Orthopaedic Biomedical Engineering Laboratory

2008 Program Update
Rose-Hulman Institute of Technology
John T. Myers Center for Technological Research with Industry
Terre Haute, Indiana

Joint Replacement Surgeons of Indiana Research Foundation
Center for Hip and Knee Surgery — St. Francis Hospital
Mooresville, Indiana

www.rose-hulman.edu/jrsi
“The JRSI Research Foundation has been uplifted with the addition of the Rose Hulman Biomedical Engineering program. Our large clinical base frequently lacked the answer for why a particular episode did or did not work. Now with the help of the engineering staff and students we are able to offer sound reason for our clinical problems. This has been a match made in heaven.”

Merrill A. Ritter, MD
President, JRSI Research Foundation
Professor of Orthopaedic Surgery, Indiana University School of Medicine

“The unique relationship with RHIT has allowed a true exchange of information, educational opportunities, and scientific thinking between surgeons and students. We have been able to combine our clinical experience with over 23,000 joint replacements with the latest engineering research techniques and experimental models. The combination of these disciplines hopefully helps students see what can be accomplished in the future. It has been a real privilege to see the engineers discover many new insights into joint replacement performance in the RHIT lab. Many great things are on the horizon.”

Michael E. Berend, MD
Orthopaedic Surgeon
Clinical Assistant Professor, Indiana University School of Medicine
The Joint Replacement Surgeons of Indiana (JRSI) Research Foundation is a not-for-profit organization committed to clinical and biomedical research in the field of orthopaedics. The mission of the Foundation is: “To foster the advancement of hip and knee replacement surgical procedures, implants, and survivorship in order to improve the long-term function and well-being of the patients who suffer from debilitating arthritis and associated disorders.”

Collaboration between the JRSI Research Foundation and Rose-Hulman began in 2004 with a generous gift from Howard Freers (Rose-Hulman Class of 1948) and the sponsorship of two biomedical engineering masters theses. In July 2007, the JRSI Research Foundation expanded the collaboration by hiring Scott Small, MS (Rose-Hulman Class of 2005) to serve as the full-time engineering director to oversee research efforts at Rose-Hulman.

A total of well over 400 peer-reviewed journal articles have been published by researchers affiliated with JRSI in the last 20 years. The Orthopaedic Biomedical Engineering Laboratory, located in the John T. Myers Center for Technological Research with Industry, unites the clinical research experience of our orthopaedic surgeons with the engineering expertise of Rose-Hulman to create a unique learning environment for students to be actively engaged in clinically relevant, real-world problem solving.
A Commitment to Education

The partnership between Rose-Hulman and the JRSI Research Foundation creates learning experiences for undergraduate and graduate engineering students that extend far beyond the classroom. With our engineering director based full-time at the Rose-Hulman campus, students have the opportunity to enroll in a JRSI-instructed research course enabling them to learn and practice orthopaedic research techniques while earning credit toward the fulfillment of their degree. Students work alongside our engineering director in experimental design, testing setup, and data collection, culminating in the preparation of a final research manuscript detailing their efforts.

In conjunction with gaining laboratory experience, students are given the unique opportunity to visit our physicians in the operating room to witness firsthand the clinical application of the procedures and prostheses they are studying in the lab. Additionally, our students have the opportunity to meet some of the world’s leading orthopaedic surgeons and researchers at conferences and during guest visits.

JRSI is committed to maintaining a diverse educational partnership with Rose-Hulman. In addition to offering the research course, JRSI has sponsored group projects in the mechanical engineering courses Machine Design and Mechatronic Systems, as well as provided our physicians and engineering director to give guest lectures in Introduction to Biomedical Engineering and Bone Biomechanics. Since 2004, JRSI has sponsored a total of six graduate thesis projects, and has employed at least one student in our summer internship program each of the past three years.
“I am really glad that I have had the opportunity to work with this type of research. I have definitely enjoyed working on a project completely separate from tests and classes. This whole experience has made me really excited about graduate school.

“I enjoyed having the consistent interaction with the surgeon we were doing the research for. It certainly makes you care more and put forth your best effort when you see how dedicated he is to the project.

“The extra perks were definitely an exciting part of research. I felt incredibly privileged being at the surgeons’ conference since it was such a small setting with few people. It was a great experience getting to see all of them present their research over knee implants and hear about their different techniques and opinions on the subject. By far, the surgery viewings were one of the most enjoyable parts of the research. I really wish that every Biomedical Engineering student could have this opportunity.”

Michael Lockhart, Biomedical Engineering Class of 2008
2007-2008
Student Involvement

Undergraduate Research Courses
Lucas Alvey
Samantha Dick
Michael Lockhart
Natalie Dickman

Mechanical Engineering Senior Design Projects
Samantha Dick
Jennifer Gordon
Stephanie Story
Elizabeth White
Susannah Yoder

Mechatronics Course Projects
Samantha Dick
Jennifer Gordon

Summer Internships
Margaret Kelly
Conference Presentations

A compilation of the work in three masters theses was presented to an audience of over 20,000 surgeons, researchers, and industry professionals as a Scientific Exhibit to the Annual Meeting of the American Academy of Orthopaedic Surgeons in San Francisco, California, on March 5-8, 2008.

