Steadman◆Hawkins Research Foundation
*A 501(c)(3) nonprofit organization*

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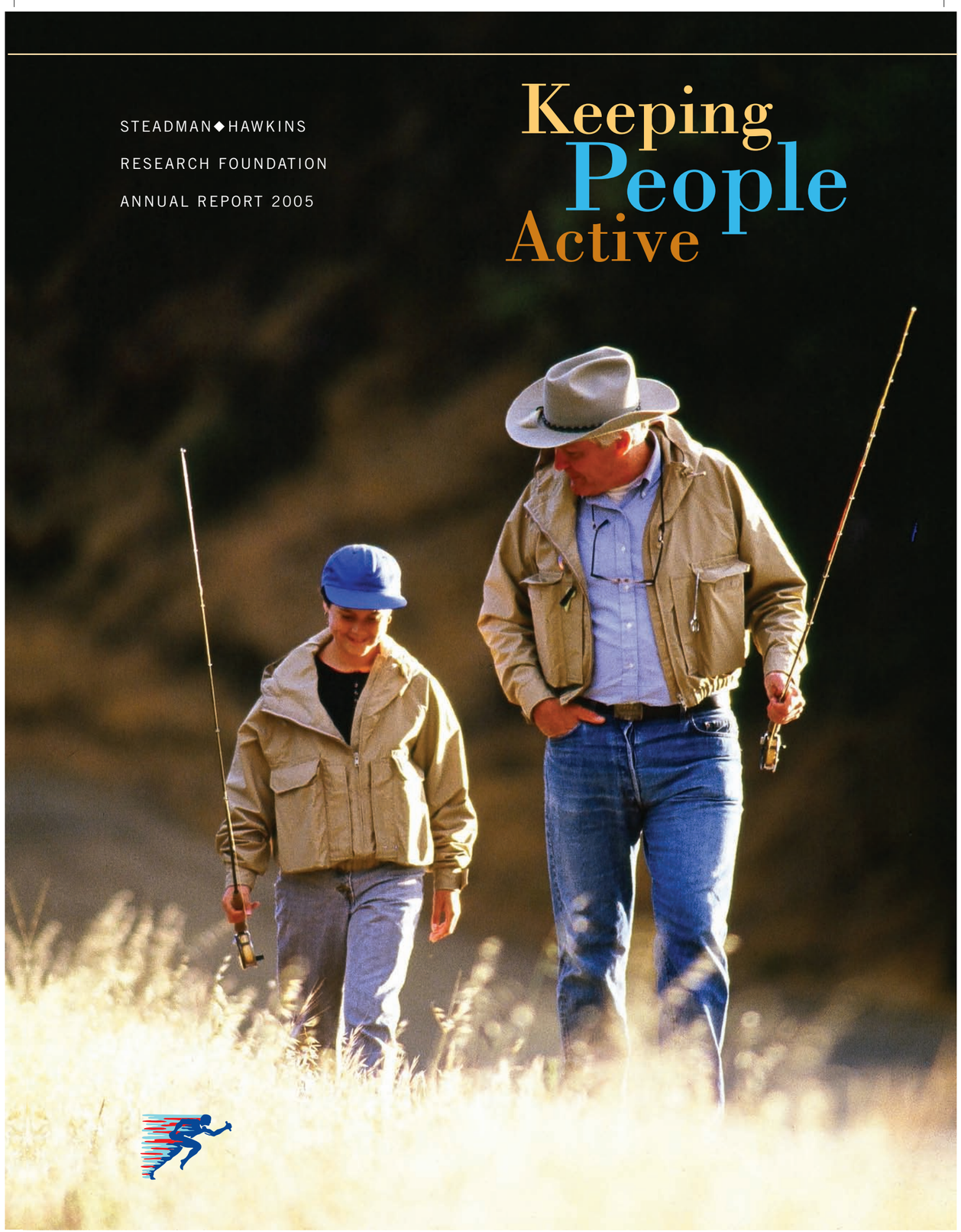
STEADMAN◆HAWKINS

RESEARCH FOUNDATION

ANNUAL REPORT 2005

# Keeping People Active



# Mission

The Steadman◆Hawkins Research Foundation is dedicated to keeping people of all ages physically active through orthopaedic research and education in the areas of arthritis, healing, rehabilitation, and injury.

# History

Founded in 1988 by orthopaedic surgeon Dr. J. Richard Steadman, the Foundation is an independent, tax-exempt (IRS code 501(c)(3)) charitable organization. Known throughout the world for its research into the causes, prevention, and treatment of orthopaedic disorders, the Steadman◆Hawkins Research Foundation is committed to solving orthopaedic problems that limit an individual's ability to maintain an active life. In 1990, Dr. Steadman was joined by renowned shoulder surgeon Dr. Richard J. Hawkins. Together, they brought the Foundation's research production in knee and shoulder studies to a new level.

## Contents



*The Steadman◆Hawkins Research Foundation wishes to express deep appreciation to John P. Kelly, who donated many of the stock photos in this year's Annual Report and contributed his time to photograph the many Foundation and operating room subjects.*

*Kelly is a renowned sports and stock photographer who approaches every photo shoot like a commando. His sense of motion combines with his obvious love of natural light to produce vibrant graphic images. He shoots extensively for a variety of prominent manufacturers in the sports and recreation industry; and his experience includes numerous assignments at the Olympics, Wimbledon, U.S. Open Golf, and World Cup Skiing. When Robert Redford needed a poster that reflected the spirit of his movie "A River Runs Through It," he called Kelly. More recently, Redford employed Kelly's photographic talents during the making of the "Horse Whisperer." Whether covering the Olympics or trekking in the Himalayas, Kelly is always ready for his next photographic adventure.*

### NOTE 3: CONTRIBUTIONS RECEIVABLE

Contributions receivable at December 31 are due as follows:

| | 2005 | 2004 |
|---|---|---|
| Due in less than one year | $ 160,750 | $ 1,900 |
| Due in one to five years | 150,000 | – |
| | 310,750 | 1,900 |
| Less: unamortized discount | (13,946) | – |
| Due from related parties | (5,750) | (1,900) |
| | $ 291,054 | $ 0 |

Discounts were 5% for 2005.

Approximately 98% and 100% of total contributions receivable at December 31, 2005 and 2004, respectively, are from one donor. The Foundation receives support and pledges from members of the Board of Directors and employees. These pledges receivable are included in contributions receivable, related party.

### NOTE 4: PROPERTY AND EQUIPMENT

Property and equipment at December 31 consists of the following:

| | 2005 | 2004 |
|---|---|---|
| Equipment | $ 774,923 | $ 710,715 |
| Furniture and fixtures | 22,326 | 22,326 |
| Leasehold improvements | 263,793 | 263,793 |
| | 1,061,042 | 996,834 |
| Less accumulated depreciation | 846,465 | 754,615 |
| | $ 214,577 | $ 242,219 |

### NOTE 5: TEMPORARILY RESTRICTED NET ASSETS

Temporarily restricted net assets at December 31 are available for the following purposes:

| | 2005 | 2004 |
|---|---|---|
| Education | $ 196,359 | $ 165,550 |
| Biomechanics research | 286,054 | – |
| Time restricted contributions and pledges | 105,000 | 1,900 |
| Administration | – | 4,483 |
| Information systems | – | 25,000 |
| | $ 587,413 | $ 196,933 |

### NOTE 6: RELEASE OF TEMPORARILY RESTRICTED NET ASSETS

Net assets were released from donor restrictions by incurring expenses satisfying the restricted purposes or by occurrence of other events specified by donors as follows:

| | 2005 | 2004 |
|---|---|---|
| Purpose restrictions accomplished | | |
| Education | $438,099 | $204,175 |
| Biomechanics research | 285,969 | 116,287 |
| Information systems | 25,000 | – |
| Basic science programs | 9,504 | 3,690 |
| Administration | 4,483 | 25,000 |
| | 763,055 | 349,152 |
| Time restrictions expired | | |
| Collection of contributions receivable | 1,900 | 87,333 |
| Total restrictions released | $764,955 | $436,485 |

### NOTE 7: OPERATING LEASES

Noncancellable operating leases for property and equipment expire in various years through 2006. Two of the property leases require the Foundation to pay all executory costs (property taxes, maintenance and insurance).

Future minimum lease payments at December 31, 2005 are:

| | |
|---|---|
| 2006 | $ 73,755 |
| 2007 | 70,815 |
| 2008 | 70,815 |
| 2009 | 70,815 |
| 2010 | 70,815 |
| | $ 357,015 |

Rental expense of $72,768 and $73,512 for the years ended December 31, 2005 and 2004, respectively, is recorded in the statements of activities.

### NOTE 8: PENSION PLAN

The Foundation has a defined contribution retirement plan under IRS Section 401(k). The plan is open to all employees after one year of employment. The Foundation's contributions to the plan are determined annually. The Foundation elected to match 50% of participants' contributions up to 6% during 2005 and 2004. Under this formula, the Foundation made contributions of $19,510 and $17,515 for the years ended December 31, 2005 and 2004, respectively.

### NOTE 9: RELATED PARTY TRANSACTIONS

During 2005 and 2004, the Foundation received approximately $244,000 and $267,000, respectively, in contributions from related parties, including various board members as well as the Steadman Hawkins Clinic.

### NOTE 10: SIGNIFICANT ESTIMATES AND CONCENTRATIONS

Accounting principles generally accepted in the United States of America require disclosure of certain significant estimates and current vulnerabilities due to certain concentrations. Those matters include the following:

#### Contributed Support

During 2005 and 2004, approximately 28% and 17%, respectively, of all contributed support was received from two donors.

The Foundation has influenced the practice of orthopaedics—from diagnosis to rehabilitation. Recognizing that the body's innate healing powers can be harnessed and manipulated to improve the healing process has led to exciting advances in surgical techniques that are used today by orthopaedists in many practices. The microfracture technique, for example, is now accepted as a treatment that may make it possible to postpone or even eliminate the need for knee replacement surgery.

One of the largest independent orthopaedic research institutes in the world, the Steadman◆Hawkins Research Foundation has become one of the most productive and innovative foundations in orthopaedic research and education. Philanthropic gifts are used to advance scientific research and to support scholarly academic programs that train physicians for the future. Through its Fellowship Program, the Foundation has now built a network of 150 Fellows and associates worldwide who share the advanced ideas and communicate the concepts they learned in Vail.

### THE FOUNDATION'S PRIMARY AREAS OF RESEARCH AND EDUCATION ARE:

- **Basic Science Research** – Undertakes studies to investigate the mysteries of degenerative arthritis, cartilage regeneration, and arthritic changes in the knee and shoulder.
- **Clinical Research** – Conducts "process" and "outcomes" orthopaedic research that aids both physicians and patients in making better-informed treatment decisions.
- **Biomechanics Research Laboratory** – Performs knee and shoulder computer modeling and related studies in an effort to reduce the need for surgical repair.
- **Education and Fellowship Program** – Administers and coordinates the physicians-in-residence fellowship program, hosts conferences and international medical meetings, and produces and distributes publications, CD-ROMS, videotapes, and webcasts for continuing medical education credits.

### SINCE ITS INCEPTION, THE FOUNDATION HAS HELPED PEOPLE OF ALL AGES REMAIN PHYSICALLY ACTIVE THROUGH ORTHOPAEDIC RESEARCH AND EDUCATION. IT CONTINUES TO PURSUE ITS GOALS OF:

- Understanding and enlisting the body's innate ability to heal.
- Designing and validating surgical and rehabilitation techniques, as well as non-operative treatments for arthritis.
- Producing and publishing scientifically validated research in leading medical and scientific journals.

# The Year in Review

## Dear Friends,

Welcome to the 2005 Annual Report. In this edition, we will present a review of our research and education programs and honor the generosity of our friends and supporters around the globe. Most notably, we wish to thank the Stavros S. Niarchos Foundation for its $450,000 grant to study the benefits of removing scar tissue in the knee. The results from this research will improve the quality of life for many people around the world. We will also pay tribute to the scientific process that is leading to improved patient care.

The Foundation's Scientific Advisory Committee has been an integral resource the past 17 years as these preeminent scientists have shaped our research and provided the Foundation with direction. We hope you will find the article, *Scientific Process Leads to Improved Patient Care*, on page 6, of interest.

We are constantly reminded of the dramatic increase in the number of people suffering from arthritis and the impact this disease is having on individual lives, families, healthcare, our nation's economy, and the ability to continue to be active. Arthritis is the leading cause of lost wages in the United States, and with the aging of our population, the number of people suffering will increase dramatically. We want to change this and are working diligently to achieve that goal.

In this report you will meet Philip Elder and learn of his battle with severe arthritis. A father of five, Philip was looking for a solution to allow him to remain active in a family activity—competitive horseback riding. The research of the Foundation has provided help and given him hope.

One of the areas of optimism is in regenerative cartilage medicine. Dr. William G. Rodkey, director of Basic Science Research, continues to focus exclusively on regeneration of cartilage tissue that is used to treat defects on the joint surface and hopefully prevent or delay the onset of arthritis. A new area of research interest involves the use of electrostimulation to speed up and enhance healing in conjunction with microfracture.

We all shared a proud moment in 2005 when a landmark manuscript on "Healing Response," a surgical technique pioneered and scientifically validated by the Foundation to repair the ACL, was accepted by the *Journal of Knee Surgery*. It will be published in 2006. This is significant because the scientific validation and information will help other orthopaedic surgeons gain confidence with the healing response procedure, making them more likely to perform it. In so doing, fewer patients will require the expense, time, inconvenience, and discomfort of a formal ACL reconstruction. Additionally, other patients unwilling to have ACL reconstruction can be offered a less invasive alternative.

With funding from the Niarchos Foundation, Dr. Michael R. Torry, director of the Biomechanics Research Laboratory, and his team of scientists have started to design studies using a high-speed, biplane fluoroscopy system. In the fall of 2006, the Foundation's Biomechanics Research Laboratory will become one of only two organizations in the world to have helped design this equipment for in-house research.

This sophisticated X-ray system creates movies of bones and joints in motion that can be tracked with sub-millimeter accuracy—allowing for the measurement of ligament lengthening. This new technology may even depict cartilage indentation during activities such as walking, running, and throwing. Currently unknown, these measurements are critical to the understanding of ligament and cartilage function, and to their surgical reconstruction and repair. This will help Foundation researchers to better understand the development and pro-

During the past 17 years, the Foundation has raised more than
$30 million in support of orthopaedic research.
The results of that research have changed the way physicians look at arthritis,
joint disease, healing, and treatments for injured joints.

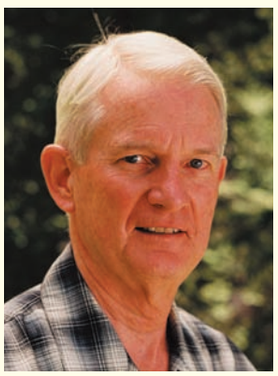
gression of arthritis, resulting in more effective treatments—perhaps prevention—and reduced healthcare costs.

Our research is expanding to include the hip joint and already the Foundation is becoming a leader in hip-related research. Karen Briggs, M.B.A., M.P.H., director of Clinical Research, reports that initial findings show that the progression of arthritis in the hip may be prevented or delayed with early intervention.

During the past 17 years, the Foundation has raised more than $30 million in support of orthopaedic research. The results of that research have changed the way physicians look at arthritis, joint disease, healing, and treatments for injured joints. We have applied philanthropic, scientific, and industry support to create tangible results. But much remains to be done, especially in the area of hips, shoulders, and the spine.

What is tomorrow's success story? It is difficult to say, but one thing is certain: continued financial support will provide the foundation for our success.

On behalf of our dedicated trustees and researchers, we wish to thank you, our donors, corporate sponsors, and foundations for your commitment in 2005.



Respectfully yours,

J. Richard Steadman, M.D.
Chairman of the Board

Norm Waite, Jr.
President and Chief Executive Officer

# Governing Boards

## BOARD OF DIRECTORS

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Spartanburg, S.C.

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Senior Advisor
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Steadman-Hawkins Clinic
Steadman◆Hawkins Research Foundation
Vail, Colo.

**J. Richard Steadman, M.D.**
Steadman-Hawkins Clinic
Steadman◆Hawkins Research Foundation
Vail, Colo.

**William I. Sterett, M.D.**
Steadman-Hawkins Clinic
Steadman ◆Hawkins Research Foundation
Vail, Colo.

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Bellaire, Fla.

**Norm Waite, Jr.**
Vice President
Booth Creek Management Corporation
Vail, Colo.

## OFFICERS

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Chairman

**Norm Waite, Jr.**
President

**John Welaj**
Chief Financial Officer and
Vice President, Administration

**John G. McMurtry**
Vice President, Development

**John Welaj**
Treasurer

**Amy Ruther**
Secretary

## COLORADO COUNCIL

The Colorado Council was established as an auxiliary board of prominent Colorado citizens who serve as ambassadors for the Foundation within the state.

**Bruce Benson**
Benson Mineral Group, Inc.
Denver

**Joan Birkland**
Executive Director
Sports Women of Colorado
Denver

**Robert Craig**
Founder and President Emeritus
The Keystone Center
Keystone

**Dave Graebel**
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Aspen Business Center Foundation
Aspen

**Charlie Meyers**
Outdoor Editor
*The Denver Post*
Denver

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Aspen Club Fitness and Research Institute
Aspen

**Warren Sheridan**
Alpine Land Associates, Ltd.
Denver

**Vernon Taylor, Jr.**
The Ruth and Vernon Taylor Foundation
Denver

**William Tutt**
Tutco, LLC
Colorado Springs

# Scientific Advisory Committee

The Scientific Advisory Committee consists of distinguished research scientists who represent the Foundation and serve as advisors in our research and education efforts, in our Fellowship Program, and to our professional staff.

**Steven P. Arnoczky, D.V.M.**
Director
Laboratory for Comparative Orthopaedic Research
Michigan State University
East Lansing, Mich.

**John A. Feagin, M.D.**
Associate Professor Emeritus of Orthopaedics Surgery
Duke University
Durham, N.C.

**Richard J. Hawkins, M.D.**
Steadman-Hawkins Clinic of the Carolinas
Spartanburg, S.C.

**Charles Ho, M.D., Ph.D.**
National Orthopaedic Imaging Associates
Sand Hill Imaging Center
Menlo Park, Calif.

**Mininder Kocher, M.D., M.P.H.**
Assistant Professor of Orthopaedic Surgery, Harvard Medical School, Harvard School of Public Health, Children's Hospital, Boston, Department of Orthopaedic Surgery
Boston, Mass.

**C. Wayne McIlwraith, D.V.M., Ph.D.**
Director of the Orthopaedic Research Laboratory
Colorado State University
Fort Collins, Colo.

**Marcus Pandy, Ph.D.**
Chair, Mechanical and Biomedical Engineering
Department of Mechanical Engineering
University of Melbourne
Melbourne, Australia

**William G. Rodkey, D.V.M.**
Director of Basic Science Research
Steadman◆Hawkins Research Foundation
Vail, Colo.

**Juan J. Rodrigo, M.D.**
Steadman Hawkins Clinic of the Carolinas
Spartanburg, S.C.

**Theodore Schlegel, M.D.**
Steadman-Hawkins Clinic
Denver, Colo.

**J. Richard Steadman, M.D.**
Steadman-Hawkins Clinic
Vail, Colo.

**William I. Sterett, M.D.**
Steadman-Hawkins Clinic
Vail, Colo.

**Savio Lau-Yuen Woo, Ph.D., D. Sc. (Hon.)**
Ferguson Professor and Director Musculoskeletal Research Center
University of Pittsburgh
Pittsburgh, Pa.

