Produced state-of-the-art simulator to test Knee Replacement implants
Methodology now adopted as an International Standard Test Method (ISO 14243-1)

We have 3 of these knee simulators in our lab and are fast becoming the top lab internationally in knee testing. Research evaluates new knee implant designs before clinical use, or produce reliable lab performance data for regulatory purposes and design improvement.

**Knee implant motion**  
Laboratory (in-vitro) simulation and testing (human walking activity)

**Knee laxity studies**

**Special jigs and fixtures built in our lab.**
This setup is almost unique in the world
To aid design of new implants with high flexion capability for younger and more active patients.
American Standard method (ASTM F1223) has recently been revised based on our results

**Our Studies published:**

**Effect of surgical misalignment of knees**

**Our published studies:**

**Hip, spine and ankle implant testing**  
State-of-the-art
AMTI 12-station Hip and Spine Simulator

**Testing machine design**

Design and prototype manufacture of new innovative biomechanics test machines

**Low-Load Knee Simulator**
Fluidic Muscle actuated

**Friciton Measuring Machine (tribometer)**
Specially high dynamic range for orthopaedic and other biomaterials

**Research contract work at our lab from:**
Astratech Inc/ Sweden
Biomet Inc / IN
Encore Orthopedics Inc / TX
Smith & Nephew Inc / IN
Depuy Johnson & Johnson Inc / IN
Kyocera Inc. / Japan
Zimmer Inc / IN

All are multinational orthopaedic manufacturing companies

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Rapid Prototyping (RP) Surgical Modeling

Most tangible & realistic representation of a patient's anatomy

…… physically in the hands of a surgeon!

We have processed (in-house)
CT imaging data, and manufactured (in-house)
rapid 3D anatomical prototypes representing complex patient anatomy.
The models were used to aid planning of knee and hip surgery in our hospital.

From medical scanner to physical 3D model to custom implant manufacture

Rapid Prototyping (RP)

Our preliminary results of this work have been published in 17 papers in:
- International Society for technology in Arthroplasty (ISTA)
- American Academy of Orthopaedic Surgeons (AAOS)
- International Society for Computer Aided Orthopedic Surgery, (CAOS)
- Orthopaedic Research Societies of Canada, U.S.A., Japan and Europe
- International Conference on Mechanics of Biomaterials & Tissues (ICMBT)
- Orthopaedic Research Society

This work has won the
HAP Paul Award
As the best research paper "...on new development in the field of orthopaedic arthroplasty" at the International Society for technology in Arthroplasty, Kyoto, Japan, 2005.

Nebraska's in-house developed Navigation System for Knee Surgery

The use of JIGS for cutting bones to fit the implant can be avoided...

…by creating a virtual 3D environment system with meaningful feedback to the surgeon for cutting freehand by navigation

Our ultimate goal

In-vivo diagnostics for early detection of:
- implant wear
- misalignment
- loosening
- self-adapting implants

Our preliminary results published in:

Philosophy of Minimally invasive surgery:
Smaller surgical access - small scar
Little bone removal – conservative, leaves options open
Less soft tissue trauma
Faster recovery time - one day operation possible
Suitable for the younger, more active patient

Finite Element Analysis
Minimally-invasive implant design

We demonstrated the feasibility of using piezoelectric ceramics to generate electrical energy within Total Knee Replacement (TKR) implants

Future promise: Smart Implants
On-board microprocessor:
- Process measurements
- Store results
- Communicate them non-invasively (by radio) to the surgeon/therapist during follow-up visits.

Pilot study conducted with the help of UNL.

Smart Instrumented Implants

Diagnostics & adaptive action

Our Studies published:
6 presentations have been made on this work in: ISTA 2005, ICMBT 2005 and ORS 2006.
The laboratory occupies 5500 square feet in the Scott Technology Center in Omaha, Nebraska. It is within 10-minute drive of the University of Nebraska Medical Center Department of Orthopaedic Surgery and Rehabilitation.

The lab is directed by Dr. Hani Haider (Associate Professor – faculty member), assisted by one Masters qualified Mechanical Engineer, another Masters qualified Biomedical Engineer/Computer Scientist, three full-time Engineering Research Technicians and one administrative assistant/secretary. All, including the director Dr. Hani Haider, have their main offices within the laboratory.

Surrounding the Biomechanics Lab central section are the Implant wear simulator laboratory, ancillary service room housing the pneumatic air-compressors, hydraulic pumps, chillers and other plant infrastructure powering the wear and biomechanics fatigue testing machines. In the same suite, are the faculty and researcher offices and desks, a computer-aided orthopaedics surgery, biomechanics-cadaveric and clinical orthopaedics research lab, a 30-40 person conference room with full multimedia audio-visual, data and teleconferencing facilities, and a mini workshop for test jig and fixture manufacture/finishing – see full machine-workshop in an adjacent building described later below).

