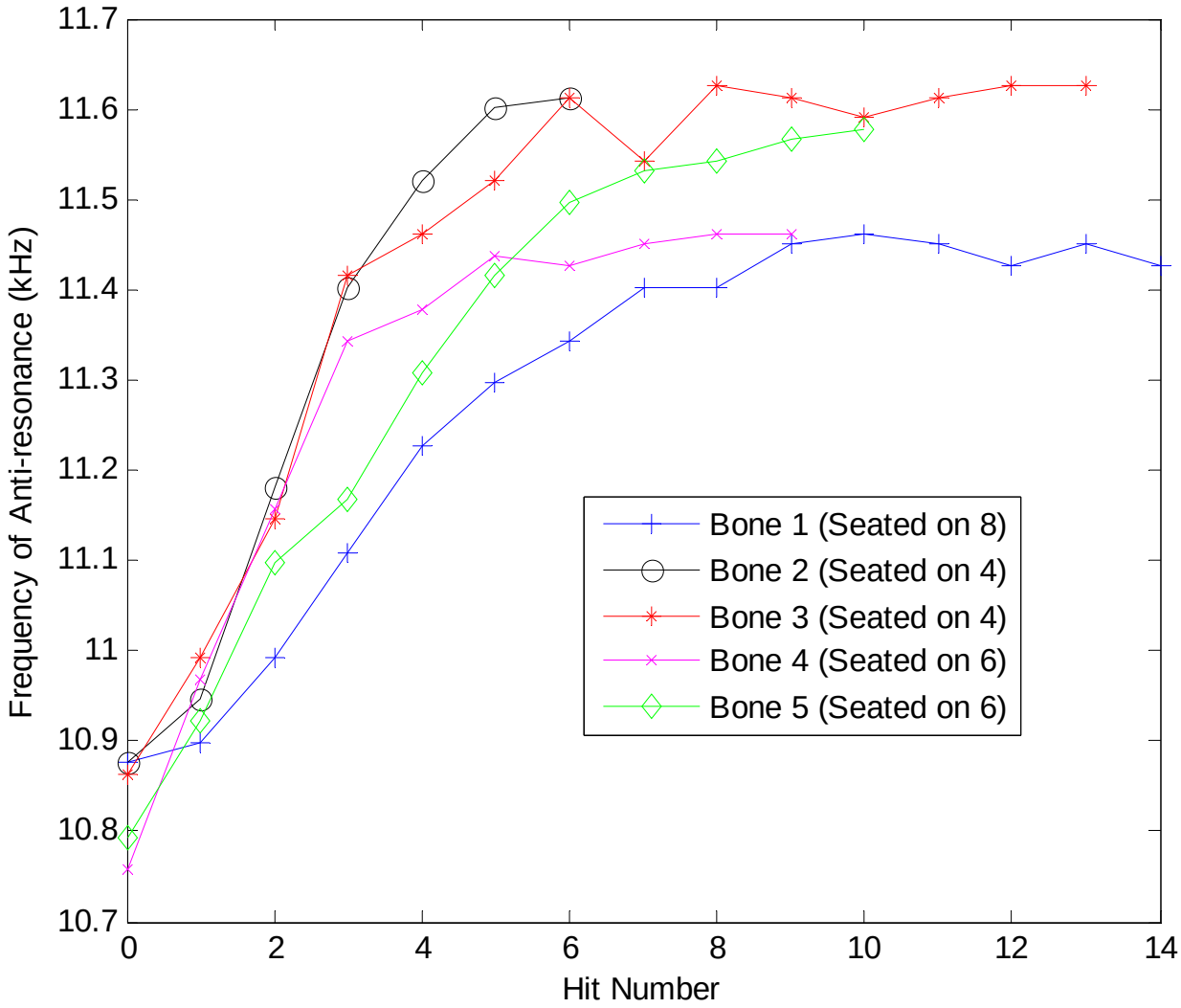
The peaks of the y-direction FRF shift upward and become shorter with insertion of the prosthesis