**Factors Affecting Loading in TKA: What is Causing Implant Failure and Loosening?**

Michael E. Berend, MD
Scott R. Small, MS  Christine A. Buckley, PhD
R. Michael Meneghini, MD  W. Kurt Dierking, MS
Merrill A. Ritter, MD  James C. Merk, MS

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**Introduction**

Overload of supporting cancellous bone leading to bony failure in the medial tibia continues to be a cause of early failure in total knee arthroplasty (TKA) leading to TKA revision1-3 (Figure 1). Several factors, including prosthetic alignment, ligament balance, and implant design may contribute to failure; however, the respective contribution of these factors to TKA failure is unknown. This study was designed to measure shear strains on the proximal tibia to identify key factors that alter or redistribute stress concentrations in the underlying bone. The Vanguard™ Complete Knee System (Biomet, Inc.) and two variations of the AGC® Total Knee System (Biomet, Inc.) were used in this study.

![Figure 1: Radiograph examples of TKA medial tibia collapse](image-url)
In the past year, work from our laboratory research has been included in podium presentations at conferences and meetings from Mooresville, Indiana, and Dallas, Texas, to Marbella, Spain.
Peer Reviewed Journals

A primary goal of the JRSI Research Foundation is to submit the results of our research to peer-reviewed scientific journals. These journals are invaluable resources to the orthopaedic and engineering communities as a means of sharing research results to improve future patient clinical outcomes. The following are our 2007-2008 contributions to the scientific community:

A Comparison in Proximal Tibial Strain between Metal-Backed and All-Polyethylene AGC Total Knee Arthroplasty Tibial Components.
Scott Small, Michael Berend, Merrill Ritter, Christine Buckley
- Included in a May 2008 Industry Sponsored Supplement to the British Journal of Bone and Joint Surgery

Effects of Femoral Component Size on Proximal Tibial Strain with AGC Total Knee Arthroplasty.
Michael Berend, Scott Small, Merrill Ritter, Christine Buckley, James Merk, Kurt Dierking
- Accepted for publication in the Journal of Arthroplasty

The Effects of Bone Resection Depth and Malalignment on Strain in the Proximal Tibia Following TKA.
Michael Berend, Scott Small, Merrill Ritter, Christine Buckley
- Under review for publication in the Journal of Arthroplasty

Effects of Coronal Plane Conformity on Tibial Loading in TKA: A Comparison of AGC© Flat vs. Conforming Articulations
Michael Berend, Scott Small, Merrill Ritter, Christine Buckley, James Merk, Kurt Dierking
- Under review for publication in the Journal of Orthopaedic Research

Bearing Mobility Affects Tibial Strain in Mobile Bearing Unicompartmental Knee Arthroplasty.
Scott Small, Michael Berend, Merrill Ritter, Christine Buckley.
- Under review for publication in the Journal of Arthroplasty
In preparation for moving forward in our research, we have established new relationships and have created new experimental setups to extend the scope of our research abilities.

In the Summer of 2008, Dr. Michael Berend and Scott Small travelled to Oxford, England to initiate a relationship with the Oxford Orthopaedic Engineering Center in the Nuffield Department of Orthopaedic Surgery of the University of Oxford. We are working with engineers and surgeons from this group to draw comparisons between our laboratory findings and their research on partial knee replacements using finite element analysis techniques.

With the help of Margaret Kelly, a Rose-Hulman Biomedical Engineering junior who served as our 2008 summer intern, we have developed testing protocols and experimental setups for the expansion of our research into pelvic and femoral loading following total hip arthroplasty and hip resurfacing procedures.
Since 2004, the collaboration between the orthopaedic surgeons of the JRSI Research Foundation and Rose-Hulman Institute of Technology has resulted in the following student research projects:

Measurement of Loading in the Human Pelvis following Total Hip Arthroplasty: Margaret Kelly (with JRSI Physician Michael Berend, RHIT Associate Professor Christine Buckley and JRSI Engineering Director Scott Small), 2008.

Strain in the Proximal Tibial Following Unicompartmental Knee Arthroplasty: A Photoelastic Study of Mobile Bearing Designs: Samantha Dick, Michael Lockhart, Lucas Alvey, Natalie Dickman (with Michael Berend, Christine Buckley, RHIT Assistant Professor Renee Rogge, and Scott Small), 2007-2008.


Initial Mechanical Stability of Acetabular Components with Screw Fixation: **Allison Stultz, Jill Watson** (with Michael Meneghini and Christine Buckley), 2006.


A Photoelastic Strain Analysis of the Proximal Tibia in Total Knee Arthroplasty: **Kurt Dierking** (with Michael Berend, Michael Meneghini and Christine Buckley), 2004-2005. Masters Thesis


The Exploration of Damage Identification Techniques to Determine Placement of the Femoral Component During Total Hip Arthroplasty: **Seana Giardini** (with Michael Meneghini and Phil Cornwell), 2004-2005. Masters Thesis
“If I have seen further, it is only by standing on the shoulders of giants.”

Sir Isaac Newton