## American Orthopaedic Society for Sports Medicine Bestows Highest International Honor on Dr. Steadman

Dr. Richard Steadman has been honored by the American Orthopaedic Society for Sports Medicine (AOSSM) with a prestigious award in the field of sports medicine, the *2005 Mr. Sports Medicine* accolade. The award is in recognition of Dr. Steadman's significant contributions to orthopaedics and sports medicine throughout his career.

The honor is bestowed annually on a person who has provided outstanding and meritorious service and made significant contributions in the field of orthopaedic sports medicine both nationally and internationally.

Dr. Steadman is the first Coloradan to receive the honor. The award was presented in Keystone, Colorado, at the annual American Orthopaedic Society for Sports Medicine meeting attended by more than 1,100 physicians.

"To be recognized by our peers is truly a great honor," said Dr. Steadman. "I genuinely believe this is a reflection of all the work that has been done both here at the clinic and through our research foundation. This award is a great credit to our team, to the Foundation, to the Vail Valley Medical Center, and the Vail community."

The Steadman◆Hawkins Research Foundation is dedicated to keeping people of all ages active through orthopaedic research and education in the areas of arthritis, healing, rehabilitation, and injury prevention. Procedures that were developed and validated over many years by Foundation researchers are routinely used today by orthopaedic surgeons everywhere.

Through its four critical areas of emphasis – basic science, biomechanics, education, and clinical research – the Foundation has developed, validated, and disseminated to the broader orthopaedic community such innovative and important surgical techniques as the microfracture and healing response techniques.

# Scientific Process Leads to Improved Patient Care

## Inside Steadman-Hawkins: The Scientific Advisory Committee

By Jim Brown, Ph.D., Executive Editor, *UCLA Arthritis Update* and *Sports Performance Journal*

The meeting begins at 8 a.m. in a conference room deep in the Vail Valley Medical Center. For the next two days, 13 of the world's preeminent scientists will assemble to consider proposals and reports that may change the direction of orthopaedic care around the world. They will listen, take notes, ask questions, and provide feedback to Steadman◆ Hawkins Research Foundation physicians, researchers, educators, and fellows. Now four of those Committee members provide a glimpse of the work that goes on inside the Scientific Advisory Committee (SAC).

"Our role is to be a scientific resource for the Foundation, to help give its work direction, and to provide midcourse corrections in terms of research efforts and the Foundation in general," says Dr. Steven Arnoczky, director of the Laboratory for Comparative Orthopaedic Research at Michigan State University. "We are a kind of liaison between the basic science ideas of Dr. Steadman, Dr. Hawkins, and their colleagues, and the realization of those ideas in a clinical setting."

### The Meeting

When Dr. William Rodkey, chairman of the committee and director of Basic Science Research at the Foundation, calls the meeting to order, he has planned an agenda that includes presentations from each outgoing Fellow, as well as from the heads of the four departments at the Foundation — Basic Science Research, Clinical Research, Biomechanics Research, and Education. Each Fellow is allowed 30 minutes to give the status of his or her research endeavor. "The committee listens to each presentation and offers constructive criticism that will help the Fellow make presentations at major meetings and to get the research published in peer-reviewed scientific journals," explains Dr. Rodkey. "Also in the room that day is the incoming class of Fellows. These young physicians listen to the presentations, discussions, and critiques. This gives them an early learning experience that might help them solidify a research idea or hear about an ongoing project they would like to pursue."

Following the Fellows' presentations, each department head summarizes the achievements of the past year — publications, presentations, projects, awards — and gives the SAC a preview of what their departments are working on for the future. They are subject to the same kind of scrutiny given to the Fellows. There is on-the-spot feedback, give-and-take discussion, and advice based on the experience and knowledge of world-class researchers.

Dr. John Feagin, associate professor emeritus of Orthopaedic Surgery, Duke University, says, "The worst thing that can happen is to waste time on a poorly designed study or one that doesn't have scientific merit. The committee prevents the Foundation from going down dead-end roads." After all the presentations have been made, the committee goes into an executive session to shape its official response for each person and department that has participated in the meeting.

The committee's involvement does not end with the meeting. In fact, it's just beginning. Each member is available for scientific consultation throughout the year. Dr. Rodkey points out that Steadman-Hawkins staff members and Fellows rely on committee members quite heavily throughout the year. "I can call any SAC member, tell him that I'm working on a certain project, and that I need guidance. I know my call will be returned and that I'll get feedback from a person who is an internationally recognized authority in his field."

### The Process

The public can become frustrated with the time it takes to get an idea from the drawing board to the clinical level. But the scientific process is slow for a reason. Although some studies can be completed in a year or two, Dr. Feagin says researchers almost have to think in ten-year time frames. At the beginning, somebody has an idea — an intuition — about a new procedure or technique. That idea has to be formalized. A working hypothesis must be developed and a study designed. Then a group of peers reviews the proposal and sends it back for further refinement before an investigation takes place.

Although this is common in the academic community, it is rare in private practice. "This is why the Scientific Advisory Committee is important to the research

*Back row, left to right: C. Wayne McIlwraith, D.V.M., Ph.D.; Charles Ho, M.D., Ph.D.; William I. Sterett, M.D.; Steven P. Arnoczky, D.V.M.; Mininder Kocher, M.D., M.P.H.; J. Richard Steadman, M.D. Front row, left to right: Theodore Schlegel, M.D.; William G. Rodkey, D.V.M.; John A. Feagin, M.D.; Juan J. Rodrigo, M.D.; Savio Lau-Yuen Woo, Ph.D., D. Sc. (Hon.); and Richard J. Hawkins, M.D.*

process," explains Dr. Savio Woo, Ferguson Professor and director of the Musculoskeletal Research Center at the University of Pittsburgh. "The committee challenges the person who proposes a study," cautions Dr. Woo. "We can't just automatically approve a novel method or research proposal. We take the position that you have to show us." He adds that, at times, the scientific process tells you to change. An idea that was brought forward several years ago may have evolved into a different concept today.

After the data have been gathered and analyzed, conclusions are drawn and a scientific presentation or paper is prepared. Many peer-reviewed journals won't even consider publishing a study until after a two-year follow-up period. "Slow and steady wins the race," says Dr. Arnoczky, "but the SAC can optimize the process to make it as short as possible."

"Even when a breakthrough procedure such as microfracture or the healing response has been recognized as a viable medical option," adds Dr. Feagin, "it takes time for it to become a widespread practice. Ten years ago very few orthopaedic surgeons used microfracture. Now as many as 85 percent of them use it."

## The Future

At any given time, the Scientific Advisory Committee is consulting with Steadman-Hawkins researchers on 25 to 30 studies that could have a significant global impact. The SAC members agree that one of the most exciting current investigations is an attempt to identify and reverse the biochemical factors that trigger arthritis. Another is designed to reduce the incidence of scar tissue following knee surgery that develops in 7 percent of patients. A third is experimenting with gene therapy to manipulate the body's own cells in ways that will activate the healing process. In a fourth project, a computer model is being developed that will enable scientists to determine what happens inside the knee during motion, which tissues are under stress, and which factors specifically contribute to injuries.

Dr. Woo sums up the work of the committee this way: "Dr. Steadman has brought together some of the best people in the world to serve on the Scientific Advisory Committee. It reflects what the Foundation has become, which is a world-class research institution. All of us want to move forward to exploit the strengths of both the clinic and the Foundation." The ultimate goal of both is to ensure that the scientific process leads to improved patient care.

# Friends of the Foundation

In 2005 we received contributions and grants from 838 individuals and foundations. This combined support, including special events, amounted to more than $1.6 million.

The Steadman◆Hawkins Research Foundation is grateful for this support and to those who have entrusted us with their charitable giving.

We are especially pleased to honor the following individuals, foundations and corporations that have provided this support. Their gifts and partnership demonstrate a commitment to keep people active through innovative programs in medical research and education. Without this support, our work could not take place.

## Lifetime Giving

### 1988 SOCIETY

On November 9, 1988, the Steadman◆Hawkins Research Foundation was incorporated as a not-for-profit educational and research organization dedicated to advancing modern medical science and the education of young physicians. The Foundation is deeply grateful to the following members of the distinguished 1988 Society whose cumulative giving totals $1 million or more.

Mr. Herb Allen

Mr. and Mrs. George N. Gillett, Jr.

Vail Valley Medical Center

Dr. and Mrs. J. Richard Steadman

## The Founders' Legacy Society

Over the years, the Steadman◆Hawkins Research Foundation has been privileged to receive generous and thoughtful gifts from friends and supporters who remembered the Foundation in their estate plans. In fact, many of our friends—strong believers and supporters of our work today—want to continue their support after their lifetimes.

Through the creation of bequests, charitable trusts and other creative gifts that benefit both our donors and the Foundation, our supporters have become visible partners with us in our mission to keep people physically active through orthopaedic research and education in arthritis, healing, rehabilitation, and injury prevention.

To honor and thank these friends, the Founders' Legacy Society was created to recognize those individuals who have invested not only in our tomorrow, but also in the health and vitality of tomorrow's generations.

Our future in accomplishing great strides—from understanding degenerative joint disease, joint biomechanics, and osteoarthritis, to providing education and training programs—is assured by the vision and forethought of friends and supporters who include us in their estate plans. The Foundation's planned giving program was established to help donors explore a variety of ways to remember the Foundation. We are most grateful to these individuals for their support in becoming founding members of the Founders' Legacy Society:

Mr. and Mrs. Robert M. Fisher
Ms. Margo Garms
Mr. Albert Hartnagle
Mr. and Mrs. John McMurtry
Mr. and Mrs. Edward J. Osmers
Mr. Al Perkins
Mr. Robert E. Repp

## HALL OF FAME

The Steadman◆Hawkins Research Foundation is grateful to the following individuals, corporations, and foundations for their support of the Foundation in 2005 at a level of $50,000 or more. Their vision ensures the advancement of medical research, science, and care, as well as the education of physicians for the future. We extend our gratitude to the following for their generous support:

Mr. Herb Allen – Allen & Company
EBI Medical Systems, Inc.
Mr. and Mrs. Earl G. Graves, Sr.
Mr. Kenneth C. Griffin
Innovation Sports
Mr. and Mrs. John W. Jordan II
Mr. and Mrs. Peter R. Kellogg
Mr. James Kennedy
NFL Charities
Stavros S. Niarchos Foundation
Smith + Nephew Endoscopy
Vail Valley Medical Center

## GOLD MEDAL CONTRIBUTORS

We are grateful to the following individuals, foundations, and corporations that contributed $20,000-$49,999 to the Foundation in 2005. Their continued generosity and commitment helps fund research such as enhancing cartilage healing. This potentially innovative treatment will help preserve the body's own joints and tissues by leading to improved quality and quantity of "repair" cartilage produced by the microfracture technique, a procedure impacting multitudes worldwide.

American Express
Mr. and Mrs. Harold Anderson
Arthrex Inc.
Mr. and Mrs. Howard Berkowitz
Bionicare Medical Technologies Inc.
Centerpulse/Orthobiologics Zimmer
Arie and Ida Crown Memorial
Mr. Douglas N. Daft
DePuy Mitek
Mr. and Mrs. Lawrence Flinn, Jr.
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## SILVER MEDAL CONTRIBUTORS

Silver Medal donors contribute $5,000-$19,999 annually to the Foundation. Their support makes it possible to fund research to determine the effectiveness of training programs to prevent arthritis, identify those who are most at risk for arthritis, and provide a basic foundation to improve post-surgical rehabilitation programs, thus improving the long-term success of surgical procedures. We extend our deep appreciation to the following for their generous support in 2005:

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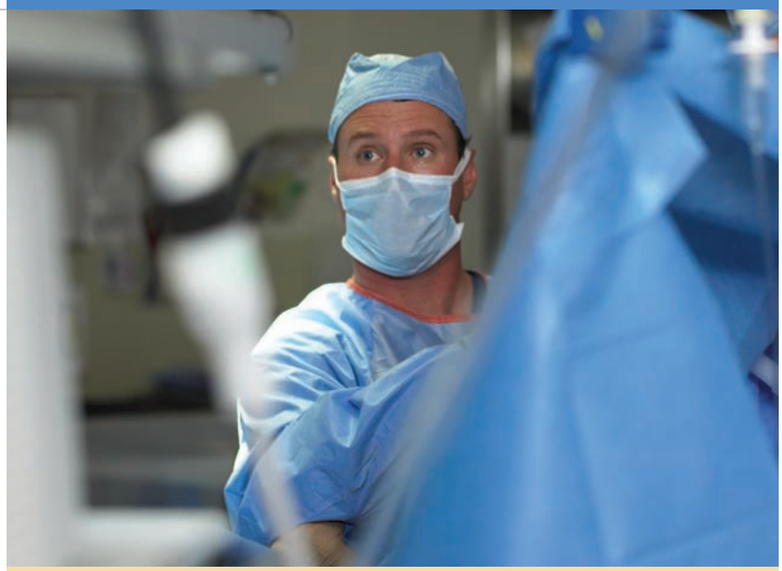

## Chairs Support Foundation Work

The education of orthopaedic surgeons is a critically important mission of the Steadman◆Hawkins Research Foundation. Academic Chairs provide the continuity of funding necessary to train physicians for the future, thus ensuring the continued advancement of medical research. Currently, more than 160 Steadman-Hawkins Fellows practice around the world. We wish to express our gratitude and appreciation to the following individuals and foundations that have made a five-year $125,000 commitment to the Fellowship Program to support medical research and education. In 2005, five chairs provided important funding for the Foundation's research and educational mission. We are most grateful for the support from the following:

Mr. and Mrs. Harold Anderson
Mr. and Mrs. Lawrence Flinn
Mr. and Mrs. John W. Jordan II
Mr. and Mrs. Peter Kellogg
Mr. and Mrs. Steven Read

## Stavros S. Niarchos Foundation Awards a $450,000 Grant to the Foundation for Arthritis Research

The Stavros S. Niarchos Foundation has awarded a substantial research grant to the Steadman◆Hawkins Research Foundation to study the benefits of surgically removing scar tissue in the knee. Scar tissue in the joint lining is a factor that can limit motion of the joint and contribute to unfavorable joint pressure resulting in arthritis.

The Stavros S. Niarchos Foundation, an international philanthropic organization, supports charitable activities in four primary areas: arts and culture, education, health and medicine, and social welfare. The Foundation makes grants to nonprofit organizations throughout the world. In addition, the Niarchos Foundation maintains a major commitment to supporting programs in Greece. Since its inception in 1996, the Stavros S. Niarchos Foundation has provided total grant commitments of $224 million to more than 1,000 nonprofit organizations.

Scarring of the knee joint causes changes in the way the knee joint normally moves. This altered motion leads to abnormal loading inside the joint that can eventually degrade the cartilage of the knee and result in osteoarthritis. In the United States alone, the cost for treating osteoarthritis and its complications is almost $65 billion. When considering its worldwide economic impact, this figure is estimated to be over $750 billion annually. Although most orthopaedic surgeons acknowledge the presence of scar tissue in people who are experiencing pain in their knees, it has been difficult to surgically address this condition because the science behind the treatment is lacking. The removal of scar tissue may be a needed surgical procedure that can promote normal motion and biomechanics, thus sparing the joint from further degeneration.

This proposed project will be conducted using a multi disciplinary approach that will integrate engineering, and it will involve radiological and surgical experts from some of the world's most renowned orthopaedic medicine and bioengineering research institutes. This consortium will investigate and determine the best treatment approach to address and alleviate this knee disorder. The cumulative results of the investigation will serve to improve the quality of life of millions of individuals worldwide.

The total budget for the three-year study is $1.2 million, with the Steadman◆Hawkins Research Foundation committed to raising an additional $720,000.

### BRONZE MEDAL CONTRIBUTORS

Medical research and education programs are supported by gifts to the Steadman◆Hawkins Research Foundation's annual fund. The Bronze Medal level was created to recognize those patients and their families, trustees, staff, and foundations who contribute $10-$4,999 annually to the Foundation. Donors at this level support many programs, including the Foundation's research to validate the success of new treatments for degenerative arthritis and identify factors that influence success. We thank the following for their support in 2005:

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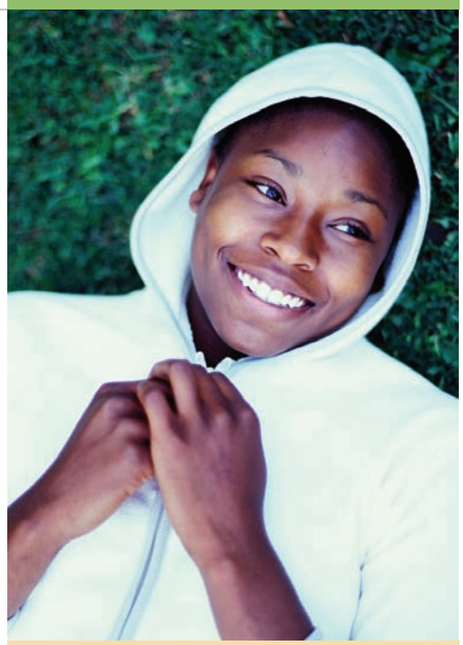

## Fellowship Benefactors

Fellowship Benefactors fund the research of one Fellow for one year at a level of $10,000. This is a fully tax-deductible contribution that provides an opportunity for the benefactor to participate in a philanthropic endeavor by not only making a financial contribution to the educational and research year, but also to get to know the designated Fellow. Each benefactor is assigned a Fellow, who provides written reports and updates of his or her work. We extend our gratitude to the following individuals for their generous support:

Mr. and Mrs. Mitch Hart
The Fred and Elli Iselin Foundation
Mr. and Mrs. John W. Jordan II
Mr. and Mrs. S. Robert Levine
Mr. and Mrs. Kent Logan
Mr. Tim McAdam
Mr. and Mrs. Jay Precourt
Mr. and Mrs. Stewart Turley

## Steadman-Hawkins Sanctuary Golf Tournament, August 31

The Steadman◆Hawkins Research Foundation was selected by RE/MAX International, a global real estate firm, to hold the first Steadman-Hawkins Golf Classic at the Sanctuary, a premier golf resort located south of Denver. Proceeds from the tournament support the development of new procedures and methodology to battle degenerative arthritis. The tournament was open to the public and included participants from the Denver Broncos and Colorado golf pros.

The Foundation is grateful to Dave and Gail Liniger, owners and co-founders of RE/MAX International, who created this unique opportunity for the Foundation to develop and enhance relationships with those who support our mission. In addition, we wish to express our sincere appreciation to the following sponsors and participants:

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**Bronze Sponsors, $5,000**
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## Foundation Celebrates Colorado Evening, Presented by WestStar Bank, August 13

A visual and culinary extravaganza was on display during August in Vail as the Steadman◆Hawkins Research Foundation hosted the "Colorado Evening." Proceeds from the evening support the research and educational programs of the Foundation. The event took place at the Red Sky Golf Club.