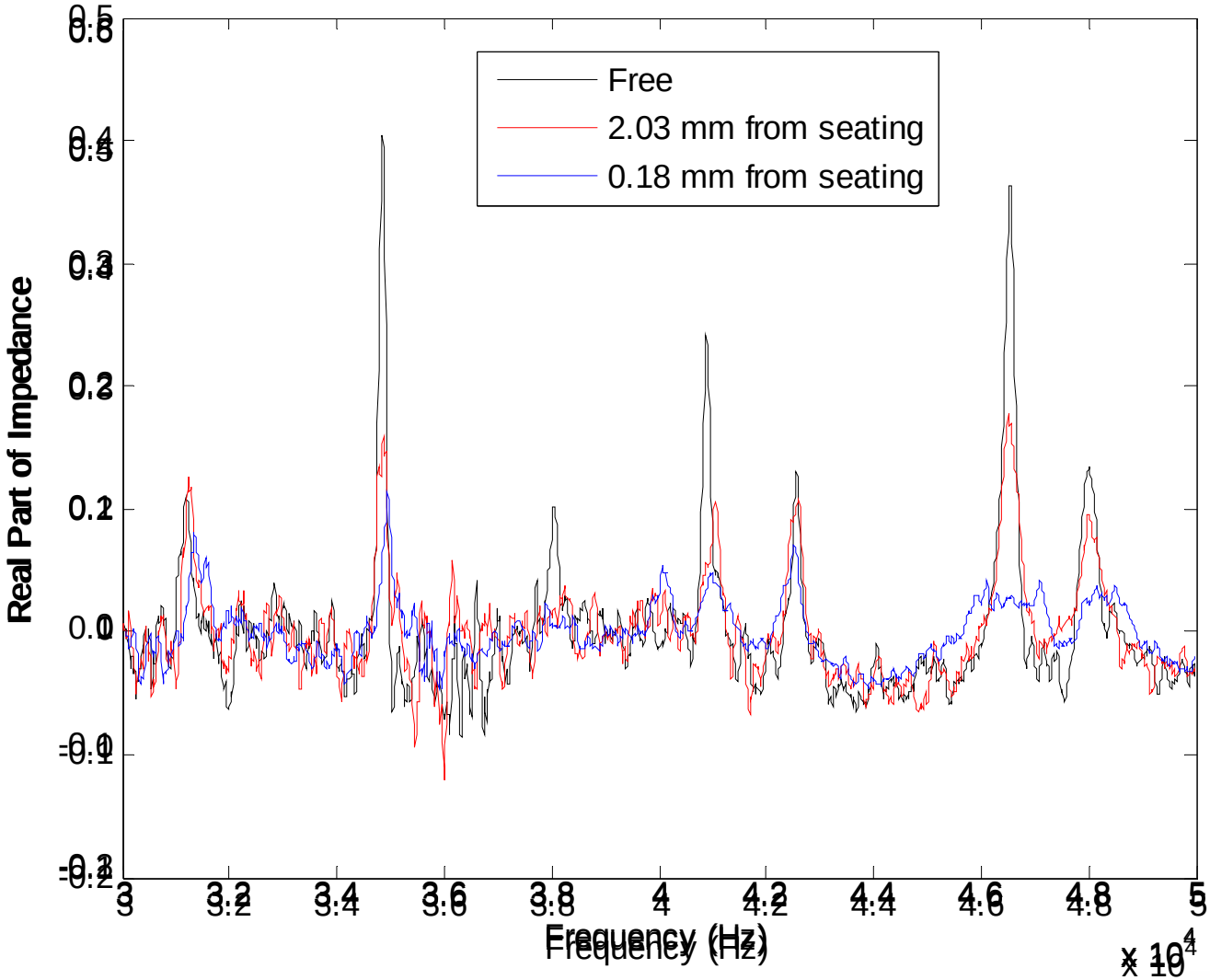
The peak magnitude in the 9-11 kHz band converges very quickly with insertion



