

Roza Mahmoodian

Postdoctoral Research Associate

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Massachusetts Institute of Technology

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Education

Ph.D., Mechanical Engineering and Mechanics

Sep. 2006 – Dec. 2010

Drexel University, College of Engineering (GPA: 3.93/4.0)

Philadelphia, PA

M.S., Mechanical and Aerospace Engineering

Aug. 2004 - Aug. 2006

University of Virginia, School of Engineering and Applied Science (GPA: 3.97/4.0)

Charlottesville, VA

B.S., Mechanical Engineering

Sep. 1999 – Mar. 2004

University of Tehran, School of Engineering

Tehran, Iran

Research Experience

LAB FOR MATERIAL CHEMOMECHANICS, MIT

Cambridge, MA

Postdoctoral Research Associate

Jan. 2011 – Present

Verified and expanded a contact mechanics based approach at the microscale, for quick and simultaneous characterization of mechanical and transport properties of hydrated gels and soft biological tissues in short durations (a few seconds in the microscale vs. hundreds of hours in the macroscale for a single poroelastic load relaxation experiment).

Design and synthesis of gels for tissue surrogate applications in collaboration with the Army Research Lab:

- Multiscale mechanical characterization of polymer and protein gels as candidates for tissue surrogacy for studying/ preventing ballistic impact trauma, via AFM and nanoindentation.
- Characterization of energy dissipation capabilities of tissues and tissue surrogate gels under high strain rate impact, via nanoscale instrumented impact indentation and Kolsky bar.
- Computational (finite element) analysis to identify optimum design of polymer gels for achieving desired mechanical properties and energy dissipation under impact.

Work within Singapore-MIT Alliance for Research and Technology:

- Studying the mechanical role of pericytes in controlling angiogenesis.
- Quantification of contractions generated by human mesenchymal stem cells (hMSCs) on physiologically-relevant substrata, to draw a mechanical parallel between hMSCs and pericytes.

BIOMECHANICS LAB, DREXEL UNIVERSITY

Philadelphia, PA

Graduate Research Assistant

Sep. 2006 – Dec. 2010

- Designed, built, and tested the experimental apparatus in the Biomechanics Lab for performing compression/indentation tests to assess mechanical properties of cartilage.
- Conducted temperature-controlled confined and unconfined compression tests on samples of immature fetal cartilage, and wrote custom codes in MATLAB for curve fitting the data to the finite deformation biphasic theory equations.

- Developed a material model in Fortran for use in ABAQUS by adapting the finite deformation biphasic theory's strain energy function to incorporate the analyzed experimental data; evaluated the user material by performing mechanical tests on whole tissue constructs in general loading conditions and comparing the finite element (FEM) results with the experiment using the material model. The soils consolidation feature was used to model interstitial fluid flow throughout the tissue pores.
- Carried out segmentation and volume rendering of the MRI scans obtained weekly of infants with congenital clubfoot deformity undergoing Ponseti's treatment (serial manipulation and immobilization of the involved foot/feet. Treatments and scanning performed at the Royal Columbian Hospital, Canada).
- Quantified the deformation mapping caused by physician's manipulation at each treatment session for all patients; obtained the distribution of various resulting mechanical quantities, e.g. strain energy density.
- Identified the growth deformation using MRI data analysis.
- Assessed the correlation between several mechanical quantities and the observed increase in the rate of ossification due to treatment using FEM.
- Tested various mechanical stimuli as candidates for regulating the ossification of tarsal bones using the developed material model and FEM.
- Assessed changes in the composition and structure of developing human fetal tarsal bones using Fourier Transform Infrared Spectroscopy.
- Determined correlations between the composition/structure of the tissue and its mechanical properties, and age.
- Suggested ways of improving the Ponseti treatment technique for better results.

ROMAC (ROTATING MACHINERY LAB), UNIVERSITY OF VIRGINIA

Charlottesville, VA

Graduate Research Assistant

Aug. 2004 - Aug. 2006

- Conducted research on employing the bearing coil current ripples to gain better robustness in levitation control of self-sensing magnetic bearings.
- Implemented various parameter estimators to estimate the air gap length of the magnetic bearing by reading the voltage and current signals.
- Implemented virtual probes to replace eddy current sensors.

Journal Publications

- I. Kalcioglu, **R. Mahmoodian**, R. Mrozek, M. Van Landingham, J. Lenhart, K. J. Van Vliet, "Tunable mechanical behavior of synthetic organogels as tissue simulants compared to biological tissues," (*Final draft; Expected submission date: September 2012*).
- I. Kalcioglu*, **R. Mahmoodian***, Y. Hu, Z. Suo, K. J. Van Vliet, "Multiscale poroelastic mechanical characterization of polyacrylamide hydrogels," *Soft Matter*, 8:3393-98, 2012 ***These authors contributed equally.***
- **R. Mahmoodian**, I. Kalcioglu, K. J. Van Vliet, "A finite element approach for design of tissue surrogate polymer systems," 2011 (*In preparation*).
- **R. Mahmoodian**, J. Leasure, P. Philip, N. Pleshko, F. Capaldi, S. Siegler, "Changes in mechanics and composition of human talar cartilage anlagen during fetal development," *Osteoarthritis and Cartilage*, 19(10):1199-209, 2011.
- **R. Mahmoodian**, S. Siegler, F. Capaldi, J. Leasure, H. Gadikota, "Mechanical properties of human fetal talus," *Clinical Orthopaedics and Related Research*, 467:1186-1194, 2009.
- **R. Mahmoodian**, S. Siegler, F. Capaldi, "Finite element implementation of the finite deformation biphasic theory," *Journal of Biomechanical Engineering* (*In preparation*).