The "Colorado Evening," presented by WestStar Bank, featured superb cuisine, courtesy of some of the Vail Valley's finest restaurants; award-winning wines from Duckhorn Wine Company, Silver Oak Cellars and Rombauer Vineyards; and an opportunity to bid on dreams of a lifetime. We wish to express our sincere appreciation to the following sponsors and participants:

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## The Beaver Creek Snowshoe Adventure Series, Presented by Pepsi-Cola

This family-oriented snowshoe event attracts everyone from the first-time snowshoer to the world's premier snowshoe athletes. The series is the largest of its kind in North America and consisted of four events throughout the 2005-06 winter season — Saturdays, December 10, 2005; January 7, 2006; February 11, 2006; and March 4, 2006. The adventure series features 5- and 10-K races, walks and runs, slope-side sponsor expos, and post-event plaza parties.

Since 2003, **Pepsi Cola** has been an active supporter of the Foundation's special efforts to find solutions—through research and education—to help people keep active and mobile by reducing or eliminating the disability and pain associated with arthritis and other joint diseases and injuries.

The North American Snowshoe Championships, the final event in the series, wraps up the season with the highest profile event in the sport.

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## Winter Winemaker Festival

On January 29, wine connoisseurs had an unparalleled opportunity to sample the wines from the Wagner Family, owners of Caymus Vineyards, and mingle with the winemaker, Joseph Wagner, while benefiting critical orthopaedic research and education. Renowned chef Thomas Salamunovich of Larkspur Restaurant in Vail, Colorado, created a special menu to complement the featured wines of Caymus Vineyards. We wish to extend our thanks and appreciation to the following for their help in making this a special evening:

Harlan Estate
Mr. and Mrs. Larry Ruvo
Mr. Thomas Salamunovich, Larkspur Restaurant
Mr. William Schneiderman
Mr. and Mrs. Jim Shpall, Applejack Wine & Spirits
Steadman◆Hawkins Research Foundation
Joseph Wagner, Caymus Vineyards

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Corporate support helps fund the Steadman◆Hawkins Research Foundation's research and educational programs. The Foundation is grateful for the generous support of our corporate donors. This will benefit patients and physicians for generations to come.

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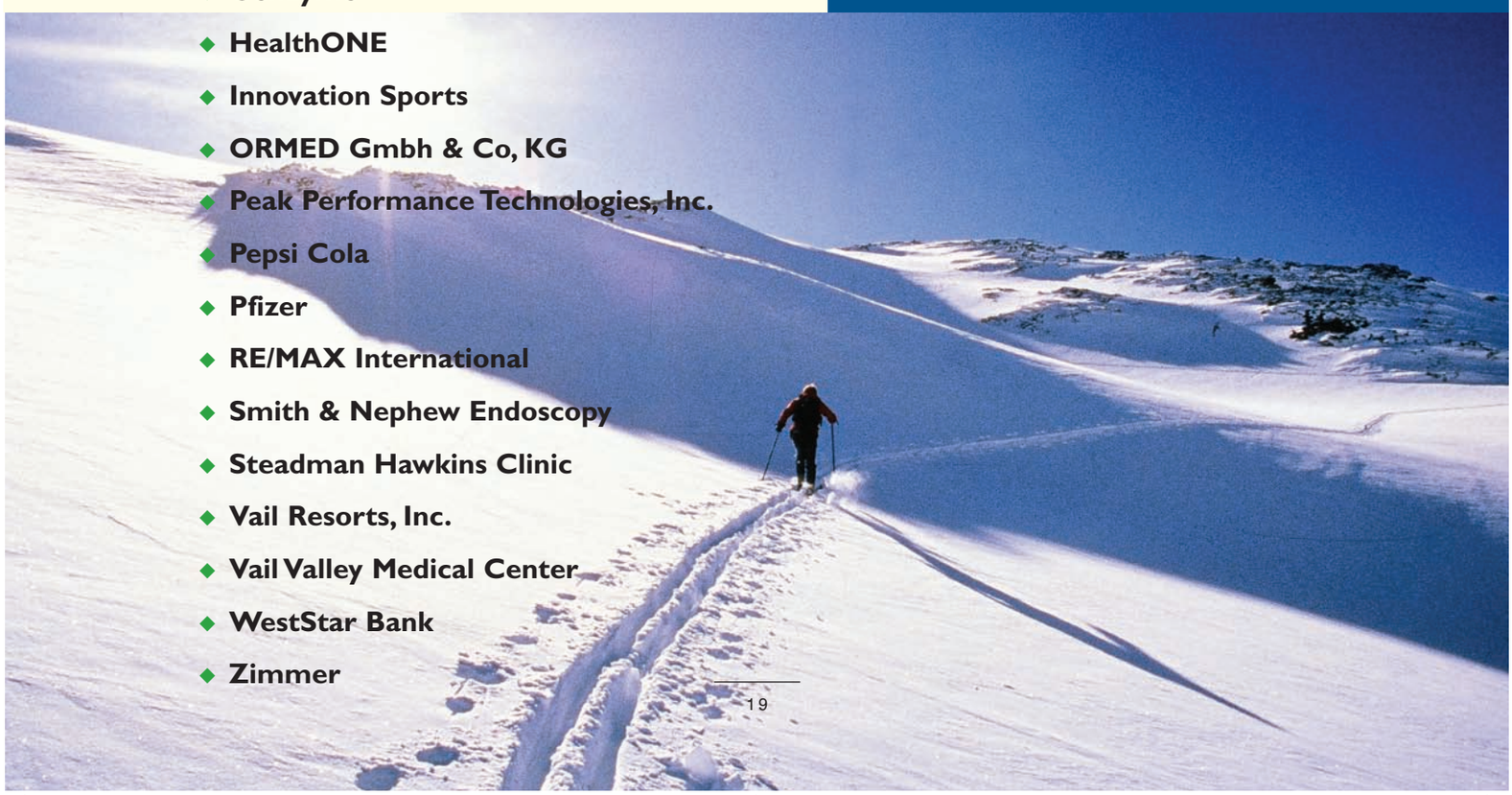
## Genzyme Funds Osteoarthritis Research. Awards $89,000 to Study Viscosupplementation

The purpose of the study is to document results following a viscosupplementation treatment protocol in which corticosteroid is used in addition to the initial Synvisc injection. Synvisc is a biomaterial used in the treatment of knee pain caused by osteoarthritis.

The goal of viscosupplementation is to replenish synovial fluid, which will improve patient symptoms and mobility for those suffering from osteoarthritis. Viscosupplementation of the knee with hyaluronic acid injections has been shown to improve symptoms in patients with osteoarthritis. Recent studies have shown that this improvement may be highly variable based on the time from treatment, especially in the first 12 weeks following treatment.

Genzyme, one of the world's foremost biotechnology companies, is dedicated to making a major positive impact on the lives of people with serious diseases. Founded in Boston in 1981, Genzyme has grown from a small start-up to a diversified enterprise with annual revenues exceeding $2 billion and more than 8,000 employees in locations spanning the globe. Genzyme Biosurgery has been a corporate sponsor of the Foundation since 2003.



# Philip Elder: Foundation Hall of Fame Candidate?

By Jim Brown, Ph.D.

A Steadman◆Hawkins Research Foundation Hall of Fame, if it existed, would consider candidates such as John Elway, Bruce Smith, Bode Miller, Judy Collins, Picabo Street, Joe Montana, and Philip Elder. Philip Elder?

"As I read the *Steadman◆Hawkins Research Foundation Newsletter*," explains Elder, "I could not help but think about who should be telling the real story of the incredibly unique Steadman-Hawkins experience. Doesn't at least part of it need to come from someone ordinary like me, who was never an Olympic medal winner or a professional athlete or a celebrity interviewed by CNN? I'm just a dad who loves his kids, is very active, and wants to stay that way — whatever it takes." What it took for Elder was a joint-preservation procedure made possible by years of research, practice, and data collection, all funded and supported by the Foundation.

Philip Elder is exactly the kind of advocate the Steadman◆Hawkins Research Foundation has been looking for. Dr. Richard Steadman, speaking for the Foundation, has often said he would like to be known as the doctor who kept millions of weekend warriors out on the links or on the slopes late into life rather than one who salvages the career of famous athletes. Close enough. Elder, though not as famous as other recipients of the research carried on by the Foundation, is more than a weekend warrior, more likely to be riding a horse at top speed than riding in a golf cart, and at 54, not exactly "late into life."

## Elder's Story

"I'm originally from Chattanooga and graduated from the University of the South in Sewanee, Tennessee. I played football for five seasons and wrestled for four years," he begins. (You'll have to get an explanation from Elder about how he managed to play five years of college football.) Sewanee is also where he met his wife of 28 years, Becky. "I first hurt my knee wrestling, then suffered some more damage playing football. I could play, but because of the swelling it had to be drained weekly. Finally, I elected to have the damaged cartilage removed. I was actually better and faster the year after the operation."

After graduating, Elder spent a year in New Zealand, where he worked and played club rugby before moving to Australia for another year. Still looking for Hall of Fame credentials? "I was the first American to get a visa extension from the government of New Zealand for the sole purpose of playing rugby. That'll have to do."

Fast-forward to 1977. Elder joined the Love Box Company, an international corporation based in Wichita, Kansas, that manufactures corrugated packaging products. Now he is the Chief Operating Officer and Vice President of the company, which has 1,500 employees and 14 locations, and whose clients include Rubbermaid, Coleman, and Anchor-Hocking.

"The knee was okay until about the mid-1980s," he remembers. "But then I started noticing twinges of pain in my bad knee and it started bowing outward. At the same time, our five children were getting involved in sports and other activities, but we were never home together at night. We were already involved in farming and ranching, so we decided to participate as a family in competitive horseback riding." The Elders hit the road, traveling throughout the Midwest and competing in events such as speed barrels, flag racing, pole bending, and western jumping. The Elders are still out there competing today. "Basically, you've got your legs wrapped around a 1,200-pound horse that is running at full speed when it's not turning, twisting, or changing directions.

"Gradually, my knee developed severe arthritis, and it was getting harder and harder to ride," he says. "I couldn't sleep and I was downing Tylenol like it was candy. I talked to some of the best orthopaedic surgeons in the country about unique solutions but didn't like what I was hearing. Most of them recommended total knee replacement. That's when a friend told me about Steadman-Hawkins. I called and they immediately asked me when I could get to Vail. I was amazed. The atmosphere was completely different from that in other high-profile treatment facilities. The doctors at Steadman-Hawkins let you talk. They ask questions. They want to know what you do and what your expectations are. They're not in a hurry. They don't look at their watches or seem anxious to get to the next appointment. I told them that I wanted to climb mountains with my children and that I was hoping they could help me walk. They made no pronouncements until they had listened and

*Philip Elder: Doing what he loves best, barrel racing.*

gathered as much evidence as they could about my specific condition. Their suggestions were made in detail and I was able to make an intelligent decision on the spot."

In November of 1998, Dr. William I. Sterett performed microfracture, which triggers a cartilage resurfacing process, and a high tibial osteotomy, which helps realign the knee to relieve pressure on the arthritic part of the joint, transferring it from the inside to the outside. "In eight weeks I was able to bear weight on the knee, I was on a horse in 12 weeks, and competing at full speed in 16 weeks. I was able to rejoin my family in competitive horse riding and felt nearly unrestrained in most of my other activities. I don't run, but I can ride a bike and ride a horse." Elder says he's been "as good as gold" since the operation in 1998. "I've gotten seven years out of it and could get another five or six," he thinks.

## The Foundation Connection

Elder was becoming increasingly aware that the research and education conducted by the Steadman◆Hawkins Research Foundation had made his entire experience at the clinic possible. "The Foundation enabled the staff to do the research and gain the knowledge to deal with problems like mine. I didn't know it at the time, but the Foundation has established one of the largest databases in the world on the type of condition I had, as well as many others, and that information is shared with other physicians. It's the most unselfish thing I can think of.

"I highly recommend that anyone who reads this article consider supporting the Foundation," Elder concludes. "I feel like I have a duty to help perpetuate its work. The payoff is incredible. The money the Foundation receives is used in direct, meaningful, and relevant ways. The research will result in a better quality of life for generations to come."

And remember, you're getting this information from Philip Elder — a potential Steadman◆Hawkins Research Foundation Hall of Famer.

*The Year In*

# Research & Education

## Basic Science Research

William G. Rodkey, D.V.M., Director

*The purpose of our Basic Science Research is to gain a better understanding of factors that lead to degenerative joint disease and osteoarthritis. Our focus is to develop new surgical techniques, innovative adjunct therapies, rehabilitative treatments, and related programs that will help prevent the development of degenerative joint disease or ameliorate the disease. In 2005, we collaborated with various educational institutions, predominantly Colorado State University and Michigan State University. We believe that our combined efforts will lead directly to slowing the degenerative processes, as well as finding new ways to enhance regeneration of injured tissues.*

The relatively new area of regenerative medicine is an exciting one. There are many new and innovative techniques under investigation by scientists around the world. In 2005, we focused our efforts almost exclusively on regeneration of an improved tissue for resurfacing of articular cartilage (chondral) defects that typically lead to degenerative osteoarthritis. We have been working in the promising area of gene therapy in collaboration with Drs. Wayne McIlwraith and David Frisbie at Colorado State University. We completed all aspects of our study looking at the effects of leaving or removing a certain layer of tissue during lesion preparation for microfracture. We also began a new area of study involving electrostimulation to enhance cartilage healing. Following is some background information and a summary of our most recent findings. This work is ongoing, and the encouraging results presented here will allow us to continue to focus on this work in the coming years.

*William G. Rodkey, D.V.M.*

Osteoarthritis is a debilitating, progressive disease characterized by the deterioration of articular cartilage accompanied by changes in the bone and soft tissues of the joint. Traumatic injury to joints is also often associated with acute damage to the articular cartilage. Unfortunately, hyaline articular (joint) cartilage is a tissue with very poor healing or regenerative potential. Once damaged, articular cartilage typically does not heal, or it may heal with functionless fibrous tissue. Such tissue does not possess the biomechanical and biochemical properties of the original hyaline cartilage; hence, the integrity of the articular surface and normal joint function are compromised. The result is often osteoarthritis.

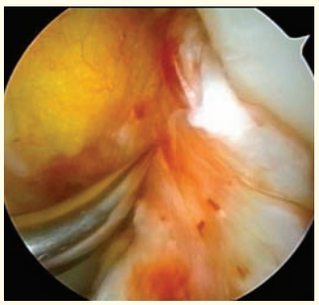
The importance of osteoarthritis must not be underestimated. The U.S. Centers for Disease Control estimate that in the next 25 years at least 71 million Americans (15 percent to 20 percent of the population) will have arthritis, including degenerative arthritis secondary to previously damaged surfaces of the joints. Osteoarthritis is the most significant cause of disability in the United States and Canada, moving ahead of low back pain and heart disease. By the year 2020, more than 60 million Americans and six million Canadians will be affected

by some degree of osteoarthritis of the knee. The economic impact is enormous. Osteoarthritis alone accounts for more than $85 billion of direct and indirect costs to the American public. The intangibles of this terrible disease include the chronic pain and psychological distress on the individual, plus the family unit. We believe that our research can have far-reaching effects by greatly enhancing the resurfacing of damaged or arthritic joints before the disease process reaches the advanced and debilitating state.

Several of our earlier studies have shown that a technique, arthroscopic subchondral bone plate microfracture, is a successful method to promote adequate cartilage healing. "Microfracture" consists of making small perforations in the bone plate beneath the layer of cartilage using a bone awl to access the cells and growth factors present in the underlying bone marrow. The technique relies on the body's own cells and proteins present in the marrow to promote healing, thus avoiding concerns of immune reactions to transplanted tissues or the need for a second surgical site or second surgery to collect grafts or cells. When we evaluated the healing of full-thickness chondral defects in exercised horses, we were able to show that the use of microfracture increases the amount of repair tissue present in the defect and improves the quality of cartilage repair by increasing the amount of type II collagen (found in normal joint cartilage) present in that repair tissue. Although microfracture was able to increase the major building block of articular cartilage tissue, it did not enhance the production of the other major components of cartilage thought to be necessary for long-term joint health. Additionally, as we have previously reported, we have found the mechanical aspect of removing a deep layer of the cartilage, called the calcified cartilage layer, is critical for optimal formation of repair tissue and healing to the bone.

With respect to our work on the calcified cartilage layer, there is a suggestion that leaving calcified cartilage inhibits the tissue healing and repair response after microfracture. Therefore, we hypothesized that removing the cartilage and retaining the underlying bone would enhance the amount of attachment of the repair tissue compared to retention of the calcified cartilage layer. In an equine study, we were able to demonstrate that removal of calcified cartilage, while maintaining the underlying bone plate, increased the overall repair tissue. An increase in the thickness of the underlying bone was also observed with removal of the calcified cartilage layer. The clinical responses, radiographic, MRI evaluations, histologic character, and various biochemical values did not appear to differ based on removal of this calcified cartilage layer. The clinical relevance to the orthopaedic surgeon is that removal of the calcified cartilage layer appears to provide an optimal amount and attachment of repair tissue in conjunction with microfracture. Therefore, close arthroscopic visualization is recommended to ensure removal of the calcified cartilage layer.