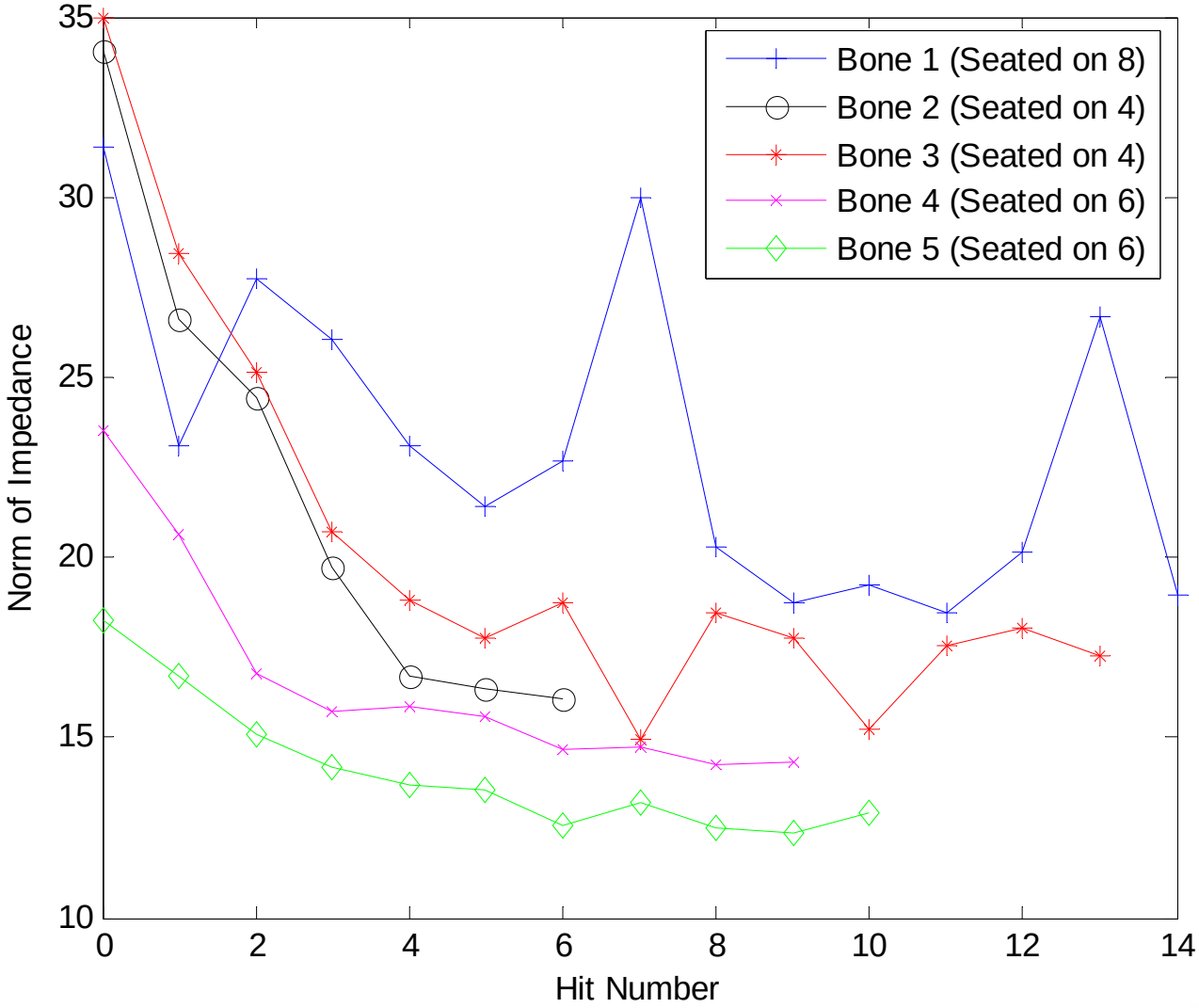
The anti-resonant frequency converges more slowly than the peak in the 9-11 kHz band



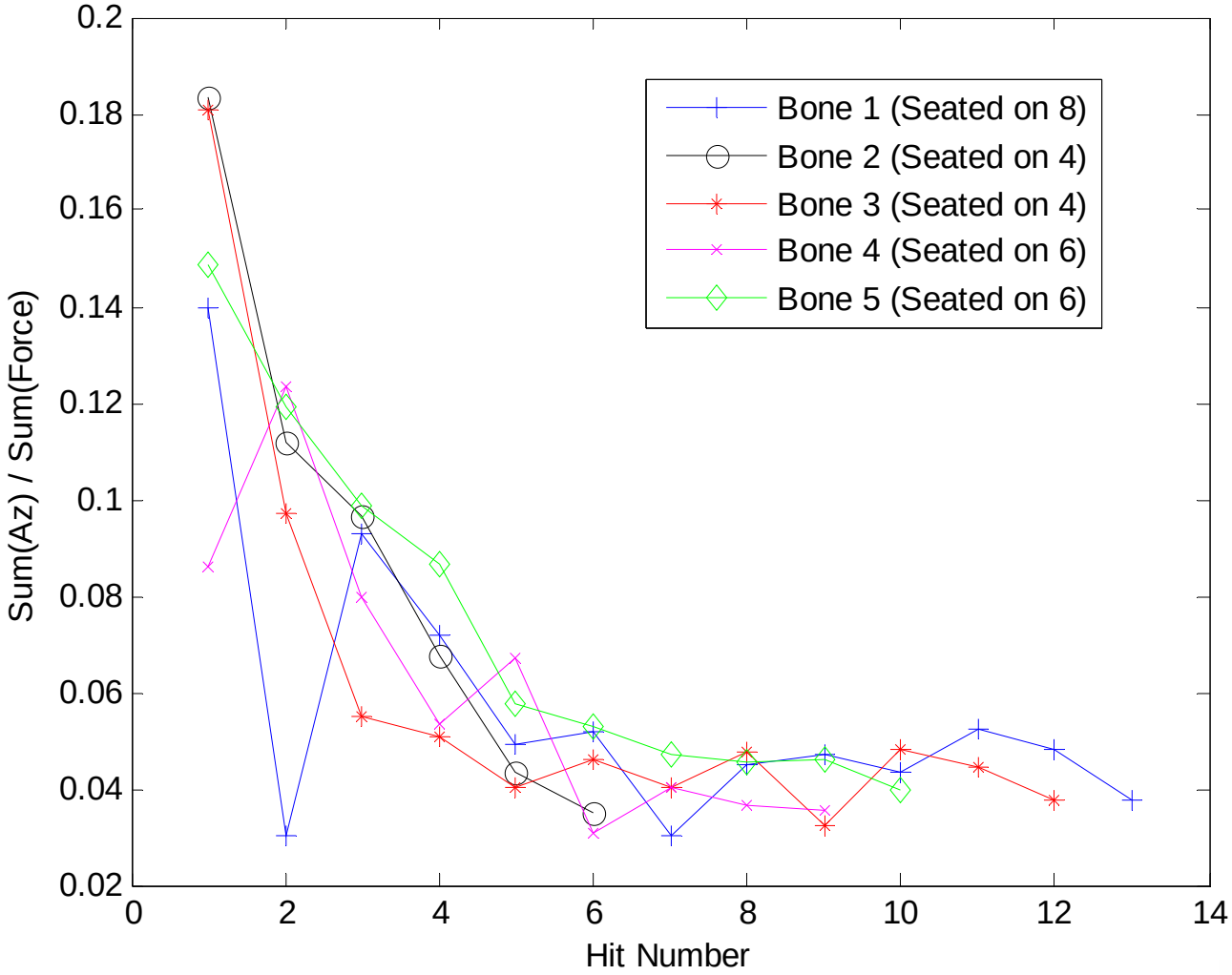
The peaks of the real part of the impedance data become shorter and wider with insertion