- E. Maslen, T. Iwasaki, **R. Mahmoodian**, “Field and gap estimation in magnetic bearings: a Lyapunov approach,” *Journal of the Japan Society of Applied Electromagnetics and Mechanics*, 16:256-265, 2008.
- **R. Mahmoodian**, S. Siegler, R.A. Brand, S. Pirani, D. Hodges, J. Udupa, “The effect of loads applied to the infant congenital clubfoot through serial casting on shape, growth, and ossification of the hindfoot anlagen,” *Journal of Biomechanics*, 40: S136, 2007.

Conference Proceedings

- **R. Mahmoodian**, S. Siegler, F. Capaldi, “Development of a finite element framework for studying growth of cartilage anlage,” *Proceedings of the ASME 2009 Summer Bioengineering Conference*, 2009.
- **R. Mahmoodian**, J. Leasure, S. Siegler, F. Capaldi, “Characterization of compressive behavior of developing human talus,” *Proceedings of the ASME International Mechanical Engineering Congress and Exposition*, 2008.
- J. Leasure, **R. Mahmoodian**, F. Capaldi, N. Pleshko, S. Siegler “Fourier transform infrared spectroscopic assessment of changes in composition of proteoglycans and collagen in developing human fetal tarsal bones,” *Proceedings of the ASME International Mechanical Engineering Congress and Exposition*, 2008.
- **R. Mahmoodian**, S. Siegler, “An MRI based study of tarsal development during manipulation and casting therapy of infant clubfoot,” *Proceedings of the ASME International Mechanical Engineering Congress and Exposition*, 2007.
- E. Maslen, T. Iwasaki, **R. Mahmoodian**, “Self-sensing magnetic bearings: development of a virtual probe,” *Proceedings of the NSF Design, Service, and Manufacturing Grantees and Research Conference*, 2006.
- E. Maslen, T. Iwasaki, **R. Mahmoodian**, “Formal parameter estimation for self-sensing,” *Proceedings of the 10th International Symposium on Magnetic Bearings*, 2006.

Presentations and Posters (presenter in bold)

- A finite element approach for design of tissue surrogate polymer systems. **R. Mahmoodian**, I. Kalcioğlu, K. J. Van Vliet. *Materials Research Society Fall Meeting*, 2011, Boston, MA.
- Molecular to macroscale exploration of fundamental properties of gels” ISN Army Industry Collaboration Conference, *Massachusetts Institute of Technology*, 2012, Cambridge, MA (poster).
- Multiscale poroelastic characterization of hydrated hydrogels via indentation. I. Kalcioğlu, **R. Mahmoodian**, Y. Hu, Z. Suo, K. J. Van Vliet. *Gordon Research Conference - Science of Adhesion*, 2011, Bates College, Lewiston, ME (poster).
- Nanoscale chemomechanics of soft tissue impact trauma (project 3.2.2): A mechanistic understanding of tissue surrogate design. **R. Mahmoodian**, I. Kalcioğlu, K. J. Van Vliet. *ISN-2 Site Review*, Institute for Soldier Nanotechnologies, 2011, Cambridge, MA.
- Mechanics and development of tarsal cartilage anlagen: insights from a human study. **R. Mahmoodian**, F. Capaldi, S. Siegler. *Graduate Seminar*, 2010, Drexel University, Philadelphia, PA.
- Development of a finite element framework for studying growth of cartilage anlage. **R. Mahmoodian**, S. Siegler. *ASME Summer Bioengineering Conference*, 2009, Lake Tahoe, CA (poster).
- Mechanics and development of infant tarsal bones with application to the study of congenital clubfoot. **R. Mahmoodian**, F. Capaldi, S. Siegler. *Graduate Seminar*, 2009, Drexel University, Philadelphia, PA.
- Characterization of compressive behavior of developing human talus. **R. Mahmoodian**, J. Leasure, S. Siegler, F. Capaldi. *ASME International Mechanical Engineering Congress and Exposition*, 2008, Boston, MA.
- Fourier transform infrared spectroscopic assessment of changes in composition of proteoglycans and collagen in developing human fetal tarsal bones. J. Leasure, **R. Mahmoodian**, F. Capaldi, N.

Pleshko, S. Siegler. *ASME International Mechanical Engineering Congress and Exposition*, 2008, Boston, MA.