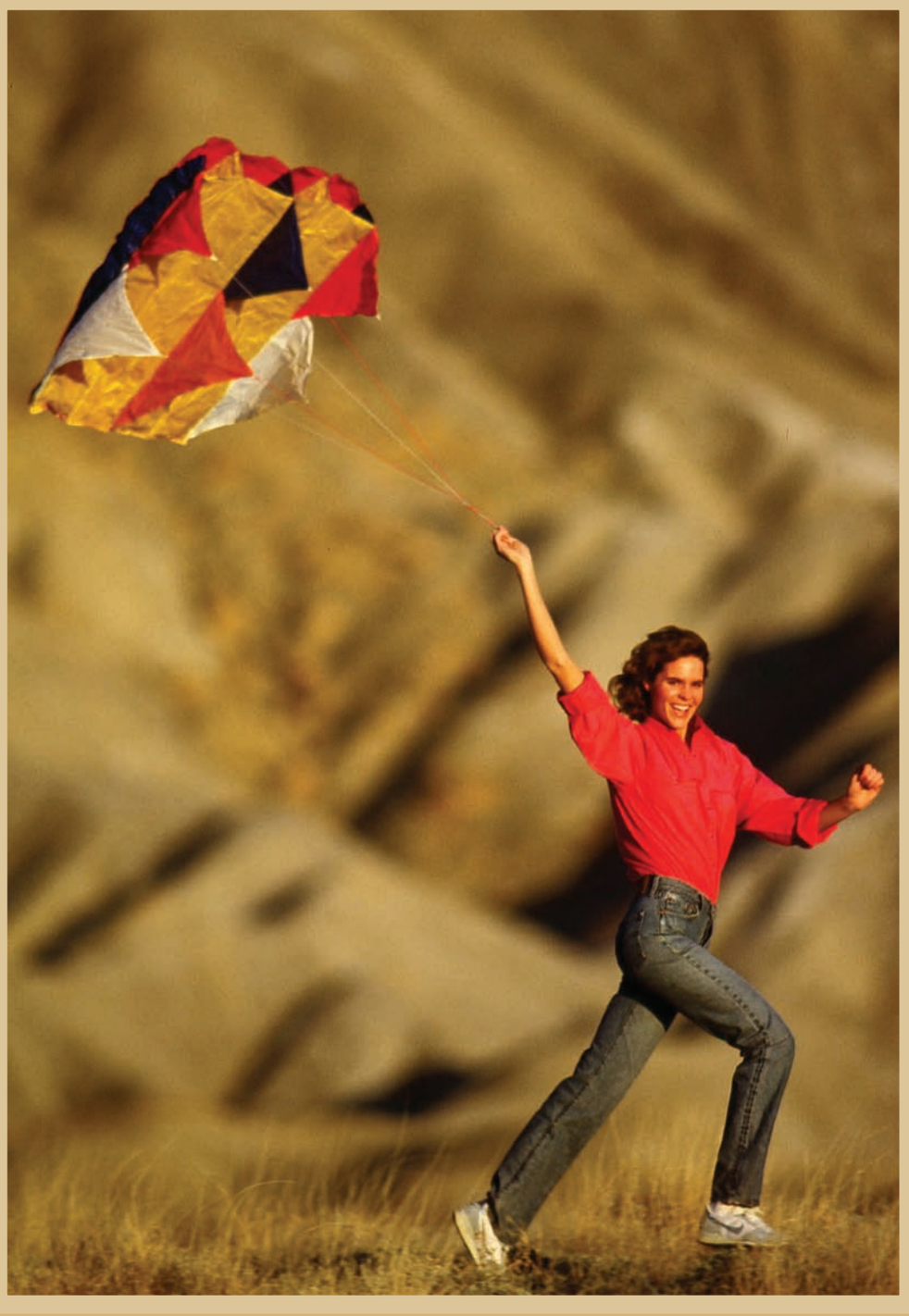
## Healing Response



In an effort to minimize the morbidity or complications associated with treatment of specific types of anterior cruciate ligament (ACL) injuries, Dr. Steadman has developed a procedure referred to as the "healing response" technique. This arthroscopic procedure involves producing three to ten microfracture holes into the bone at the origin of the ACL, as well as repeatedly perforating the stump of the remaining ACL with the microfracture awl. No other intervention is performed, and the blood clot from the bleeding bone is relied upon to capture the disrupted end of the ACL and eventually provide stability in a suitable healing environment.

A new area of research that has attracted our attention involves use of electrostimulation to speed or enhance healing of cartilage defects in conjunction with microfracture. Some reports in the literature indicate that electrostimulation may help relieve pain in joints with advanced arthritis. However, no studies have been reported that evaluate potential benefits of electrostimulation used in treatment of acute cartilage injuries or in conjunction with resurfacing procedures such as microfracture. The initial steps to study electrostimulation are now underway.

Our laboratory-model work on the "healing response" is now complete. This work was done with Dr. Steven Arnoczky at Michigan State University. The manuscript was submitted to a peer-reviewed journal, and it was accepted late in 2004. Final revisions were made to the manuscript in 2005, and publication is set for early 2006. The next step is to carry out a study to assess the strength and biomechanical properties of the healing tissues. Information obtained will explain the time course of the healing and at what point full activity should be permitted in human patients. This information will also help other orthopaedic surgeons gain confidence with the healing response procedure, making them more likely to perform it. In so doing, fewer patients will require the expense, time, inconvenience, and discomfort of a formal ACL reconstruction. Additionally, other patients unwilling to have ACL reconstruction can be offered a viable alternative.



# The Package: New Treatment Breakthroughs for the Arthritic Knee

By Bruce S. Miller, M.D.

Editor's Note: Dr. Miller is an Assistant Professor of Orthopaedic Surgery at the University of Michigan in Ann Arbor, Michigan. He specializes in sports medicine surgery and is a team physician for the University of Michigan Athletic Department and the U.S. Ski Team. Dr. Miller is a graduate of the Steadman-Hawkins Fellowship Program.

Osteoarthritis is one of the most common maladies in adults and is estimated to affect 70 million Americans (nearly one in three adults). The disease is caused by degeneration of joints, specifically the loss of cartilage that caps the end of bones and enables smooth and painless motion of joints. Arthritis is characterized by pain, stiffness, and swelling of the joints. In addition, roughened joint surfaces or fragments of bone and cartilage can lead to "mechanical" symptoms of catching and locking of the joint.

Although there is presently no cure for arthritis of the knee, many treatment options provide relief of symptoms. Weight loss, well-cushioned shoes, and a general strengthening program may alleviate some symptoms of arthritis. Certain medications, including anti-inflammatory agents (ibuprofen, for example) and acetaminophen (Tylenol) are known to provide relief. Some of these medications may have harmful side effects or interactions with other medications and should be monitored by a physician. Nutritional supplements such as glucosamine and chondroitin sulfate may also benefit the patient. Additional nonsurgical options include the use of braces to help improve alignment of the knee and the injection of anti-inflammatory or lubricating medications.

While knee replacement surgery is considered the gold standard treatment for end-stage arthritis of the knee and provides predictable pain relief, it is not appropriate for everyone. Many individuals with arthritis of the knee are either too young or are unwilling to accept the physical restrictions that accompany replacement surgery. Other interventions exist for these individuals.

Arthroscopy is a minimally invasive procedure that can be a potent treatment option for the arthritic knee. Arthro-scopy involves the use of video-guided instruments through small punctures in the skin. This procedure is safe, effective, and allows for rapid recovery. Dr. Steadman, a pioneer in arthroscopic surgery of the knee, has developed and popularized many techniques that are used around the world for the treatment of cartilage injuries and arthritis of the knee. When used together, these techniques offer an effective treatment package for the arthritic knee. The Foundation's continued research and the powerful database are providing information about this package, which shows great promise as a treatment for arthritis.

## Arthroscopic Treatment

Arthritis of the knee does not simply result in thinning of cartilage. Rather, the disease affects the joint in many ways. The components of the arthritic knee may include stiffening or scarring of the joint capsule, inflammation of the joint lining, tears of the meniscus cartilage, thinning and roughening of the articular cartilage, the formation of bone spurs, and the presence of loose bodies floating in the joint. Each of these components contributes to the symptoms of the degenerative knee. These components are addressed in the following paragraphs.

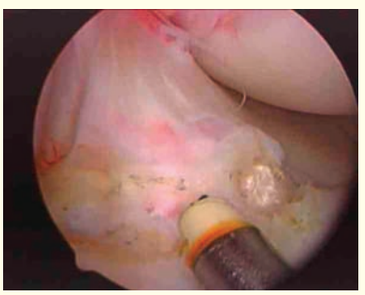
## Insufflation

The joint lining and capsule of the arthritic knee can become stiff with time. This stiffness can limit motion of the joint and can also lead to increased pressure on the joint. Excessive pressure can contribute to further deterioration of cartilage. At the time of surgery, after an anesthetic has been administered but before the arthroscope is introduced into the knee, the joint is injected with fluid under pressure. This injection helps stretch the contracted joint lining and improve motion of the knee.

*Joint is injected with fluid.*

## Lysis of Adhesions

Adhesions, or scarring of the joint lining, are another factor that can limit motion of the joint and contribute to unfavorable joint pressure. These adhesions



*Special device cuts scar tissue.*

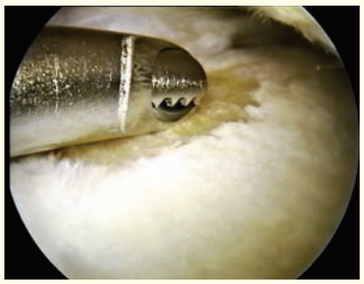
are commonly encountered in a knee that has undergone previous surgery. At the time of arthroscopy, these adhesions are identified and released with the use of a special device that can simultaneously cut scar tissue and control unwanted bleeding. Adhesions behind the patellar tendon are frequently encountered after ACL surgery and may contribute to anterior (front) knee pain. Removing these adhesions with an "anterior interval release" has been demonstrated to improve pain under the patella.

## Loose-Body Removal

*Bone spur.*

"Loose bodies" floating in the knee are like having a bothersome pebble in the shoe. These loose bodies consist of cartilage and/or bone and may grow with time as they derive nutrition from normal joint fluid. Loose bodies can contribute to the mechanical symptoms of catching and locking in the arthritic knee. At the time of arthroscopy, a thorough inspection of all areas of the knee allows for identification and removal of loose bodies.

## Chondroplasty



*Shaving device smooths irregular surfaces.*

The common denominator in all arthritic knees is the presence of degenerated cartilage. There is a spectrum of cartilage damage, ranging from simple softening of the cartilage to complete loss of cartilage with exposed bone. Early to mid degeneration is often characterized by a shaggy appearance of the previously smooth joint surface. During arthroscopic surgery, a motorized shaving device is employed to help smooth irregular surfaces.

## Synovectomy

The synovium is the thin lining of joints and is composed of cells that produce normal joint fluid. The synovium also possesses a rich nerve supply. In arthritis and other inflammatory conditions, the synovium becomes inflamed. Synovitis (inflamed joint-lining tissue) is painful and contributes to recurrent swelling in the knee. During arthroscopy, areas of inflamed synovium can be removed, resulting in diminished pain and swelling.

## Osteophyte Resection

Bone spurs are a common finding in the arthritic knee and can contribute to pain and loss of motion. Careful removal of bone spurs with a motorized shaving device may be of benefit if the spurs are contributing to a block of joint motion.

## Meniscectomy

The meniscus is the shock absorber of the knee. With age, the meniscus cartilage can become stiff and predispose the tissue to tearing. A torn meniscus is a very common component of the arthritic knee and contributes to pain, catching, and locking. Although the healthy meniscus plays a critical role in normal joint function, the torn meniscus in the degenerative knee has lost its protective function. A limited resection, or removal, of the torn tissue can alleviate pain and mechanical symptoms while leaving behind the remainder of the meniscus that retains functional properties.

## Microfracture

Although there is no true cure for arthritis, there are several surgical techniques aimed at cartilage repair or regeneration. Dr. Steadman and the Steadman◆Hawkins Research Foundation have pioneered, validated, and popularized the microfracture technique of cartilage regeneration. This technique taps the body's own healing potential. In a recently published study,* the microfracture procedure significantly improved all the characteristics evaluated (pain, swelling, limping, walking, climbing stairs and descending stairs, sports level, strenuous work, and activities of daily living) in the study population. Patient satisfaction and functional outcome showed improvement on subjective and objective scales after microfracture of the degenerative knee.

Arthritis is a complex disease and affects the knee joint in many ways. Although there is presently no cure for this condition, many treatment options exist to help alleviate the symptoms. In certain patients with degenerative disease of the knee, a careful arthroscopic surgery that addresses all of the components of the arthritic knee can provide dramatic relief.

*Miller, Bruce S., M.D.; Steadman, J. Richard, M.D.; Briggs, Karen K., M.B.A., M.P.H.; Rodrigo, Juan J., M.D.; Rodkey, William G., D.V.M. Patient satisfaction and Outcome after Microfracture of the Degenerative Knee. *Journal of Knee Surgery.* 2004;17:13-7.

# Clinical Research – 2005

Karen K. Briggs, M.P.H., M.B.A., Director; Marilee Horan, Research Associate; Lauren Matheny, Research Associate; Mara Schenker, Research Intern; David Kuppersmith, Research Intern; Anna Fay, Research Intern

*Outcomes research provides a tool to link the patient's perspective and the effectiveness of health treatment. In Clinical Research, we strive to improve the quality of patient-reported outcomes following surgical procedures. Our department focuses on results based on physician/patient assessment of improvement of the function and quality of life. Our goal is to learn from the experiences of patients to validate treatment protocols and assist patients in making decisions regarding their health care.*

Clinical Research at the Steadman◆Hawkins Research Foundation gathers data from patients who seek treatment for knee, shoulder and hip disorders. Information is stored in a database and is the key to our research. There is a great opportunity to learn from patients before and after they have surgery. Future research will focus on predictors of disability caused by arthritis, predictors of successful surgery, predictors of patient satisfaction, patient expectation of treatment, and patient outcomes following surgery. The goal of this research program is to carry out clinical outcomes research in the area of orthopaedic medicine that will aid both physicians and patients in making better-informed decisions regarding medical treatment.

"Worldwide, musculoskeletal conditions are the most common causes of severe long-term pain and physical disability."

Bone and Joint Decade, www.Boneandjointdecade.org

## OSTEOARTHRITIS

### Expectations of treatment in patients with osteoarthritis

There are many different treatment pathways for osteoarthritis of the knee. However, the outcome may not match the patient's expectations. The purpose of this study was to identify the expectations of treatment in patients with osteoarthritis of the knee. A survey was completed by 130 individuals, 50 years or older, who were diagnosed with knee osteoarthritis. There were 54 women and 76 men with a mean age of 63 years (range, 50 to 91).

The most common expectation rated as very important in this group was avoiding future knee degeneration. This was followed by improving the ability to maintain health, having confidence in the knee, and improving ability to walk. The least common expectation was for the knee to be back to the way it was before the problem started, followed by improved ability to run. It was more important to females to avoid future degeneration than it was to males. It was also more important to females to improve their ability to use stairs and improve their ability to kneel. For males it was more important to stop the knee from giving way when stopping quickly. Pain relief was more important to younger patients, as was improving the ability to participate in sports. Improving ability to maintain health was more important to older individuals, as was avoiding future degeneration of the knee. Patient expectations are influenced by age and gender. These differences are important in clinical decision-making. Further understanding of patients' expectations of treatment may improve treatment outcome and patient satisfaction. This study was presented at the 133rd American Public Health Association Annual Meeting. The authors of this study are Karen Briggs and Dr. Steadman.

### Predictors of decreased function and activity level in patients seeking treatment for osteoarthritis of the knee

One of three adults in the United States is affected by arthritis or chronic joint symptoms. Arthritis is currently the leading cause of disability in the United States. As the population ages, these numbers will increase. Increased prevalence of arthritis is also associated with decreased activity. Decreased activity can contribute to other chronic diseases. Identifying factors associated with increased disability and

*Back row left to right: Karen Briggs, M.B.A., M.P.H.; and David Kuppersmith. Front row left to right: Lauren Matheny; Anna Fey; Marilee Horan; and Mara Schenker.*

decreased activity may help develop early treatment programs that can decrease the impact of arthritis.

The purpose of this study was to identify determinants of patient disability (decreased function) by Lysholm score,* and to define the patients' activity level by Tegner Activity Level score.* We sought to identify the determining factors for evaluation of osteoarthritis of the knee. The study included patients with a diagnosis of osteoarthritis of the knee. There were 569 patients with an average age of 57. Fifty-eight percent of the patients reported prior surgeries, 90 percent reported knee stiffness, 80 percent had joint space narrowing on X-ray, 45 percent had documented extension deficits, and 73 percent had documented flexion deficits. The average Lysholm score was 54 in this study population (a Lysholm score of >85 is normal knee function). The average Tegner activity level was 3 (a Tegner >4 is the score for being able to participate in recreational sports).

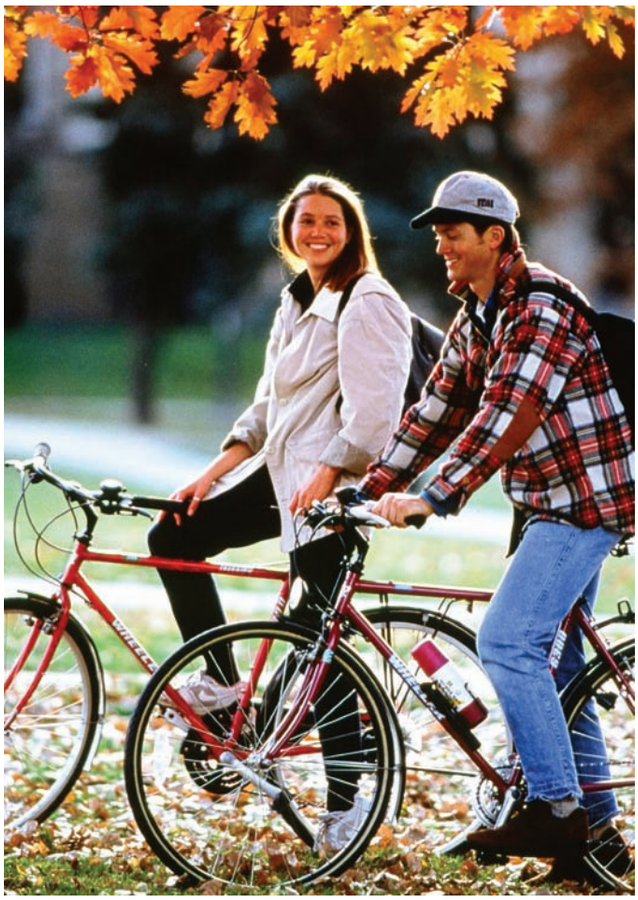
Function and activity level were significantly associated with age, gender, decreased knee range of motion, and knee stiffness. Patients reporting severe stiffness had an average Lysholm score of 24 points less than those with no stiffness. The Tegner scores were associated with the number of prior surgeries, with knees operated on two or more times having significantly lower scores ($P<0.05$). Joint space narrowing and patient-reported stiffness were identified as independent predictors of Lysholm. Independent predictors of Tegner activity level were age, gender, patient-reported stiffness, flexion deficit, and Lysholm score.

Determining factors of decreased function and decreased activity level in patients seeking treatment for osteoarthritis of the knee were established. Patient-reported stiffness and range-of-motion deficit were associated with both decreased activity level and decreased Lysholm score. These factors may be important in developing early treatment programs aimed at improving function and maintaining activity level in patients with osteoarthritis. The authors of this study are Karen Briggs and Dr. Steadman. This study was presented at the 133rd American Public Health Association Annual Meeting.

## CHONDRAL LESIONS

### Association between patellar mobility and patellofemoral chondral defects

Anterior (front) knee pain is a common complication after knee injuries and arthroscopic surgery. Decreased kneecap mobility is often seen in patients with anterior knee pain. Patellofemoral chondral defects can cause significant pain and disability. The purpose of this study was to determine whether kneecap mobility was associated with chondral defects of the patellar or trochlear groove. We studied 410 knees whose patellar mobility was documented. After surgery, the presence of patellar tightness was documented in four separate positions by an orthopaedic surgeon. Forty-one percent had patellar tightness in at least one direction. Twenty-four percent had patellar tightness in all four directions, 9 percent had inferior and superior only, and 3 percent had medial and lateral only. Severe chondral damage of the patellofemoral compartment was seen in 40 percent of the knees. There was an association between the presence of patellar tightness in any direction and the presence of severe chondral damage in the patellofemoral compartment.



Many causes for lack of patellar mobility exist, including anterior interval contracture, compartmentalization by plica, and suprapatellar scarring. Restricted kneecap mobility was associated with chondral damage in the patellofemoral compartment. Early signs of patellar tightness could be a risk factor for changes in the patellofemoral compartment. This study will be presented at the 2006 International Cartilage Repair Symposium. The authors of this study are J. Richard Steadman, M.D.; Karen K. Briggs, M.B.A., M.P.H.; and William G. Rodkey, D.V.M.