The lab has over 25 PC computers and Unix workstations all interconnected with a local area network and the University campus wide network and each has access to the Internet. Over 15 PCs are interfaced to the test machinery and instrumentation for control, data-logging, and acquisition, and the same network connectivity. There are over 10 separate telephone voice lines.

The following are the major items of Biomechanics research equipment housed in this laboratory.
The lab houses three separate state-of-the-art force-control Instron-Stanmore Knee Simulators. Each is a 4-station Total Knee Replacement joint simulation and wear testing under the force control method ISO 14243-1.

The simulators can drive separate stations on an 8-station Fatigue testing machine (shown later below) to work as active (loaded) soak controls.

These three test knee simulators at Nebraska have been upgraded with over 20-30 design and control software improvements over the original versions. All these upgrades were performed by the same engineer (Dr. Hani Haider) who led the production of the original Instron-Stanmore versions in England between 1997-2000.
Pin-on-disk wear testing machines

AMTI Orthopod Pin-on-Disk wear testing machine
(flexible programmable motions and loads for orthopaedic joint couples)

Specimen Lapping machine

Linear reciprocating Pin-on-Disk wear testing machine
(for hard on hard orthopaedic joint couples)

Polishing machine
Friction measuring machine with high dynamic friction and stress range
(Manufactured in the Biomechanics Lab at UNMC for orthopaedic implant research utilizing frictionless air-bearing technology)

AMTI Hip Implant Wear Simulator
General Biomechanics Testing Systems

Advanced four-axis computer controlled MTS Bionix fatigue testing machine, with highly customised knee and ankle constraint/laxity measurement systems, and specialised multi-axis control configurations. The fixtures shown opposite have been built with 6-degrees of freedom for knee and ankle, tests (all instrumented with sensors) with adjustability for posterior sloped installation and various contact angle and laxity/constraint and joint fatigue studies.

Together with the two MTS single axis Mini-Bionix the machines, and an electro-mechanical Model 1000 Instron testing machine (not shown here), an 8-axis fatigue testing machine, and the many standard and custom made jigs and holders, this assortment facilitates a large number, and a very wide range of biomechanical testing needs.
In-house manufacture of jigs and fixtures

Our Rapid Manufacturing Machine Workshop is in a separate building only 200 yards away from our Biomechanics Lab. Our laboratory technicians have full access to this manufacturing facility.

CNC Lathe and CNC Mill
(Computer Numerically Controlled)

Rapid Prototyping Machine

Wire Electro Discharge Machining Center (EDM)

Welding Equipment
(Conventional, inert gas, stainless steel and Alum alloys etc)

Abrasive Water Jet Cutting Machine

Wire Electro Discharge Machining Center (EDM)
Dr. Hani Haider studied in England for his first degree and PhD in Mechanical Engineering. He was first appointed Lecturer in the University of Sheffield, from 1988 to 1996, with research in fluid dynamics, mechatronics, robotics and information technology. In 1997, he joined the faculty of University College London at the well known Centre of Biomedical Engineering in Stanmore. He was the principal mechanical and software engineer who produced the Instron-Stanmore Knee Simulator and the International Standards Organization (ISO) method for simulation and wear testing of knee replacement systems. He was invited to join the faculty of the University of Nebraska Medical Center in March 2000 as an Associate Professor at the Department of Orthopaedic Surgery and Rehabilitation. His main mission was to make its Orthopaedics Biomechanics Laboratory a leading facility known internationally for implant technology.

Dr. Haider has received over 25 research grants and contracts, mostly from the orthopaedic companies in the USA, and from Europe and Japan. He has presented over 100 papers in peer reviewed journals and international conferences in engineering and orthopedics biomechanics. He had won various academic prizes in his university years, then the “The KLINGER International Research Prize”/Austria for innovative engineering research work. In 2005, he won the HAP Paul Award by the International Society for Technology in Arthroplasty for “…the most innovative research paper on orthopaedics joint replacement technology”. In 2006, he won two awards from the University of Nebraska Medical Center for Special and Outstanding Professional Achievement. Dr. Haider is a Member of the United Kingdom’s Engineering Council, and its Institution of Mechanical Engineers, and various American professional societies. He co-chairs the committee for Knee Implant Wear Testing of ASTM International, and chairs the ASTM Total Ankle Specification/Testing standard committee. He also chairs the International Standards Organization (ISO) Review Workgroup of Knee Wear standards.