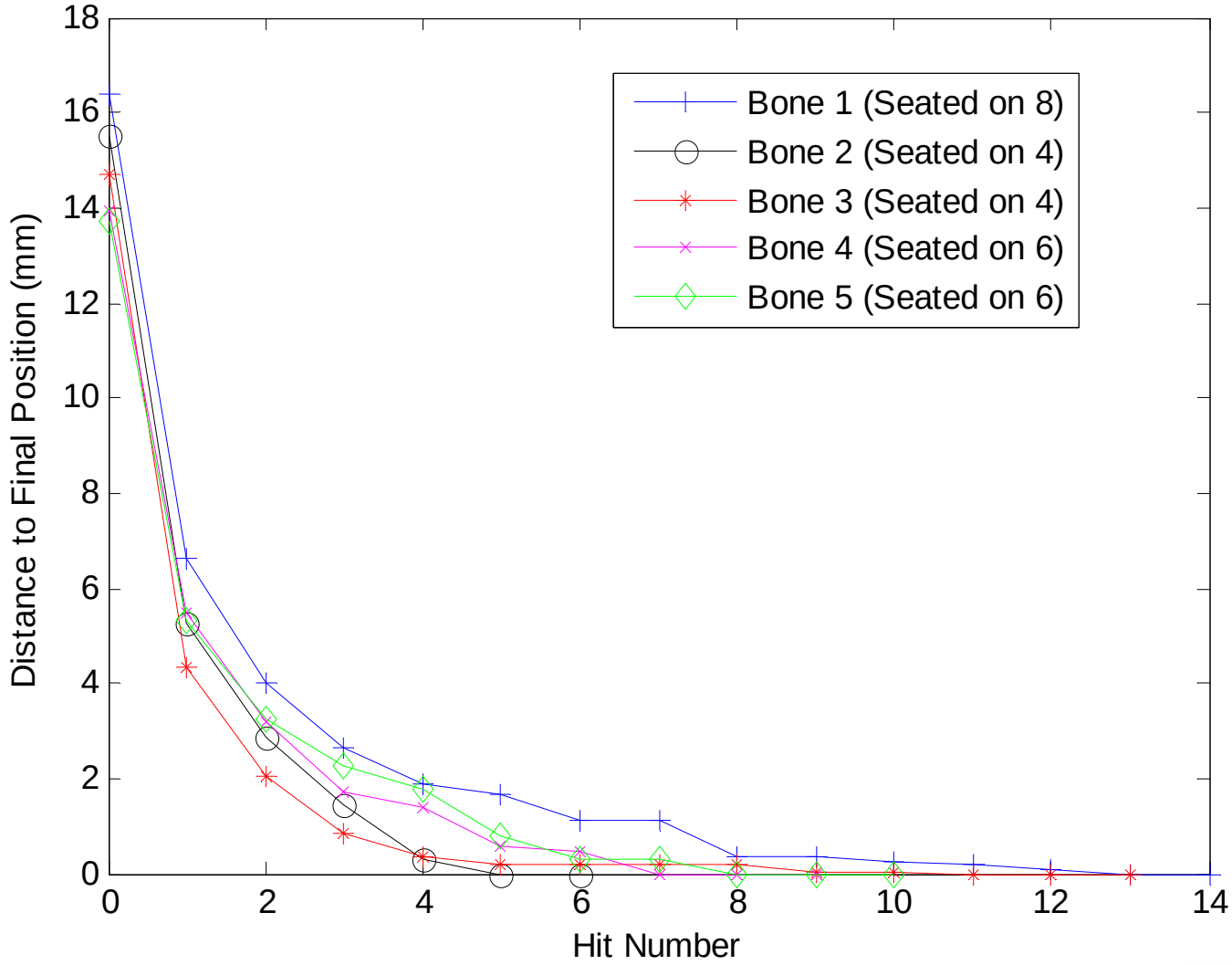
The norm of the impedance looks good for bones 2, 4, and 5, but is erratic for bones 1 and 3