** The Lysholm score is a knee functional outcome score. It measures patients' symptoms and function to determine the outcome following arthroscopic knee surgery. The Tegner score is an activity scale from 0 to 10 in which patients rate their current sport activity level.*

**Second-look arthroscopy of chondral lesions of the acetabulum treated with arthroscopic microfracture**

Chondral injuries in the hip often result from traumatic injury. These injuries are commonly associated with other intra-articular hip abnormalities and disorders, including acetabular labral tears, femoroacetabular impingement (FAI), and degenerative joint disease. Research has shown that chondral defects rarely heal on their own. Microfracture has increased in popularity among orthopaedic surgeons as the preferred treatment for chondral defects in the knee. Several studies have shown good clinical results following arthroscopic microfracture. Although microfracture of the hip has fewer studies than the knee, the same basic principles are thought to apply.

We studied nine hips that were treated for full-thickness acetabular chondral defect with microfracture and which required a subsequent hip arthroscopy. Five were active in professional sports (dance, baseball, football, hockey, golf) at the time of microfracture.

The average acetabular chondral lesion size that was microfractured measured 163 $mm^2$. Six of the chondral lesions were isolated; one was associated with a femoral head chondral defect; and two were associated with diffuse joint degeneration. At an average of 1.6 years following microfracture, patients underwent second-look arthroscopy. At second look, the overall percent fill of the defects with repair tissue was 91 percent (range, 25 percent to 100 percent). The percent fill in patients with an isolated acetabular chondral defect was 99 percent (range, 95 percent to 100 percent). The percent fill in the patient with a femoral head chondral defect was 100 percent. Of the two patients with diffuse osteoarthritis, one had 25 percent fill of the chondral lesion and the other had 100 percent fill. Four of the five professional athletes returned to the same high level of sport following the revision arthroscopy.

Chondral lesions of the acetabulum may be effectively treated with arthroscopic microfracture in patients with proper indications for surgery. Long-term follow-up of the arthroscopic microfracture of the hip is not well understood, however, and we continue to follow up on all of our patients who have undergone microfracture of the hip. Based on these findings, we recommend early intervention to optimize the success of the microfracture technique. This study will be presented at the 2006 Arthroscopy Association of North America Annual Meeting. The authors of this study are Marc J. Philippon, M.D.; Mara Schenker; and Karen K. Briggs, M.B.A., M.P.H.

**Factors associated with large chondral defects in the hip identified at arthroscopy**

Chondral injuries are a common pathology of the hip and are often seen in impact sports such as football. The purpose of this study was to identify factors that were associated with large cartilage defects in the hip. We studied 288 hip arthroscopies. The average patient age was 36 years. Large chondral defects were defined as an area of greater than 1.5 cm. If labral pathology or impingement was present, this was documented.

Of all the surgeries studied, 97 percent had a chondral defect; however, only 22 percent of these were large chondral defects. Large defects on the acetabulum were associated with detached labral tears, yet this relationship was not true for hips without cam-type impingement. In hips with CAM impingement, hips with large acetabular chondral defects were 2.3 times more likely to have a detached labral tear. Large defects on the acetabulum were also associated with degenerative labral tears. In hips with pincer-type impingement, hips with degenerative labrums were 4.4 times more likely to have a chondral defect. On the femoral head, large defects were associated with pincer impingement, but not with cam impingement.

"Disability accompanying all types of arthritis can be minimized through early diagnosis and management (secondary prevention). Successful secondary prevention reduces the impact of the disease."

National Arthritis Action Plan: A Public Health Strategy, 1999

Other studies have shown that cam impingement increases the stress on cartilage, and the labrum is stretched. Separation between the labrum and articular cartilage can occur. The femoral head neck junction is forced into the labrum. For chondral injuries with pincer impingement other studies have shown that the labrum is compressed between the femoral neck and acetabulum. Acetabular over-coverage is also seen. The chronic leverage of the head into the acetabular rim causes chondral damage in the acetabulum. As a result of advances in hip arthroscopy, large chondral defects are becoming increasingly recognized in the hip. Large chondral defects in the hip are associated with cam and pincer impingement. These defects are common in athletes. This study will be presented at the 2006 International Cartilage Repair Symposium. The authors of the study are Marc J. Philippon, M.D.; Karen Briggs, M.B.A., M.P.H.; Mara Schenker; and Allston Stubbs, M.D.

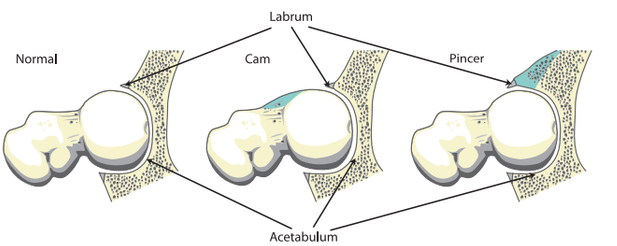



Illustration: Marty Bee

*Highlighted areas indicate cam and pincer impingement.*

## INJURY TREATMENT TO MAINTAIN FUNCTION AND ACTIVITY

### Validation of the IKDC in meniscus pathology

Meniscus injuries of the knee are commonly encountered by orthopaedists. Injury to the meniscus cartilage is perhaps the most common reason to undergo arthroscopic knee surgery. Outcome

measures after the treatment of meniscus tears have typically utilized various outcome instruments such as the Tapper and Hoover system, the Knee Injury and Osteoarthritis Outcome Score, the Lysholm knee score, the Cincinnati Knee Rating Scale, the Tegner Activity Scale, and the International Knee Documentation Committee score.

The International Knee Documentation Committee (IKDC) score is a knee-specific, rather than disease-specific, measure of symptoms, function, and sports activity. A score of 100 is interpreted to mean no limitation with activities of daily living or sports activities and the absence of symptoms. Although initially designed to assess ligament injuries of the knee, the IKDC Subjective Knee Form has been used for a number of knee conditions.

The use of outcome instruments with vigorously established psychometric properties is essential. The important psychometric properties of an outcome instrument include reliability, validity, and responsiveness. The purpose of this study was to determine the psychometric properties of the International Knee Documentation Committee score for meniscus abnormalities of the knee.

The reliability was measured by test-retest reliability. This determines whether a person completes the form in a similar fashion if given the form twice. There was acceptable test-retest reliability for the overall IKDC score. For validity, we first compared the IKDC to a questionnaire that has already been validated, the SF-12®. There were significant correlations between the IKDC score and the physical component of the SF-12® scale. For content validity we determined the floor and ceiling effects for the IKDC. This refers to how many people answer the lowest score possible (floor) or the highest score possible (ceiling). There were acceptable (<30 percent) floor and

ceiling effects for the overall IKDC score. For construct validity, seven hypotheses were tested. These included the following:

1. Patients with lower activity levels had lower IKDC scores ($p<0.001$).
2. Patients with a workers' compensation claim had lower IKDC scores than patients without a workers' compensation claim ($p<0.05$).
3. Patients with more difficulty with activities of daily living had lower IKDC scores than patients with less difficulty with activities of daily living ($r = 0.680$, $p<0.001$).
4. Patients with more difficulty working because of their knees had lower IKDC scores than patients with less difficulty working because of their knees ($r = 0.645$, $p<0.001$).
5. Patients with more difficulty with sports because of their knees had lower IKDC scores than patients with less difficulty with sports because of their knees ($r = 0.638$, $p<0.001$).
6. Patients with abnormal or severely abnormal assessment of overall knee function had lower IKDC scores than patients with a normal or nearly normal assessment of overall knee function (abnormal knee function mean = 36.5; normal knee function mean = 52.8; $p<0.001$).
7. Patients with degenerative/complex meniscus tears had lower IKDC scores than patients with simple tears of the meniscus (degenerative/complex tears, mean = 39.7; simple tears, mean = 45.3; $p = 0.004$).

Finally, the responsiveness of the score is measured. This determines whether the score can measure change. For the overall IKDC, there was a large overall effect size. The minimum detectable change (MDC95) was 8.8 points.

In this study, the IKDC score demonstrated acceptable psychometric parameters (test-retest reliability, content validity, criterion validity, responsiveness, construct validity, and internal consistency) to justify its use as an outcomes assessment instrument for meniscus injuries of the knee. This study will be presented at the 2006 Arthroscopy Association of North America Annual Meeting. The authors are Kevin Crawford, M.D.; J. Richard Steadman, M.D.; Karen K. Briggs, M.B.A., M.P.H.; and William G. Rodkey, D.V.M.

### Operative findings and outcomes following surgical management of patellar tendinopathy

Patellar tendinopathy (tendon abnormality) is a common cause of anterior (front) knee pain in recreational and competitive athletes. Sports that involve repetitive, sudden, ballistic movements of the knee, such as volleyball, basketball, soccer, and dancing, seem to be particularly prone to this problem. Surgical treatment is recommended if nonoperative treatments are not effective. The purpose of this study is to review surgical findings and clinical results in 53 patients treated for patellar tendinopathy.

A diagnosis of patellar tendinopathy was made based on history, physical examination, and an MRI. All patients continued to have symptoms after a series of nonsurgical treatments. The surgical procedure consisted of a diagnostic arthroscopy to document and treat intra-articular abnormality. The presence of a plica was addressed with a surgical release to remove any tethers on the extensor mechanism. A shaving chondroplasty was performed on the patella for unstable cartilage flaps. Following the arthroscopic portion of the procedure, an open approach was made to the patellar tendon. Patients with thickening of the tendon underwent removal of any inflamed tissue, fenestration (opening) of the tendon, and drilling the kneecap. Any abnormal tissue identified on MRI was also removed. The surgical division of the tendon was then loosely approximated with absorbable suture, and the tendon sheath was left open.

Patients were allowed to return to sporting activity at four months if they did not exhibit symptoms. Eleven of the 55 knees required a second operation to treat residual problems with the knee. The mean Lysholm score after surgery was 83. Of the 27 competitive athletes in our study, 22 returned to their sport at or above their previous level of competition. Nineteen of these 22 patients were professional or world-class athletes.

Patellar tendinopathy can cause significant disability due to anterior knee pain. In our study, the most common pathology found in association with patellar tendinopathy was infrapatellar and/or suprapatellar plica (a groove or fold) and most knees required removal of degenerative tendon tissue. However, patients showed significant improvement in function and returned to athletics. The authors of this study are R. Matthew Dumigan, M.D.; Sophia Hines; and J. Richard Steadman, M.D.

### Factors associated with patient satisfaction after instability for multidirectional instability

While traumatic shoulder dislocation and treatment were noted by Hippocrates in 400 B.C., multidirectional instability (MDI) has only been recognized since the early 1980s when it was first described by Drs. Neer and Foster. A person with MDI has a humeral head (the top of the bone in the upper arm) that moves unusually far in one or more directions within the shoulder joint. This unusual motion in the shoulder is due to an excessively loose capsule, which can be present from birth or can develop over time with repetitive overhead activities such as swimming or gymnastics. Many MDI patients have increased laxity in more than one joint (as in people who are "double jointed" in the elbows or knees). Initial treatment for MDI is strengthening the rotator cuff and scapular muscles surrounding the shoulder joint. When rehabilitation fails, surgery may be needed to strengthen the shoulder capsule. In this study we looked at factors associated with surgical satisfaction after MDI surgery.

Fifty shoulders in 46 patients underwent surgery for instability. Univariate analysis showed no significant differences for age, gender, or workers' compensation in patient satisfaction or the American Shoulder and Elbow Score (ASES). Patients with a prior stabilization procedure had a significantly lower ASES score (P = 0 .001). Patients who had an arthroscopic treatment versus an open had a higher ASES score (P <0 .05). Subjective variable analysis showed that satisfaction and ASES score were significantly associated with questions regarding pain, instability, and upper extremity use (P <0 .01). Analysis showed (P <0 .05) independent determinants of patient satisfaction to be a change in feelings of instability and the ASES score. Subjective variables of symptoms and motion have the greatest correlation with patient satisfaction and ASES score following surgery for multidirectional shoulder instability.

Focusing on these subjective variables may improve patient satisfaction with MDI stabilization. The authors of this study are S. Austin Yeargan, M.D.; Richard J. Hawkins, M.D.; Marilee Horan; and Aaron Black.

### Outcomes of large and massive rotator cuff repairs using a porcine patch

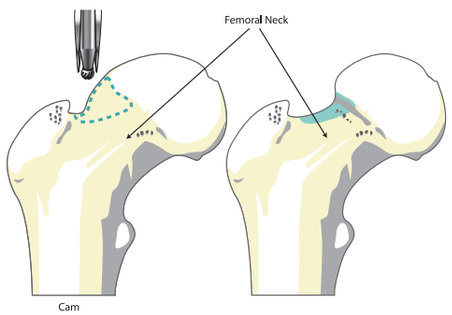
Large to massive rotator cuff tears often defy traditional repair techniques and have led to a variety of treatment recommendations. Because there is no consensus on the best treatment option for these cuff tears, new surgical techniques are constantly being developed. Recently, a porcine biologic scaffold or patch has shown numerous structural and functional properties that may direct cell growth and support in tendon healing. Enhancing the biological process of tendon healing by using a collagen matrix patch may improve the ultimate success of rotator cuff repair. While the goal of rotator cuff surgery is to alleviate shoulder pain and improve function, it is also helpful to document the integrity of the repaired tissue. The purpose of this study was to document the clinical and MRI results of large and massive rotator cuff repairs with the SIS patch.

Eleven massive cuff repairs were augmented with the SIS patch and evaluated two years after surgery. Patients completed a mailed questionnaire at an average of 3.6 years. Six patients in the study were able to return for an MRI scan. The average age of the patient at the time of surgery was 55 years (range, 43 to 75). One patient failed the SIS repair and the rotator cuff was revised following an acute re-injury. Ten remaining patients reported significant relief in pain and improvement in function postoperative. Seven patients were satisfied with their surgical outcomes. Six patients received a physical examination and MRI at an average of 4.3 years postoperatively. Four of the six MRIs did not show a tear. However, all six patients demonstrated arm strength weakness. Open cuff repair with the SIS resulted in significant pain improvement but postoperative objective assessments demonstrated improvement only in forward elevation. Additionally, MRI scans showed reasonable cuff integrity in four of six patients.

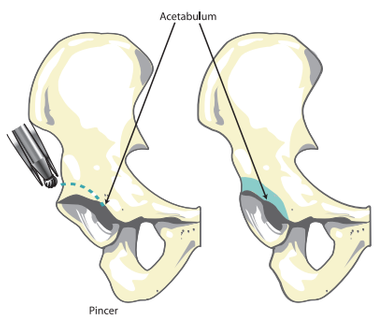
The results of this study demonstrate that the SIS patch should be used with caution to augment a tenuous rotator cuff repair or cover a small defect in the cuff tendons. The authors of this study are Allston Stubbs, M.D.; Richard J. Hawkins, M.D.; Charles Ho, M.D.; Catey Bradford; and Marilee Horan.

### Return to sport in 45 athletes following femoroacetabular impingement (FAI)

Femoroacetabular impingement (FAI) occurs when bony abnormality of the proximal femur (CAM) or acetabulum (pincer) triggers damage to the acetabular labrum and articular cartilage in the hip. Both types of FAI are common in athletes with hip pain and motion loss. An open surgical approach to decompressing FAI has shown good clinical outcomes; however; the surgical trauma sustained may delay a high-level athlete's return to professional play. We studied the return of professional athletes to high-level sports following arthroscopic treatment of FAI.




*With cam impingement, the burr, a small cutting intrument, is used to remove excess bone from femoral neck.*




Illustrations: Marty Bee

*With pincer impingement, the burr, a small cutting instrument, is used to remove excess bone from acetabulum.*

Forty-five professional athletes underwent hip arthroscopy for the decompression of FAI. Most athletes were hockey players, followed by golfers, football players, soccer players, dancers, baseball players, martial artists, tennis players, and jockeys.

All 45 athletes had improvement in their symptoms following hip arthroscopy. Forty-two athletes (93 percent) returned to professional sport following hip arthroscopy. Three players (one football player, one hockey player, and one baseball player) did not return to play following arthroscopy. Each of these patients had diffuse osteoarthritis at the time of arthroscopy. Five athletes required re-operation. Three of the athletes required lysis of adhesions and two required symptomatic treatment of extensive osteoarthritis. All of the patients who underwent revision surgery for lysis of adhesions returned to professional play; the two with extensive osteoarthritis did not return to play. Thirty-five of the 45 athletes remain active at the professional level at an average of 1.6 years after hip arthroscopy.

Various motions exerted during sport, particularly flexion combined with internal rotation (hockey-goalie stance), have been suggested as potential causes of overuse hip injury. In these positions, impingement may occur between the femoral neck and acetabular rim. FAI is a likely trigger of early hip joint degeneration. In our experience, FAI is a common problem that only recently has been recognized in athletes with a primary hip complaint. This study has demonstrated that full return to professional competitive sport is possible following arthroscopic treatment of FAI. This study will be presented at the 2006 American Orthopaedic Society for Sports Medicine Specialty Day. The authors are Marc J. Philippon, M.D.; Mara Schenker; David Kuppersmith; and Karen K. Briggs, M.B.A., M.P.H.

### Patient knee function and activity level five-year postarthroscopy compared to normal values

The Lysholm score and Tegner activity level are common scoring systems utilized to evaluate outcomes of arthroscopic knee surgery. The Lysholm score measures symptoms and function. The Tegner categorizes individuals based on the activities in which they participate. Outcomes following arthroscopic knee surgery have recently shifted focus to the patient's perspective. Patient perspective is often driven by various factors, including previous experiences. The Lysholm score and Tegner activity level measure the patient's perspective of function and activity. The presurgical score is often compared to the follow-up score to rate improvement. Improvement in function and activity, along with patient satisfaction, are the primary goals for most knee surgeries. However, these results do not say how the knee compares to someone with normal knee function.

The purpose of this study was to determine whether patients who perceived their knee function to be normal and were at least five

years past surgery had different function and activity level compared to individuals who considered their knee function normal, but had never had knee surgery or recent injury.

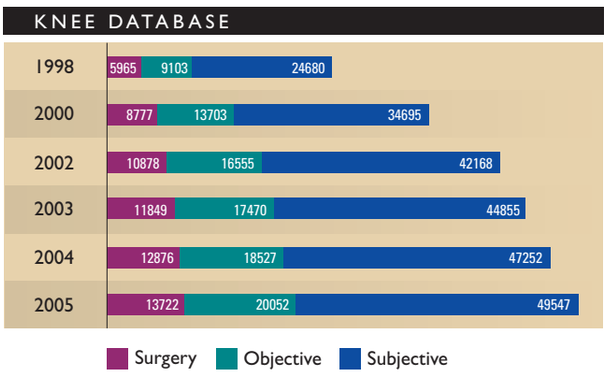
A group of 226 patients who were at least five years postoperative from arthroscopic knee surgery were compared to 391 individuals who had never had surgery. All participants considered their knee function normal.