- Effect of Ponseti technique on development of tarsal bones in clubfoot patients. **R. Mahmoodian**, S. Siegler. *Drexel Engineering Research Symposium*, 2007, Drexel University, Philadelphia, PA.
- Effect of loads applied to the infant clubfoot through serial casting on shape, growth and ossification of hindfoot anlagen. **R. Mahmoodian**, S. Siegler. *Drexel Research, Innovation, Scholarship, and Creativity Day*, 2007, Drexel University, Philadelphia, PA.
- An MRI based study of tarsal development during manipulation and casting therapy of infant clubfoot. **R. Mahmoodian**, S. Siegler. *ASME International Mechanical Engineering Congress and Exposition*, 2007, Seattle, WA.
- Self-sensing magnetic bearings. **R. Mahmoodian**, E. Maslen. *ROMAC Industry Visit*, 2005, University of Virginia, Charlottesville, VA.

Theses and Dissertations

- **R. Mahmoodian**, F. Capaldi, S. Siegler, “Mechanics and development of tarsal cartilage anlagen – insights from a human study,” Ph.D. Dissertation, *Drexel University*, Philadelphia, PA, 2010.
- **R. Mahmoodian**, E. Maslen, “Formal parameter estimation for self-sensing magnetic bearings,” M.S. Thesis. *University of Virginia*, Charlottesville, VA, 2007.
- **R. Mahmoodian**, A. Ataei, H. Mahjoub, “Design, fabrication and control of a ball-on-beam balancer system,” B.S. Thesis, *University of Tehran*, Tehran, Iran, 2004.

Skills and Qualifications

- Cell imaging and probing; cell culture, staining, transformation and transfection, fractionation; gel electrophoresis; Western blot; fluorescent microscopy, flow cytometry; cytoskeleton- inhibiting drug treatments.
- Synthesis of hydrogels such as polyacrylamide gels.
- Mechanical characterization of gels, cells and soft tissues using tensile, confined/unconfined compression experiments, nanoindentation, atomic force microscopy, and rheology.
- Fourier transform infrared microscopy, atomic force microscopy, confocal microscopy.
- Programming: Fortran, Visual Basic, C++, Pascal, MATLAB and MATLAB Simulink
- Software packages: SPSS (statistics), ABAQUS, ANSYS, Patran, Pro/E, Geomagic, Mimics and Analyze (both medical image processing software).
- Developing material models using Fortran for implementation in ABAQUS.
- Medical image processing (used Analyze Visualization and Analysis Software, and Mimics).

Awards and Honors

- Dissertation Award of the International Society of Biomechanics 2007
- Graduate Fellowship of the University of Virginia 2004
- Award of College of Engineering of the University of Tehran for outstanding results in the public universities' entrance exam and maintaining academic excellence 2000, 2003
- Silver Medal in the National Physics Olympiads 1998

Service and Peer Review

- Peer-reviewer for journals: Biomedical Materials; Mechanics of Materials; Journal of Biomedical Materials Research – Part A 2010 – Present
- Peer-reviewer for the Materials Research Society publications. Present
- Vice President of the Engineering Graduate Association, Drexel University 2008 - 2009
 - Organized seminars, social and athletic events

- Member of the 2009 Drexel Engineering Research Symposium committee Mar. 2009
 - Significantly reduced the operating costs of the event as compared to the previous years
 - Focused on increasing the industry involvement and making the event accessible to the University community
- Reviewed for the ASME International Mechanical Engineering Congress and Exposition, Boston, MA 2008
- Co-Chair of the “Modeling and Simulation-I” session of the Symposium on Bio Engineering/Medical Applications at the ASME International Mechanical Engineering Congress and Exposition, Seattle, WA. 2007

Teaching Experience

- Teaching two students Finite Element Analysis as applied to the design of tissue surrogate materials for ballistic applications, Lab for Material Chemomechanics, MIT, Cambridge, MA 2011- Present
- Teaching assistant for *Advanced Dynamics* (MEM 666), Dept. of Mechanical Engineering and Mechanics, Drexel University, Philadelphia, PA 2010
- Teaching assistant for *Statics* (MEM 202), Dept. of Mechanical Engineering and Mechanics, Drexel University, Philadelphia, PA 2010
- Teaching assistant for *Dynamics* (MEM 238), Dept. of Mechanical Engineering and Mechanics, Drexel University, Philadelphia, PA 2010
- Teaching assistant for the *graduate level Finite Element Methods I* (MEM 681), Dept. of Mechanical Engineering and Mechanics, Drexel University, Philadelphia, PA 2009, 2010
- Teaching assistant for *undergraduate level Finite Element Methods* (MEM 427), Dept. of Mechanical Engineering and Mechanics, Drexel University, Philadelphia, PA 2009
- Teaching assistant for *Statics*, Dept. of Metallurgical Engineering, University of Tehran 2002
- Teaching assistant for *Statics*, Dept. of Mechanical Engineering, University of Tehran 2001
- Developed course materials and taught *Advanced Dynamics* to students preparing for the International Physics Olympiad, Farzanegan high school, Karaj, Iran 1999 - 2000

Research Interests

Biomaterials; Regenerative medicine; Medical devices

Professional Affiliations

- Materials Research Society
- Biophysical Society
- American Society of Biomechanics
- American Physical Society
- American Society of Mechanical Engineers