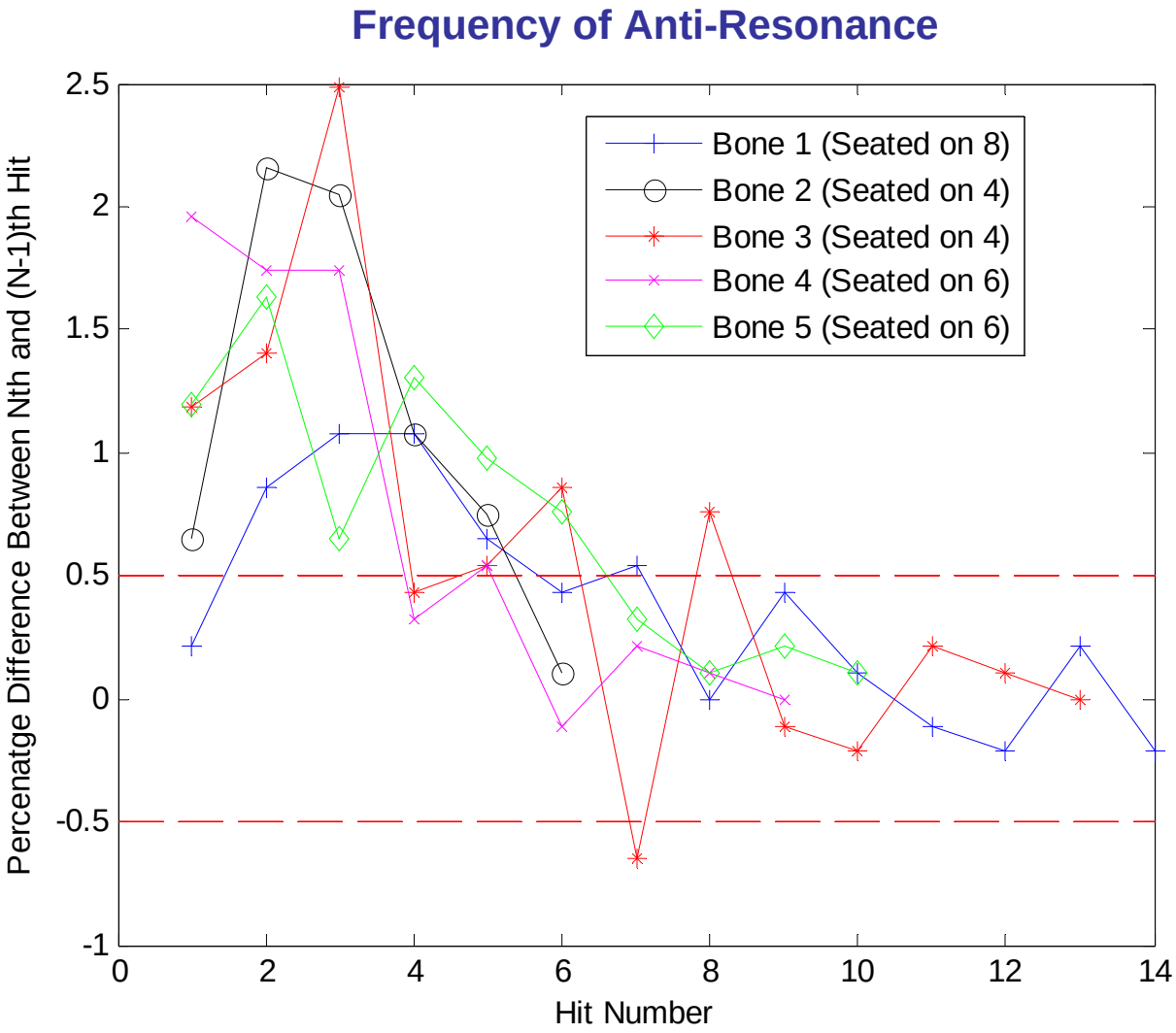
The sum of the acceleration in the axial direction divided by the sum of the force was the only useful metric based upon the impact time histories