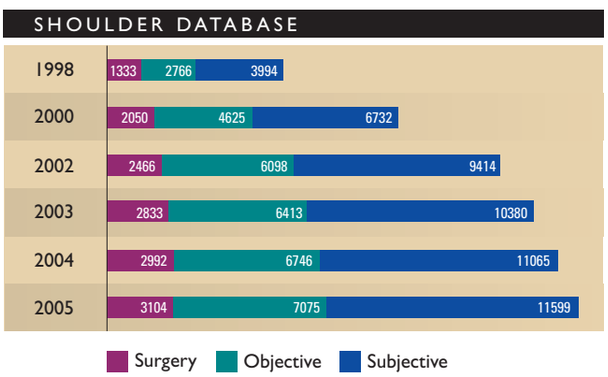
The scores did not differ between the two groups. In the postarthroscopy group, the average Lysholm was 93.9, and the average Tegner was 6.0. In the nonarthroscopy group, the average Lysholm was 94 and the average Tegner was 5.6. There were also no differences in Lysholm and Tegner by gender between groups. When the groups were broken into age categories (18-30, 31-45, 46-60, >60), there was no difference between postarthroscopy and the no-surgical group in average Lysholm for any age group. However, for Tegner activity, postarthroscopy patients aged 46-60 and >60 had higher Tegner scores (5.7 vs. 4.6) when compared to the nonarthroscopy population.

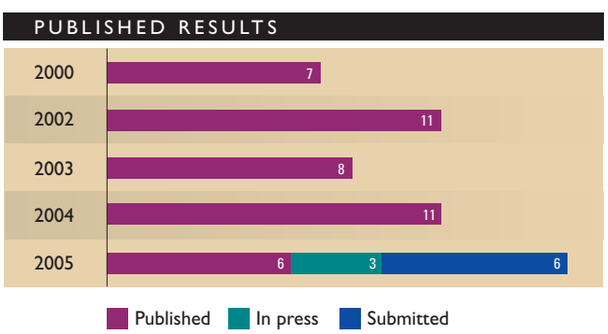
In conclusion, the Lysholm knee score and Tegner activity level are similar in patients five years following knee surgery and in individuals who have never had knee surgery. This information may be important in future patient education and defining what patients can expect from their surgery. It may also help define where a patient is in the recovery process. This shows not only that a patient can return to normal levels but also that the perspective of normal knee function is similar between the groups. It is important to note that individuals over the age of 45 did have lower activity levels. It may be that the arthroscopy group is getting degeneration of their knee treated while the nonarthroscopy group is coping with it as part of getting older. This emphasizes the importance of early treatment of osteoarthritis of the knee to prevent decreases in activity levels that contribute to osteoarthritis and other chronic diseases. This study will be presented at the 2006 American Academy of Orthopaedic Surgeons. The authors of this study are Karen Briggs, M.B.A., M.P.H.; Sophie Hines; and J. Richard Steadman, M.D.

## THE CLINICAL RESEARCH DATABASE

In its eleventh year of existence, the Clinical Research Database continues to grow. In 2005, hip arthroscopy was added to the database. The key to the success of this database is effective management of information. At the Steadman◆Hawkins Research Foundation, we have developed a method of managing patients' outcome information. In an effort to assess patient outcome following treatment at the Steadman-Hawkins Clinic, data are collected on every patient seen at the clinic. These data consist of both patient and physician assessment of improvement over the preoperative status. All of the collected data is stored in a Clinical Research Database. Our goal is to learn from our patients and validate our treatment protocols, all in an effort to provide high-quality health care. This database is governed by an Internal Review Board from Vail Valley Medical Center.



# Biomechanics Research Laboratory

Michael R. Torry, Ph.D., Director; Kevin Shelburne, Ph.D., Senior Staff Scientist; J. Erik Giphart, Ph.D., Staff Scientist; and Takashi Yanagawa, M.A.

*The Foundation's Biomechanics Research Laboratory (BRL) is a multidisciplinary laboratory in which the principles of mathematics and engineering are applied to solving complex problems in orthopaedic medicine. A main objective of the BRL is to explain (empirically) the how and why injuries, treatments, surgeries, and various therapies work for some individuals and not for others.*

## MISSION AND GOALS

The Biomechanics Research Laboratory's mission is to further the scientific understanding of basic biological processes and to develop innovative approaches for the understanding, prevention, diagnosis, and treatment of musculoskeletal disease.

**Our goals are to:**

1. Foster excellence in teaching, research, scholarship, and service in orthopaedic biomedical engineering.
2. Prepare orthopaedic medical doctors with functional capabilities to utilize biomedical technology to enhance patient care.
3. Educate the medical profession on the uses of such technical equipment in the clinical decision-making process.
4. Serve as a center for education and research in biomedical engineering.
5. Prepare students for careers in biomedical engineering characterized by leadership, communication skills, and a commitment to life-long learning.
6. Educate the public about the uses of biomedical engineering in orthopaedic medicine.
7. Publish scholarly research in scientific peer-reviewed journals in order to increase the quality of care in orthopaedics in general.

## OVERVIEW

The Foundation's Biomechanics Research Laboratory (BRL) is a multidisciplinary laboratory in which the principles of engineering are applied to solving problems in orthopaedic medicine. It applies quantitative, analytical, and integrative methods to the field of orthopaedic medicine. The staff of kinesiologists, mechanical engineers, and biomedical engineers integrate clinical care, research, and education with the resources of world-renowned medical doctors in order to improve the treatment of musculoskeletal diseases. This focused approach is designed to maintain and enhance athletic performance, health, and quality of life for the professional, semiprofessional, collegiate, high school, and the recreationally active individual. The programs provided by the Biomechanics Research Laboratory are unique, diverse, and encompass a complete range of services for the physically active or those wishing to return to an active lifestyle after injury.

*Left to right: Arvin Ramanujam, M.A.; Takashi Yanagawa, M.A.; Michael R. Torry, Ph.D.; Kevin Shelburne, Ph.D.; and J. Erik Giphart, Ph.D.*

With the statement *"helping physicians to make clinical decisions"* as its doctrine, the Biomechanics Research Laboratory also seeks to enhance a world-renowned medical doctor Fellowship Program by providing quality research education, guidance, support, and consultation to the partners and medical Fellows of the Steadman-Hawkins Clinic.

The work output of the BRL for the year 2005 has been exemplary, with ten refereed abstracts presented at four national and international conferences. The group has also produced seven original full-length research papers (four publications; three in press). Notwithstanding, the quantity of the work is backed by substantial quality. "Each year our research gets stronger and we are receiving recognition from our peers for the quality of our work," states Dr. Mike Torry. Some of the research that the BRL has initiated and/or completed in the year 2005 is described below.

### Determination of How the Knee Carries Load During Activities

The onset and progression of knee osteoarthritis is often attributed to an injury or pathology that alters load distribution between the medial and lateral compartments of the tibiofemoral joint. The distribution of force between the medial and lateral compartments depends on two factors: (1) the magnitude of the external varus or valgus moment acting about the knee, and (2) the contributions that the muscles and ligaments make to support this moment. In walking,

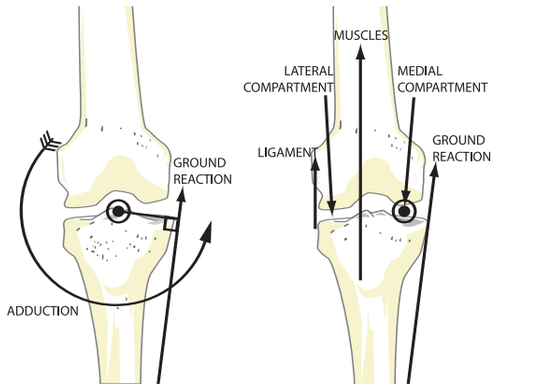



Illustration: Marty Bee

*Figure 1: Contribution of muscle and ligament to abduction movement at the knee during walking (calculated about the medial compartment center of pressure).*

the moment acting in the frontal plane (the external adductor moment) bends the leg inward, causing most of the tibiofemoral joint load to be transmitted by the medial compartment. Dr. Kevin Shelburne, assistant director of the Steadman◆Hawkins Research Foundation's Biomechanics Research Laboratory, and Scientific Advisory Committee member Dr. Marcus Pandy at the University of Melbourne, Australia, have developed a computer model of the knee and lower extremity that can determine loads inside the knee joint during walking. The major aim of the present study was to determine which muscles and ligaments resist the external adductor moment applied at the knee during normal walking.

Early results suggest that the peak external knee adductor moment in the simulation of normal walking (3.5 Nm/weight height) was near the top of the normal range reported for normal gait in healthy adults. The total knee adductor moment was balanced by the abductor moments applied by the muscles and ligaments crossing the knee (Figure 1). Muscles provided most of the resistance during single-leg stance. The knee ligaments contributed significantly during early stance and midstance.

The quadriceps and gastrocnemius muscles dominated the total abductor moment at the knee. The first peak in the abductor moment occurred at contralateral toe-off and was due to the force developed by the quadriceps. The second peak occurred at contralateral heel-strike and was caused by the force in gastrocnemius. The hamstrings contributed significantly only during early stance. The tensor fascia latae, sartorius, and gracilis contributed much less than the other muscles crossing the knee. The ligaments of the posterior lateral corner (PLC) provided the primary passive resistance to knee adduction during early stance and midstance. The ACL and posterior capsule offered little resistance to knee adduction throughout the stance phase of walking.

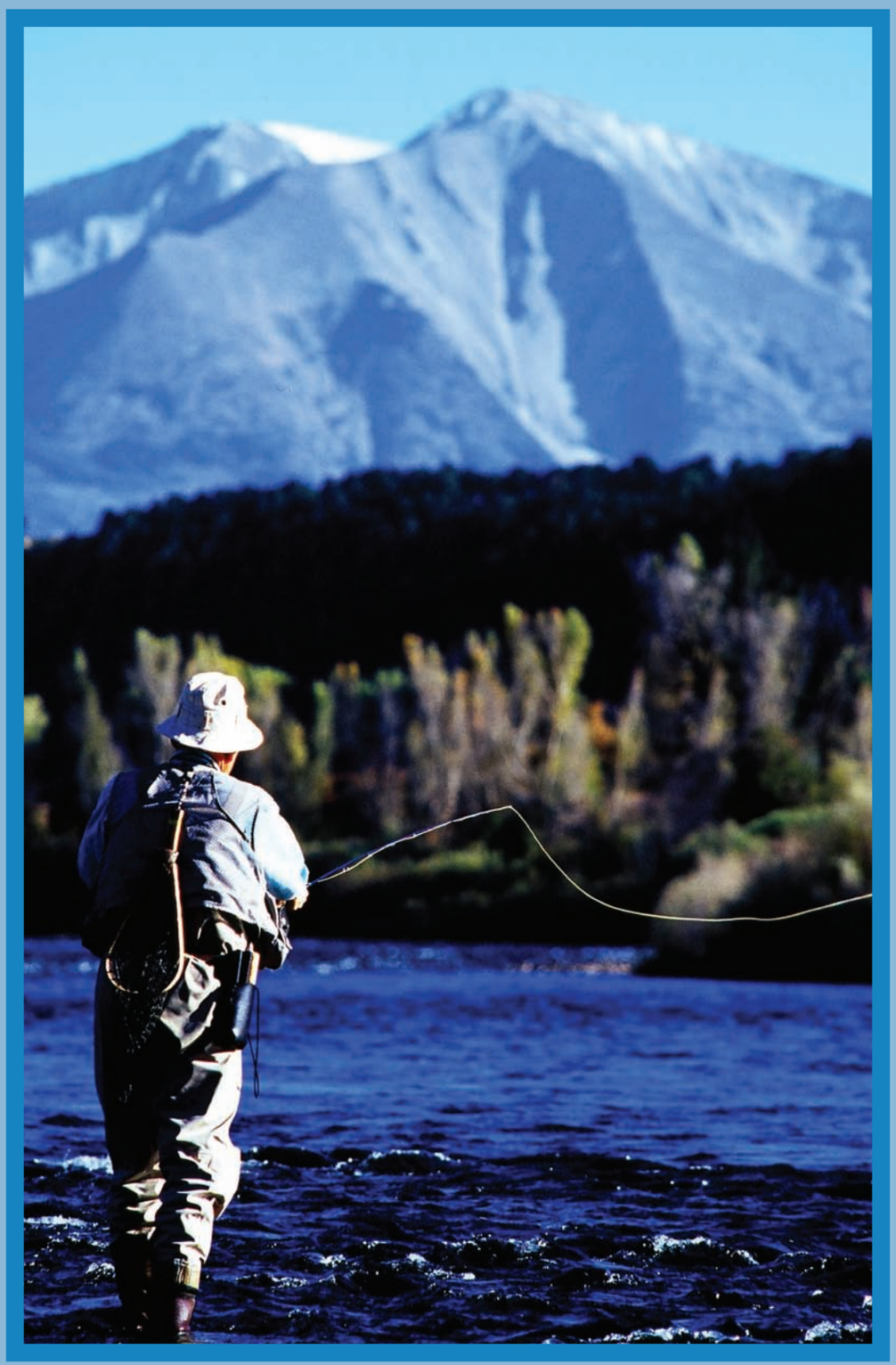
The muscles that contribute most to support and forward progression in normal walking also contribute most to knee stability in the frontal plane. The quadriceps contributed most of the muscular moment needed to resist knee adduction during the early portion of single-leg stance and is supported by in vivo analysis, whereas the gastrocnemius provided most of the moment needed to resist adduction in late stance. This finding provides the most compelling reason why postoperative rehabilitation of quadriceps strength is so important for the success of most knee surgeries. Dr. Shelburne's research helps physicians better understand how and why conservative and surgical treatments are effective in restoring normal load bearing at the knee. This research also provides a basic understanding of the loads that a knee must be able to withstand, which allows physicians to select surgical procedures most appropriate to meet those demands in the active individual.

### Analysis of the Golf Swing Mechanics in the Professional and Amateur Golfer

In professional golfers, the highest percentage of injuries (80 percent) affect the spine, followed by the wrist (10 percent). In amateur golfers, back injuries and back pain constitute 27 percent of injuries requiring loss of playing time and medical treatment. The incidence of back injury is followed closely by elbow injury and to a lesser extent, hand, wrist, shoulder, and knee maladies. The reason for the discrepancy between amateurs and professionals is not known, but it may be attributed to overuse, poor swing mechanics, and improper conditioning.

*Topper Hagerman, Ph.D., of the Howard Head Sports Medicine Center participated in the BRL golf research program.*

Golf is one of the most popular recreational sports in men and women 50 years of age in the United States. Golf is also becoming more affordable and thus more accessible to youth as well. Unfortunately, golf requires excessive and repetitive rotary motions that often cause injury in youth and/or exacerbate injury in adult populations.



Very little information exists to describe the motion of the body in the young, adult, and older (>60 years) golfer. The research project is designed to provide performance data on the golf swing in golfers ranging in age from 12 to over the age of 80. The golf data derived from this study will be compared among the age ranges to determine similarities and differences in swing mechanics across the lifespan. These data, we hope, will provide information on how and why both young and aging golfers obtain or exacerbate orthopaedic injuries.

### Determining How and Why Little League Baseball Pitchers Get Injured

After four years of investigating major-league baseball (MLB) pitching mechanics and injuries in association with Drs. Tom Noonan (Steadman-Hawkins Clinic – Denver) and Tom Hackett and the MLB's Colorado Rockies medical staff, Dr. Torry and the BRL team have focused their efforts on understanding the mechanics behind the Little League pitchers' throwing patterns and how these patterns contribute to their injury potential. The injuries seen in younger pitchers are much different from those observed in professional pitchers. This observation led us to believe that the pitching mechanics are most likely very different as well. Recently, the BRL has published several abstracts and papers that detail the pitching mechanics of Little Leaguers and, in conjunction with our professional pitching database, we are able to compare throwing patterns of developing young pitchers to the throwing patterns of successful mature pitchers. Although significant differences exist, there are many more similarities.

For instance, Little Leaguers only throw about 50-65 mph fastballs. However, given the shorter distance from home plate to the pitchers mound, this translates into a professional pitch velocity equivalent of 80-95 mph. Our research has also shown that Little League pitchers actually execute the pitch sequence in a similar manner, with major differences from the pros being partly attributed to height, weight, and physical strength.


So why are the injuries patterns so different? This is most likely due to the physical strength and the skeletal maturity of the athletes. As we mature, the tissues become more rigid and able to withstand higher forces. An outcome of our research distinctly shows that young players (as early as 13 years old) need to have proper techniques taught to them because, at this age, these athletes are already developing pitching mechanics that they will carry into adolescence. Also, the unique aspects of the developing skeleton in youths make their bodies more susceptible to a spectrum of injuries not commonly seen in adult pitchers. Although these injuries may be due to the musculoskeletal changes occurring during growth, they may also be, at least in part, due to pitching technique. Since the trunk (shoulders and hips) can be utilized to create enormous power and increased ball speed during the baseball pitch, it may be that the differences we observed in trunk motions between the young and professional baseball pitchers also may help explain the differences in patterns of injury between these groups. The Steadman-Hawkins BRL investigated the rotations of the trunk during the pitch between young and professional pitchers. The peak rotational velocities of both the upper trunk and pelvis were greater in young baseball pitchers than in professional pitchers. Peak upper trunk rotational velocity was 2102 ± 324 percent in young pitchers and 1193 ± 176 percent in professional pitchers. Our data support the observation that young baseball pitchers control their trunk motion in a less efficient way than elite pitchers. Peak pelvis rotation velocity occurred near the time of stride foot contact in the professionals, while it occurred much later in the young pitchers. Proper timing of pelvis and upper trunk rotation are necessary to effectively transfer energy from the trunk to the throwing arm. Therefore, increased trunk rotational velocity may be a compensation for improper timing of segment rotations or insufficient muscle strength in young pitchers. Improper energy transfer from the trunk to the upper extremity may lead to the increased shoulder internal rotation and elbow extension velocities in young pitchers compared to the professionals. Ongoing research in this area will focus on pitch counts, arm fatigue, and how these two factors can contribute to injury mechanisms in the young thrower.

"Understanding injury mechanisms in this group is fundamentally important," states Dr. Torry, "but what we really want to do is utilize this scientific information and make solid recommendations for youth-league coaches about safe pitching techniques and limits — a true grass-roots effort to reduce injuries in these kids." Understanding and reducing injuries in youth baseball is very important because there is an alarming national trend occurring in youth baseball in which parents are bringing their children into the sports medicine clinic and inquiring about surgeries such as the *Tommy-John* (a relatively common shoulder surgery performed on professional pitchers)."This is just unacceptable," remarks Dr. Torry, "and we can make a clear difference and global impact with our research

in this area." This research is being recognized by the scientific community as both Drs. Noonan and Hackett presented these findings to the American College of Sports Medicine in June 2006.

### The Virtual Shoulder

Like the virtual knee model, the Biomechanics Research Laboratory (under Dr. Kevin Shelburne and Takashi Yanagawa), in association with Dr. Marcus Pandy at the University of Melbourne, Australia, are leading the way in the development of a revolutionary virtual shoulder model. Next to a knee joint, a shoulder joint is prone to injury because of its complexity. It has four joints and involves four bones and many muscles that surround it. Many other structures also contribute to the joint stability of the shoulder. Determining just how each of these structures contributes or fails to contribute to the shoulder joint stability is paramount to being able to surgically treat the shoulder more successfully.

The virtual shoulder model allows for many individualized research questions to be asked and investigated. For instance, we may ask how much force is applied to the glenohumeral joint if one of the rotator cuff (or any combination of) muscles is weak or injured. Thus, the shoulder model can be applied to nearly any "what if" scenario that an orthopaedic surgeon could envision. Engaging in this type of research would be financially impractical utilizing conventional methods of working with cadavers.

As with any virtual model, prior to being applied clinically it must be validated. "Takashi Yanagawa has been working very hard in validating our current model," states Dr. Torry, "and this validation process is no small endeavor, as it involves tedious computer programming. We have recently submitted a manuscript to the *Journal of Biomechanics*, which shows this validation process. With this advancement, we are close to applying the model in a useful and clinically relevant manner. I have no doubt that this model will revolutionize our basic understanding of how the shoulder really moves and what muscles and ligaments are involved." This information will forge the way for better surgical techniques and rehabilitation protocols.

### Clinical and Mechanical Validation of Lysis of Knee Adhesion Surgical Procedures

Knee adhesions (Figure 2), often referred to as "scarring" of the knee joint, cause changes in the way the knee joint normally moves. This altered motion leads to abnormal loading inside the knee joint that can eventually degrade the cartilage of the knee and result in the development of osteoarthritis. In the United States alone, the cost for treating osteoarthritis and its complications is almost $65 billion. When considering its worldwide economic impact, this figure is estimated to be over $750 billion annually. Although most orthopaedic surgeons acknowledge the presence of these adhesions in persons who are experiencing pain at the anterior aspect of their knee, it has been difficult to surgically address this condition, as the science behind the treatment is lacking. The lysis of adhesion may be a needed surgical procedure that can potentially remove these adhesions and promote normal patellofemoral and tibiofemoral motion and biomechanics, thus sparing the joint from further osteoarthritis degeneration. This study aims to provide surgical, clinical, and scientific validation that the lysis of knee adhesion surgical technique can spare the knee joint from excessively high loads that would otherwise cause degenerative osteoarthritis.

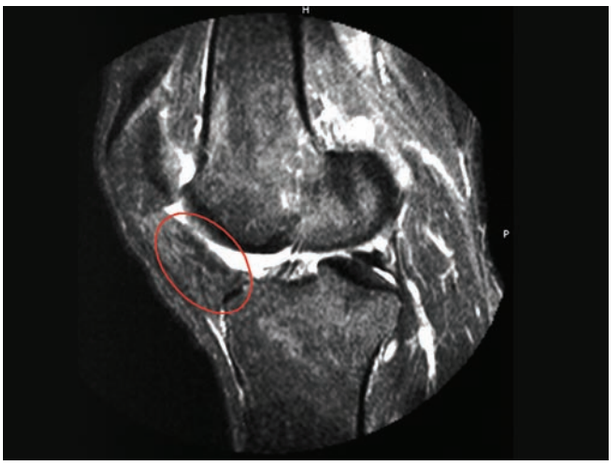
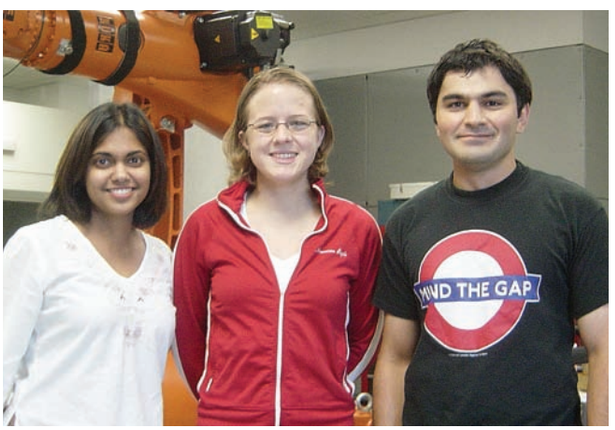


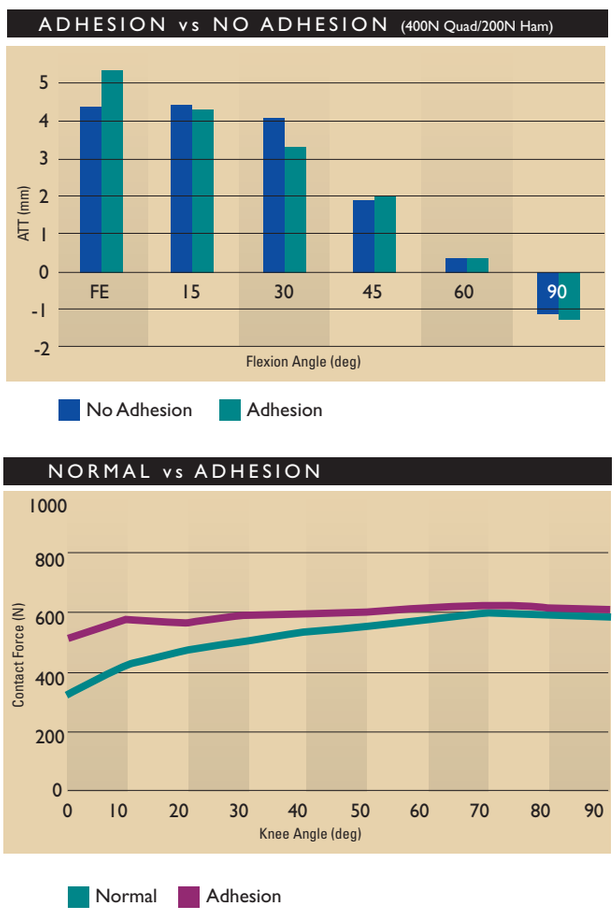
*Figure 2. MRI illustrating scarring of the anterior interval. Note the dense scarring (in the red circle) on the posterior border of the fat pad and its attachment to the transverse ligament.*

The proposal will integrate the world leaders in musculoskeletal experimentation, modeling, MRI, and clinical medicine to describe




*Staff researchers at the University of Pittsburgh Musculoskeletal Research Center. Behind is the high-payload robot that will test the cadavers.*

and determine the anatomy, dynamic imaging, biomechanics, clinical diagnosis, and arthroscopic treatment, plus assessment of clinical outcomes at various intervals. These goals will be accomplished by a three-step approach involving two research centers and three departments: Musculoskeletal Research Center (MSRC), Department of Bioengineering, University of Pittsburgh; Department of Clinical Research, Steadman◆Hawkins Research Foundation; and Department of Biomechanics, Steadman◆Hawkins Research Foundation. The MSRC, headed by SAC member Savio Woo, Ph.D., D.Sc., will collaborate with orthopaedic surgeons and researchers of the Steadman-Hawkins Clinic and the Research Foundation to create "lifelike adhesions" in the cadaveric knee. These knees will then be tested using high-payload robotic technology and computational mechanics designed to describe the mechanical influences of knee adhesions on internal loading and knee joint function.




*Figures 3a and 3b: (3a) Data from MSRC showing that the knee adhesions can cause increased tibiofemoral translation. (3b) Data from SHRF knee modeling showing adhesions can increase patellofemoral contact forces.*

The preliminary results are promising. Dr. Woo and his staff at the MSRC have shown that anterior motion of the tibia and femur can increase due to adhesions (Figure 3a). These data are further supported by computational modeling efforts conducted by Kevin Shelburne, Ph.D., at the Steadman◆Hawkins Research Foundation, which shows adhesions can cause increased loading between the patella and femur (Figure 3b).

At the conclusion of this study, we anticipate the identification and description of the successful surgical treatment of patellar tendon adhesions that is supported by objective and subjective clinical data. Additionally, we will provide biomechanical evidence that identifies the significant factors determining the pretreatment mechanics associated with anterior knee pain due to the adhesions. We will also be able to demonstrate changes in knee kinematics and mechanics associated with the successful treatment of this pathology utilizing dynamic MRI techniques.

There is the appeal of both clinical and scientific impact associated with this research project. This research will have wide-reaching appeal across the field of orthopaedics as this problem is encountered across most of the subdisciplines of orthopaedics. Thus, many surgeons will benefit from the knowledge gained in both surgical treatment and patient satisfaction after these procedures. Although we have focused on the knee, this research may also allow experts working within other joints (shoulder, wrist, for example) to apply and expand upon the surgical and scientific techniques developed in this proposal to their own needs, thus addressing issues of intra-articular adhesions across a wider range of patients. Scientifically, the development and application of a dynamic MRI technique that employs novel 3D computer modeling methods will have a great impact on clinical use of dynamic MRI for diagnostic purposes for subtle knee disorders. It will also allow for technological advances in the noninvasive measurement of human motion.

The future direction of this research lies in the ability of scientists to generate subject-specific, anatomically correct 3D images of each patient, and to apply motion to integrate that anatomy with computer modeling and simulation techniques that can show precise bone segment rotations and translations and to estimate intra-articular forces as they occur. Once established and validated, these methods can be applied pre- and postmedical treatment, allowing assessment of subtle changes in anatomic motions after treatments. Also after validation of the methods, advances in computer modeling can explain and even predict successful surgical outcomes.

"This project is exciting for us on many levels," states Dr. Torry. "First, we have received the largest external grant ever awarded to the Steadman◆Hawkins Research Foundation by the Greece-based Stavros Niarchos Foundation. This means our research and the quality, as well as the potential of our research, is being recognized all over the world. Second, as engineers we are able to apply our technical skills

to a real clinical problem. This is always gratifying since we know what we are doing is truly helping people. Third, this grant allows the engineers at the Steadman◆Hawkins Research Foundation to work closely and formally with Dr. Savio Woo and his staff and students at the MSRC. It is always gratifying to collaborate and work at such a high level of scientific inquiry."

## NEW RESEARCH INITIATIVE: A STEP INTO THE FUTURE

The Biomechanics Research Laboratory has excelled over the past four years, winning five international and national research awards in acknowledgment of its pioneering work in orthopaedic research. "Conducting research is easy, but to excel and remain at the cutting-edge level in our research, we must persistently develop new technology to meet the needs of the orthopaedic surgeon and ultimately the patient. That is the hard part," states Dr. Torry. This Annual Report constitutes a major turning point in our research agenda. In the last five years, we have successfully accomplished all our planned five-year goals. Thus, for the next five-year plan, the Biomechanics group is proposing an ambitious, innovative research initiative that will keep its work at the forefront of orthopaedic technology. Titled "*A Step Into the Future*," the Biomechanics Research Laboratory proposes the development of a 3D Dynamic Motion Imaging System to investigate human motion at a level of detail and scrutiny that has not been possible until recently.

Why is this advancement in technology required and how will it help patients? Nearly everyone reading the 2005 Annual Report has experienced a trip to the orthopaedic surgeon's office. This trip is most often associated with an additional trip to the MRI station and/or the X-ray station so the doctors can get a "view" of what is inside the joint. While taking the MRI or X-ray scan, the imaging technician tells us to remain perfectly still. This is a major problem and is in stark contrast to the doctor's assessment in which the clinician often requires the patient to bend or flex the joint in an attempt to reproduce and localize the pain. Thus, most often the pain a patient feels in a joint actually occurs while moving, not lying still as was imaged by the MRI or X-ray. So the fundamental basis for this new research initiative is quite simple — to combine the MRI and X-ray data with patient's motion and report the movements of the bones while the patient is actually moving. With this combination, we can create a set of 3D Dynamic Motion Images that can be viewed from any perspective. The potential for this information in its practical application to orthopaedic surgery is limitless. "We will start with simple motion such as walking, hence the title, *A Step Into the Future*, and then progress into more dynamic motions. This project offers a unique opportunity to investigate numerous research questions that are persistently plaguing the orthopaedic practice," remarks Dr. Torry. This new development will also allow for the collaboration with such noted researchers as Dr. Savio Woo (University of Pittsburgh), and it will allow us to compete at the top tier for National Institutes of Health (NIH) and National Science Foundation (NSF) grants. For more information and how to donate to the capital campaign for this new research initiative, please contact John McMurtry or Dr. Michael Torry.

# Mapping the Geometry of a Joint—Creating Patient-Specific Models from Diagnostic Images

By Michael R. Torry, Ph.D., and Kevin Shelburne, Ph.D.

Musculoskeletal joints are intricate mechanisms composed of soft tissues (muscle, ligaments, cartilage) and bone that must stretch, twist, and flex in order to handle extreme loads of pressure. For instance, even during a seemingly simple action like walking, the inside of the knee must be able to withstand 1,500 pounds per square inch.

Unfortunately, musculoskeletal joints are also well hidden under muscle and skin. No matter how much experience an orthopaedic surgeon has, the physician has no idea of how the joint functions during activity. Without this knowledge, there is no sure way to plan an operation or reliably predict its success. Until now, surgeons have relied heavily on X-rays or magnetic resonance imaging (MRI) and computed tomography (CT) to see inside the body. But these scans are only a motionless snapshot of the joint, and the surgeon must sift through 40-60+ pictures to find the specific two or three that show the injury. Consider this workload when a surgeon typically sees 30 to 40 patients per day. This equates to 130 to180+ scans the surgeon must intensively study in order to find each specific injury.

In a healthy joint, this endeavor is like searching for a needle in a haystack. In a severely injured joint, this is similar to searching for a needle in a stack of needles. Thus, being able to quickly and reliably view the complete anatomy of a joint in 3D, as well as to see how that specific joint's different components interact with each other during activity, would be of immense value to doctors and therapists. The power of this unprecedented view of a joint would eliminate the guesswork in devising and adapting therapies to suit an injured or disease-affected joint.

## Creating Patient-Specific Models from Diagnostic Images

With the problem understood, the Foundation's Biomechanics Research Laboratory took up the monumental task of successfully creating technology to represent the knees and shoulders of patients accurately in three dimensions. Utilizing MRI and CT scans, these images are converted into thousands of mathematical equations — the basic language understood by computers. These one-of-a-kind virtual models of the knee and shoulder joints allow the researchers to see and manipulate the tissues in 3D. The models also allow basic research to determine how these tissues are stressed during activities of daily living or how people injure themselves during athletic events, as well as predict the outcomes of different surgeries and therapies. Direct access to such detailed information about their own bodies immensely aids patients and their physicians in choosing the premier healing protocol for that situation.

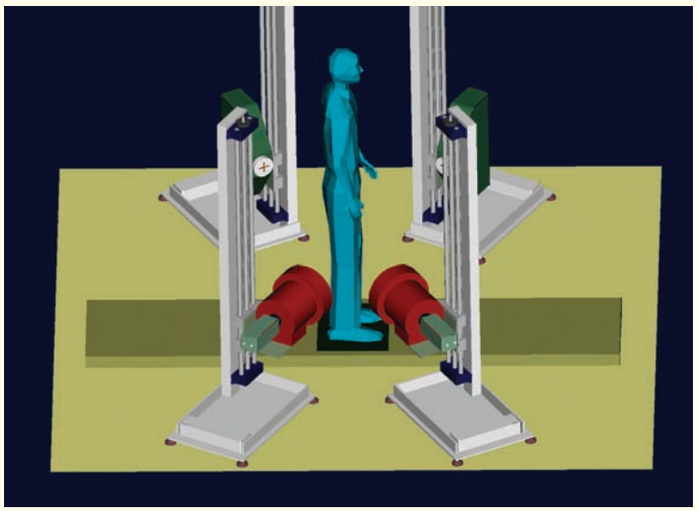
## 3D Models in Motion

Creating a stationary 3D model to allow clinicians to see inside of the joint is only half the problem. A model must be able to behave like the real joint because motion reveals pathology. It is motion that typically causes pain and exacerbates further damage to a joint. It is not only the geometry of the joint but also a combination of the 3D geometry and the 3D motion that really complicates the understanding of how knee and shoulder joints function. Moreover, every person's joints move a little differently from others and these motions can be very subtle (0.15 to 0 .05 mm) but meaningful in understanding damaging loads to structures such as knee cartilage.

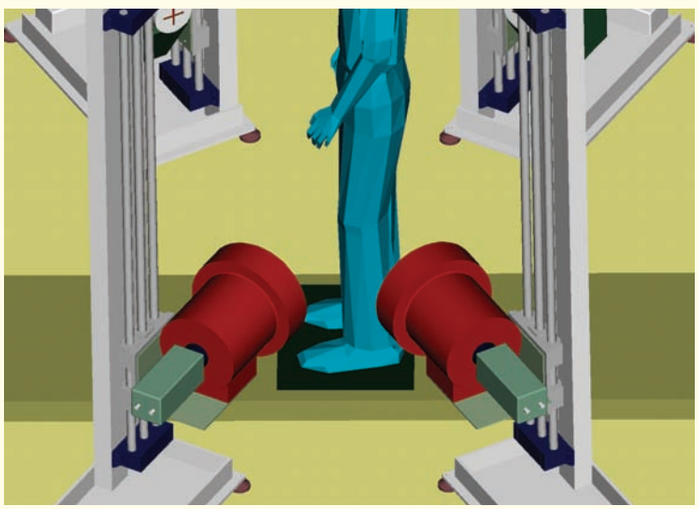
These complexities compound the surgical options as well as the potential for error when physicians must decide on a course of surgery and rehabilitation that would best suit their patients. The Foundation's Biomechanics Research Laboratory has embarked on a novel method of measuring the exact motion of these joints to accuracy levels of 0.014 mm or less. The core of this research initiative is *dual plane fluoroscopy*. This technology is based on integrating dynamic fluoroscopy (X-ray), stereoscopic vision, and MRI and CT to allow true 3D motion to be obtained from patients as they move about the laboratory. Once completed, this initiative will provide an advanced, accurate, and comprehensive description of motion in the shoulder and knee that has not been achieved previously.

## Seeing Inside while Staying Outside

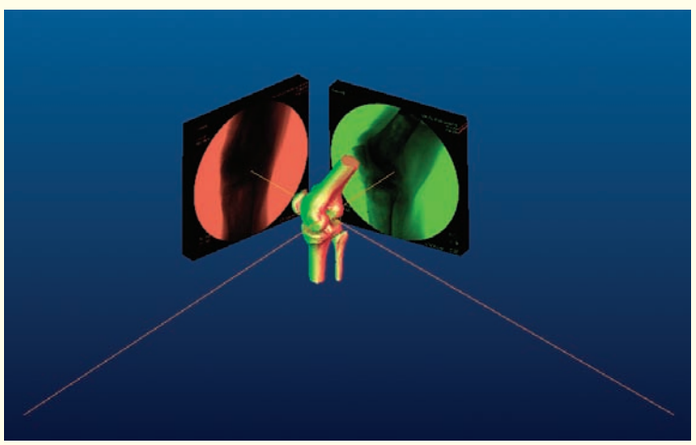
The Steadman◆Hawkins Research Foundation's Biomechanics Research Laboratory and other researchers around the world are pioneering the highly promising field of patient-specific computer simulation. Combining a 3D model of the patient's joint via MRI and CT with highly accurate human motion analysis via dual-plane fluoroscopy will allow physicians, therapists, and researchers the freedom to simulate different healing and correction protocols on the injured, malaligned, or diseased joint. Then they can select the optimum surgical and rehabilitative procedures without even touching the patient. We are pushing the advances in this technology already made by the Foundation into a new realm. The ultimate scenario will be for a physician to bring a 3D model of his or her patient's injured or damaged joint into virtual reality on a desktop computer, perform different surgical procedures, and immediately view the results on that particular joint's motion and ability to handle loads and forces.