To assess the merit of each metric, it is helpful to adopt a definition of seating



Examining the percentage change in these metrics eliminates the variance from bone to bone



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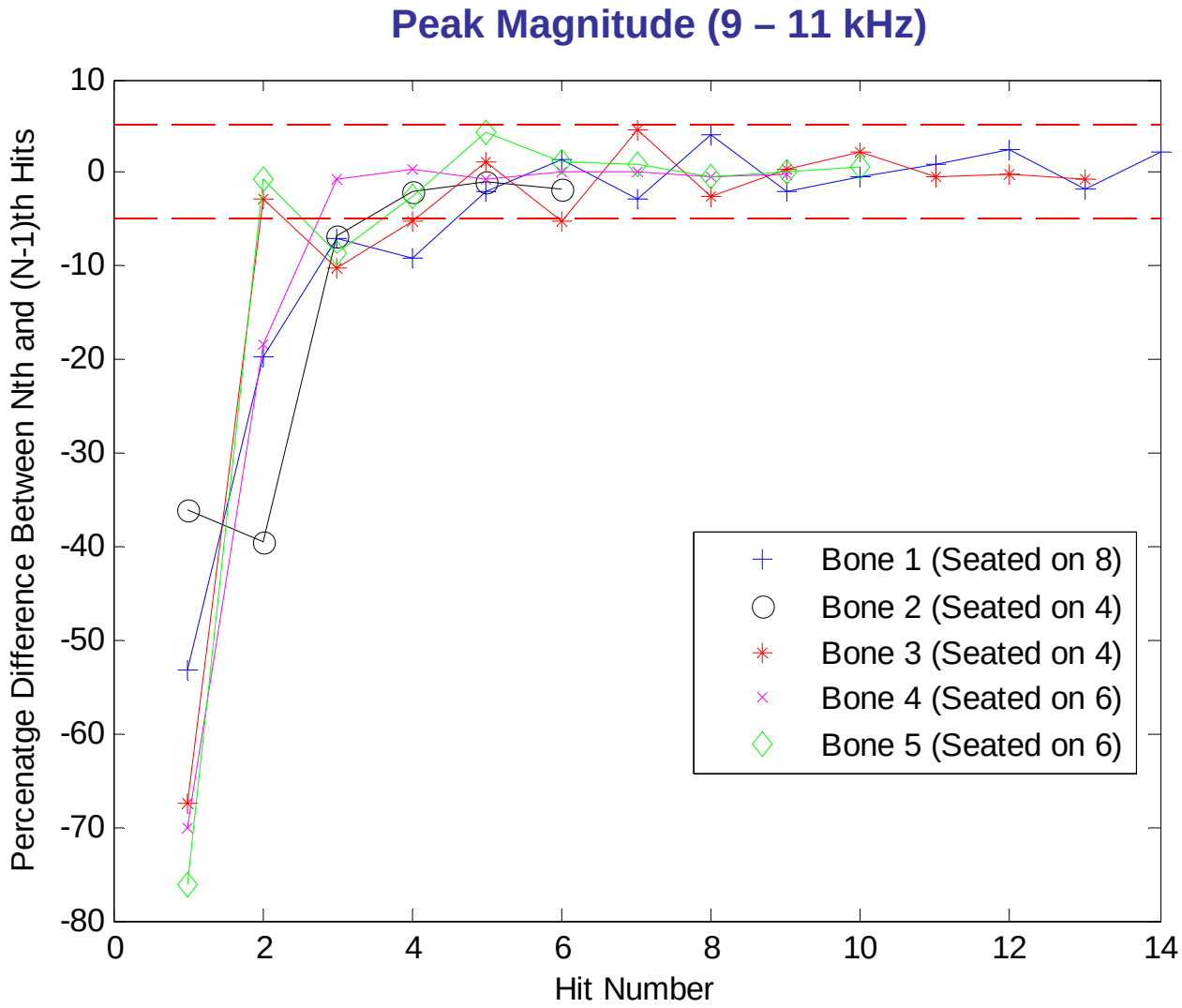

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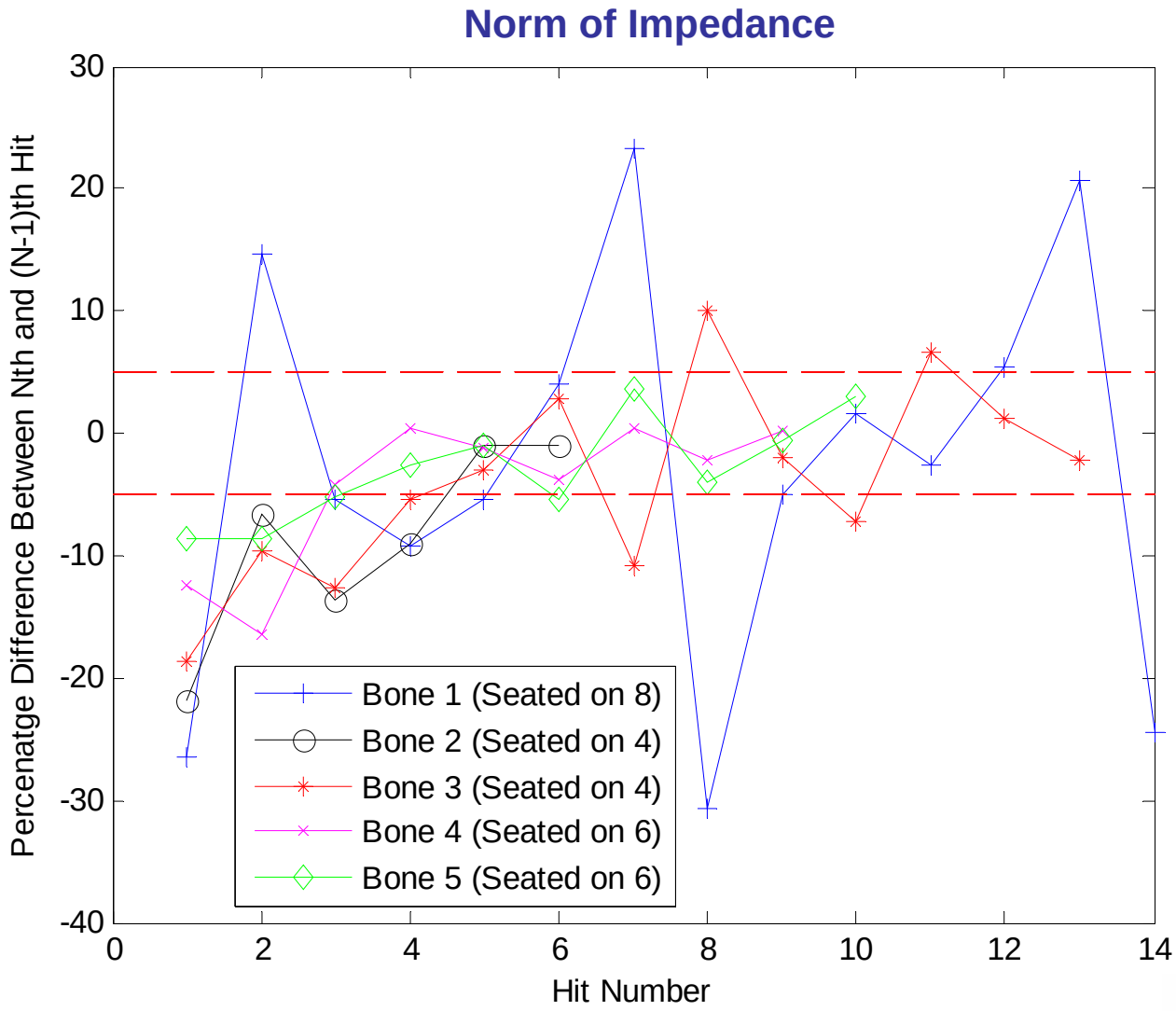

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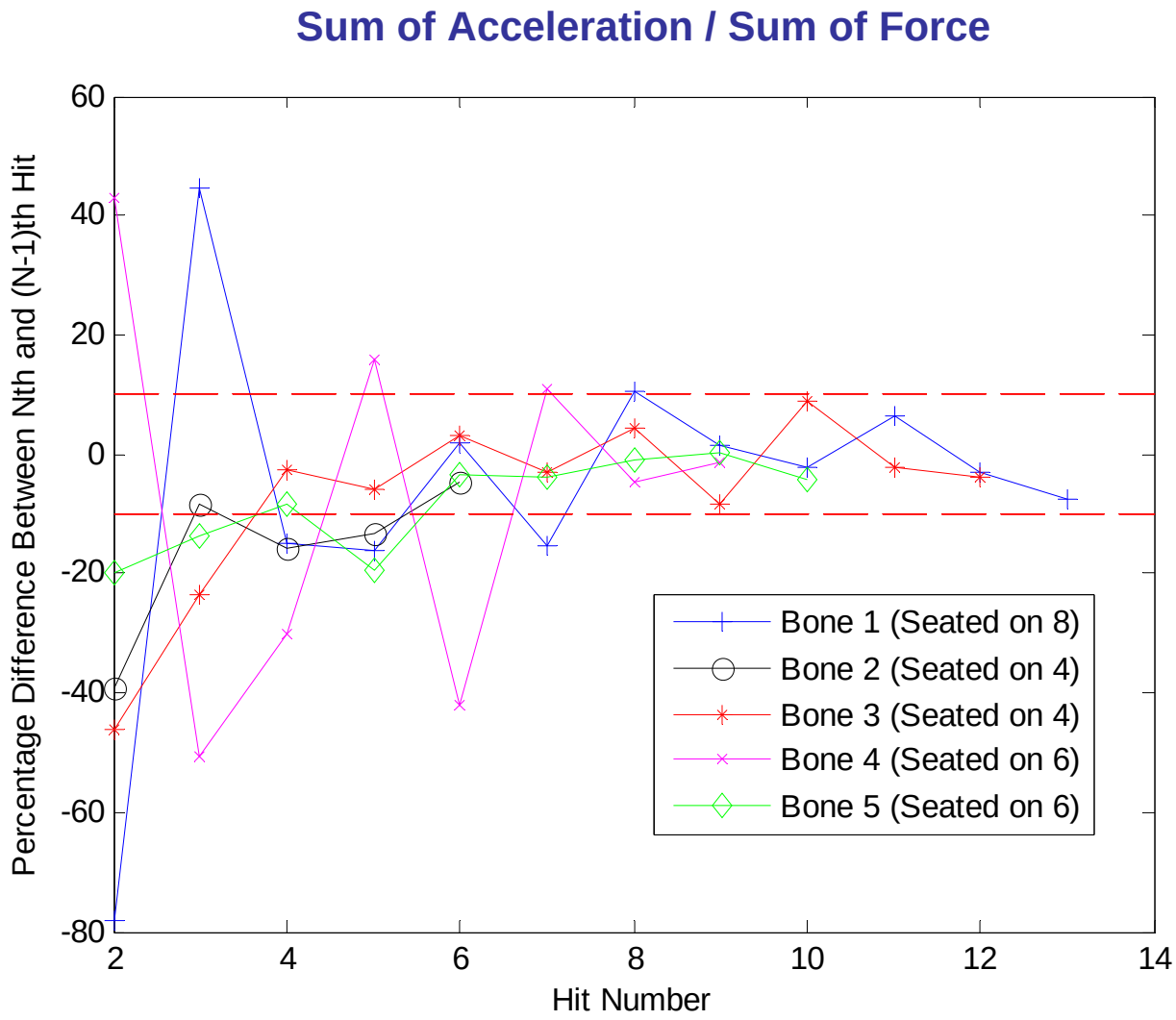


The acceleration divided by force metric seems to predict seating of the prosthesis best

		Def'n of Converg-ence	Number of Hits to Convergence				
			Bone 1	**Bone 2**	**Bone 3**	**Bone 4**	**Bone 5**
Prosthesis		within 0.5 mm	8	4	4	6	6
METRIC	**Anti-resonance**	change less than 0.5 %	8	6	9	6	7
	Max Value in 9-11kHz Band	change less than 5.0 %	5	4	4	3	4
	Norm of Impedance	change less than 5.0 %	Never	6	13	4	8
	Sum(Accel)/ Sum(Force)	change less than 10.0 %	9	6	4	7	6

There are many exciting opportunities for future work

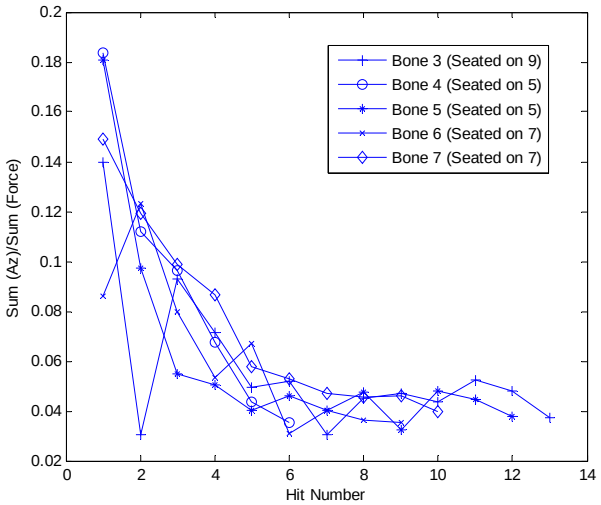
Replicate human characteristics more closely

Model actual surgical conditions

New seating detection techniques

www.rkm.com.au/ imagelibrary/

The final results of this project show promise



LADSS

www.cornair.com/.../ operating-room.html

Los Alamos

We would like to acknowledge…

Engineering Sciences and Applications Division at Los Alamos National Laboratory

The Mathworks, Inc. (MATLAB Software)

Vibrant Technology Inc. (MEScope Software)

Mentors and others who helped advise us along the way