*Full view of the dual-plane fluoroscopy system set-up: This innovative system is designed to measure motions of the bones in the body. Here the system is poised to measure motion of the knee during walking. This system has the ability to track the motion of the knee bones at an accuracy of .2 mm or less. This highly accurate method of motion capture will allow the Biomechanics researchers to determine loads of knee ligaments and even the cartilage in the knee during activities of daily living such as walking and stair climbing.*



*Close-up view of dual-pland fluoroscopy system: The two large cylinders emit X-ray beams that the subjects walk through. The beams pass through the skin and muscle to project a view of the bones of the knee that is captured on the smaller plates (marked with an "x" in the background).*



*The two X-ray projections are combined with a 3D model of the knee and together they are used to recreate the measured motion of the knee in the computer.*

# Education

Greta Campanale, coordinator; Dina Proietti, assistant

*The Foundation's primary mission is to conduct research that can be applied directly to orthopaedic medicine. To this end, education is also an important part of our work. We offer training throughout the year to physicians in residence, to visiting medical personnnel, and during international medical meetings. In addition, the education department produces videotapes and educational programs on the internet. Members of the staff report their research through publications, presentations, and posters. The education department provides administrative support for educational programs and conferences, responds to the press, and teaches high school students about human anatomy and injury.*

## FELLOWSHIP PROGRAM: Learning As We Teach

Considered one of the most prominent and rigorous academic fellowship programs in orthopaedic sports medicine, the Steadman-Hawkins Fellowship Program is at the core of the Foundation's educational effort. Each year, six young orthopaedic surgeons are chosen from more than 100 candidates to become Steadman-Hawkins Fellows. They are with us for an intensive 12-month training period to refine their skills in orthopaedic surgery and to investigate the causes, prevention, and cures of degenerative arthritis, as well as the treatment and prevention of injuries. Our goal is to prepare our Fellows to be the leaders in the field of orthopaedics for the remainder of their careers.

The Foundation currently maintains a network of more than 150 Fellows who share advanced ideas and inspire each other to higher levels. We are fortunate in Vail to work with the best young physicians in the world. Their insights and enthusiasm during this rewarding program have demonstrated to us many times over that we, too, learn as we teach.

## 2005-06 Fellows

Six new fellowship surgeons spend their year refining skills and learning new surgical techniques, as well as participating in research with Foundation scientists as they make final preparations for a career as orthopaedic surgeons.

## German Orthopaedic Surgeons Visit, Sponsored by ORMED GmbH & Co. KG, June 13-15, 2005

By Greta Campanale, Education Coordinator

Twelve orthopaedic surgeons from Germany visited the Steadman◆Hawkins Research Foundation for three days in June 2005. Sponsored by ORMED GmbH & Co. KG, the European visitors observed three live surgeries performed by surgeons of the Steadman-Hawkins Clinic: a high tibial osteotomy procedure performed by Dr. William Sterett, a knee arthroscopy performed by Dr. Richard Steadman, and a hip arthroscopy performed by Dr. Marc Philippon. In addition, the group heard lecture presentations given by members of the Steadman-Hawkins Clinic, the Steadman◆Hawkins Research Foundation, and the Howard Head Sports Medicine Center. The presentations focused on Steadman-Hawkins treatment approaches to lower and upper extremity sports medicine injuries and degenerative joint disease.

While in Vail, the group enjoyed touring the valley, biking, whitewater-rafting tours, and dining out. The three-day educational program provided an exciting forum for the exchange of ideas between the European and North American orthopaedic surgeons.

Founded in 1992, Ormed has three subsidiaries and 65 distribution centers throughout Germany. The company specializes in manufacturing and distributing passive-motion devices and other therapeutic systems, braces and splints, and medical breakthrough surgical technology in cartilage repair. The rental service team organizes outpatient treatment, including instructions on care and treatment of therapeutic modalities following surgery. Ormed's philosophy encompasses the development of innovative products, a carefully trained staff and sales force, and a well-established rental service throughout Germany. The company is a market leader in Germany for continuous-passive-motion devices.

## Where are they now. . .

The graduating class of 2004/2005 Steadman-Hawkins Fellows is busy establishing new careers in orthopaedics.

**Kevin Crawford, M.D.**, moved back to Lubbock, Texas, to practice with Lubbock Sports Medicine.

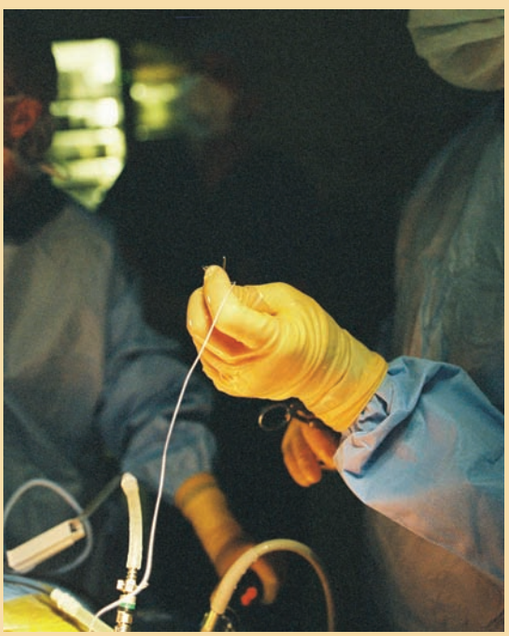
**Jason Dragoo, M.D.,** has joined Stanford University Medical Center's Department of Orthopaedic Surgery as an Assistant Professor of Sports Medicine in Palo Alto, California.

**Matt Dumigan, M.D.**, joined former fellow, Mike Zafuta, M.D., in Pittsburg, Kansas, at New Century Sports Medicine.

**Sonny Gill, M.D.,** moved to Arnold, Maryland, to begin his practice with Bay Orthopaedics.

**Al Stubbs, M.D**., stayed on to do a six-month hip fellowship with Mark J. Philippon, M.D.

**Austin Yeargan, M.D.**, moved to San Luis Obispo, California, to establish a new practice.



Each Fellow has the opportunity to be actively involved in clinical research, basic science, and biomechanics research. They also experience hands-on medical coverage of Major-League Baseball's Colorado Rockies, the NFL's Denver Broncos, the U.S. Ski Team, and Eagle County High School sports teams.

The stream of knowledge and information flows both ways. The Fellows, having completed their formal training in leading orthopaedic programs, share knowledge they have gained from years of training with the physicians and scientists of the Foundation.

**Mark S. Adickes, M.D.**

Dr. Adickes attended Baylor University as an undergraduate student of business and then earned his medical degree at Harvard Medical School. He performed his orthopaedic surgery residency at the Mayo Clinic in Rochester, Minnesota. Dr. Adickes' career in medicine follows a remarkable decade-long career in the National Football League, during which he was a member of the 1991 Super Bowl Championship Washington Redskins team. He also has extensive volunteer experience with inner-city students, terminally ill children, and the Special Olympics.

**Dominic S. Carreira, M.D.**

Dr. Carreira earned his undergraduate degree in psychology at the University of Notre Dame. He proceeded to the University of Illinois at Chicago to receive his degree in medicine and was named to the Alpha Omega Alpha Medical Honor Society. He completed his residency at Rush University Medical Center. Dr. Carreira has been involved in numerous sports medicine research projects, most notably his study of arthroscopic Bankart repairs, and he has published articles in *The Orthopaedic Clinics of North America* and *Orthopaedics*.

**Alexander Martin Clark, M.D. (Marty)**

Dr. Clark graduated cum laude from Harvard with a degree in biology and earned his medical degree from Columbia University. He performed his orthopaedic surgery residency at New York - Presbyterian Hospital, where he was named the Arnold P. Gold Resident of the Year. A former professional squash player and four-time U.S. National Champion, Dr. Clark has a keen interest in the clinical research of injuries sustained by amateur and professional squash players.

**Stephen A. Hunt, M.D.**

Dr. Hunt studied history as an undergraduate at Yale University, where he captained the varsity lacrosse team and received the Donald J. Reape Lacrosse Award in his junior and senior years. He received his medical degree from New York University and was a member of the Alpha Omega Alpha Medical Honor Society. He then completed his residency at New York University's Hospital for Joint Diseases. Dr. Hunt has been published numerous times in such journals as *Arthroscopy, Journal of the American Academy of Orthopaedic Surgeons, Journal of Trauma,* and *Foot & Ankle International.*

**Todd L. Johnston, M.D.**

Dr. Johnston graduated magna cum laude from the University of Notre Dame with a double major in science pre-professional studies and Japanese, and he also received the Knute Rockne Scholar Athlete Award for outstanding achievement in academics and athletics. He went on to study medicine at the University of Iowa, where he completed an orthopaedic and medical elective in Japan. Dr. Johnston performed his orthopaedic residency at Northwestern University, and his research experience includes radiographic evaluations of cervical pedicles, as well as studying the biomechanical comparison of multiaxial cervical pedicle screws.

**William Scott Kimmerly, M.D.**

Dr. Kimmerly received his undergraduate degree in political science from the University of North Carolina at Chapel Hill, and he attended medical school at the University of Tennessee at Memphis. His orthopaedic surgery residency was completed at Emory University, where Dr. Kimmerly assisted with team coverage for the Georgia Tech and Emory collegiate teams. His research experience includes analysis of arthroscopic repair of rotator cuff tears, diagnosis and management of medial tibial stress syndrome, and arthroscopic shoulder stabilization procedures.

## Reaching Out to the World

The Foundation's research findings are shared with physicians and scientists around the world. We offer training throughout the year to physicians-in-residence, visiting medical personnel, and participants at the international medical conferences that we host.

To reach professionals who are unable to come to us, Foundation scientists and physicians report their research worldwide through peer-reviewed publications and presentations. We have produced more than 400 papers, 1,000 presentations and 60 teaching videos—many award-winning—that have been accepted by medical and scientific journals and organizations worldwide.

We disseminate our findings to the general public and school students as well, through videotapes, educational programs, the Internet, and media outlets.

# Steadman-Hawkins Hosts Third Vail Cartilage Symposium

On August 4-6, 2005, the professionals and staff of the Steadman◆Hawkins Research Foundation hosted the Third Vail Cartilage Symposium at the Lodge at Vail. The two-day meeting, funded by educational grants from Pfizer, Inc.; Genzyme Biosurgery; Innovation Sports, Inc.; and GlaxoSmithKline, featured a world-renowned, international faculty of orthopaedic surgeons, each of whom has pioneered innovative procedures for treating articular cartilage injuries.

Co-chairs of the event were Dr. J. Richard Steadman, founder of the Steadman◆Hawkins Research Foundation and principal of the Vail-based Steadman-Hawkins Clinic, and Dr. Martin Boublik, principal of the Steadman-Hawkins Denver Clinic. The two-day meeting for practicing orthopaedic surgeons included teaching sessions, presenter discussions, and a bioskills procedural laboratory.

The symposium was funded primarily by an educational grant from Pfizer, Inc., a $52.5 billion, global, research-based company, with a long-standing commitment to health education. Additional grants were provided by Genzyme Biosurgery; Innovation Sports, Inc.; and GlaxoSmithKline. The symposium faculty included:

- Dr. J. Richard Steadman, who presented a lecture and demonstration on microfracture, a surgical procedure he has developed that recruits stem cells from bone marrow to form new cartilage over areas in the joint where bare bone is exposed.
- Dr. Lars Peterson from Sweden, who demonstrated autologous chondrocyte transplantation, a two-stage procedure where cartilage cells are collected from a patient's knee, grown outside of the body in a laboratory, and re-implanted into the knee joint surface defect.
- Dr. László Hangody from Hungary, who presented his experience with mosaicplasty. In this procedure, pieces of cartilage and bone are removed from a non-weight-bearing area of the knee and transplanted to a weight-bearing surface to fill in where the cartilage has worn away.
- Dr. Allan Gross from Toronto, Ontario, who presented his experience with allografting of chondral defects. In this procedure, large segments of bone and cartilage are removed from a donor cadaver knee and implanted into a usually large defect.
- Dr. Riley Williams from New York City, who lectured on and demonstrated the allograft OATS procedure (osteochondral autograft transplantation system), in which a cylinder of bone and cartilage is transferred from a cadaver to fill a patient's cartilage defect.
- Dr. Richard Hawkins from the Steadman-Hawkins Clinic of the Carolinas in Spartanburg, South Carolina, who discussed joint surface injuries in the shoulder.
- Dr. Marc Philippon from the Vail-based Steadman-Hawkins Clinic, who presented his experiences in treating sports injuries of the hip.

With growing worldwide interest and concern over the increase in degenerative arthritis, this seminar is timely and relevant to both the orthopaedic world and the lay community.

An online webcast and DVD of the Third Vail Cartilage Symposium is available to physicians worldwide to access upon request and free of charge, thereby broadening the potential audience and making this unique educational program available to many who otherwise would not be able to participate.

For further information on the Vail Cartilage Symposium, please visit www.vailcartilage.com. To request the conference program, please contact Greta Campanale, educational program coordinator for the Steadman◆Hawkins Research Foundation, at (970) 479-5782.

# Presentations and Publications

A primary goal of the Foundation is to distribute the results of its research. In 2005, principal investigators and Fellows published 39 papers in scientific and medical journals and delivered 175 presentations to a variety of professional and lay audiences worldwide.

## 2005 PRESENTATIONS

**Boublik M.**
Patellar tendon ruptures in professional football players. *National Football League Physicians Society Annual Scientific Meeting,* Indianapolis, Feb 2005.

**Briggs KK, Cameron ML, Steadman JR.**
Factors associated with severe chondral damage in patients with ACL deficiency. *2005 International Society of Arthroscopy, Knee Surgery, & Orthopedic Sports Medicine Congress*, Miami, Apr 2005.

**Briggs KK, Hawkins RJ, Horan MP, Maxwell RB.**
The prevalence of chondral damage in patients with rotator cuff pathology. *2005 International Society of Arthroscopy, Knee Surgery, & Orthopedic Sports Medicine Congress,* Miami, Apr 2005.

**Briggs KK, Kocher MS, Steadman JR, Rodkey WG.**
Validity and responsiveness of the Tegner activity scale for meniscus injuries of the knee. Poster, *2005 International Society of Arthroscopy, Knee Surgery, & Orthopedic Sports Medicine Congress,* Miami, Apr 2005.

**Briggs KK, Steadman JR.**
Predictors of decreased function and activity level in patients seeking treatment for osteoarthritis of the knee. Poster, *2005 International Society of Arthroscopy, Knee Surgery, & Orthopedic Sports Medicine Congress,* Miami, Apr 2005.

**Briggs KK, Kocher MS, Steadman JR, Rodkey WG.**
Reliability, validity, and responsiveness of the Lysholm knee score and Tegner activity scale for meniscus injuries of the knee. Poster, *Arthroscopy Association of North America 2005 Annual Meeting,* Vancouver, British Columbia, May 2005.

**Briggs KK, Ciotti A, Steadman JR.**
Expectations of treatment in patients with osteoarthritis. *133rd American Public Health Association Annual Meeting,* Philadelphia, Dec 2005.

**Briggs KK, Steadman JR.**
Predictors of decreased function and activity level in patients seeking treatment for osteoarthritis of the knee. Poster, *133rd American Public Health Association Annual Meeting,* Philadelphia, Dec 2005.

**Briggs KK, Steadman JR, Sterett WI, Rodkey WG.**
Expectations of treatment in patients 50 years or older with osteoarthritis of the knee. Poster, *World Congress on Osteoarthritis*, Boston, Dec 2005.

**Cameron ML, Briggs KK, Steadman JR.**
Factors associated with severe chondral damage in patients with ACL deficiency. Poster, *American Academy of Orthopaedic Surgeons 72nd Annual Meeting,* Washington, DC, Feb 2005.

**Chen AL, Bradford C, Briggs KK, Steadman JR.**
The prevalence of and factors associated with proximal tears of the ACL. Poster, *Arthroscopy Association of North America 2005 Annual Meeting,* Vancouver, British Columbia, May 2005.

**Clavert P, Millett PJ, Warner JJP.**
What are the limits of glenoid implantation in eccentric glenoid erosion? Abstract, *American Academy of Orthopaedic Surgeons, ASES Specialty Day*, Washington, DC, Feb 2005.

**Corenman DS.**
Recognition and treatment of cervical radiculopathy. *Colorado Rockies Spring Training Conference,* Denver, Jan 2005.

Rheumatological & inflammatory spinal disorders. *2004-05 Steadman-Hawkins Orthopaedics & Spine Lecture Series,* Vail, Feb 2005.

Spinal cord injuries. *Vail Ski Patrol*, Vail, Dec 2005.

**Frisbie DD, Rodkey WG, Steadman JR, McIlwraith.**
Effects of calcified cartilage on healing of chondral defects treated with microfracture in horses. *American Academy of Orthopaedic Surgeons,* Washington, DC, Feb 2005.

Effects of calcified cartilage on healing of chondral defects treated with microfracture in horses. Poster, *American Orthopaedic Society for Sports Medicine,* Washington, DC, Feb 2005.

Effects of calcified cartilage on healing of chondral defects treated with microfracture in horses. *7th Congress of the European Federation of National Associations of Orthopaedics and Traumatology (EFORT 2005),* Lisbon, Portugal, Jun 2005.

**Frisbie DD, Rodkey WG, Steadman JR, Morisset S, McIlwraith CW.**
Effects of calcified cartilage on healing of chondral defects treated with microfracture in horses. *10th World Congress on Osteoarthritis, Osteoarthritis Research Society International,* Boston, Dec 2005.

**Giphart JE, Torry MR, Yanagawa T, Shelburne KB, Hawkins RJ.**
Differences in onset activation times between rotator cuff, deltoid and pectoralis major muscles during goal directed movement. Abstract, *American Society of Mechanical Engineers, Summer Bioengineering Conference,* Vail, Jun 2005.

**Gobezie R, Ponce BA, Ahluwahlia R, Mazzocca A, Warner JJP, Millett PJ.**
The lesser tuberosity osteotomy in total shoulder arthroplasty: A biomechanical and clinical analysis. Abstract, *Orthopaedic Research and Educational Foundation Resident Research Symposium,* Washington, DC, May 2005.

Complications associated with the use of pain-catheter infusion pumps (PCIPs) in arthroscopic surgery. Abstract, *19th Congress, European Society for Surgery of the Shoulder and the Elbow,* Rome, Italy, Sept 2005.

**Goodwin, CJ; Yanagawa, T; Shelburne, KB; Hawkins, RJ; Torry, MR; Frankle, M; Pandy, MG:**
Estimation Of Shoulder Muscle Forces During Abduction and Flexion Using a Musculoskeletal Model, Abstract, *American Society of Mechanical Engineers, Summer Bioengineering Conference,* Vail, June 2005.

**Hawkins RJ, Horan MP, Briggs KK.**
Determinants of patients' satisfaction after SLAP surgery. Poster, *2005 International Society of Arthroscopy, Knee Surgery, & Orthopedic Sports Medicine Congress,* Miami, Apr 2005.

**Kelly BT, Martin RL, Philippon MJ.**
Factors associated with labral pathology in the hip. Presentation, *International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine,* Miami, Apr 2005.

**Kelly BT, Philippon MJ.**
The role of capsulolabral complex hip injuries in return to play for professional football athletes. Poster, *International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine,* Miami, Apr 2005.

**Kocher MS, Horan MP, Briggs KK, Richardson TR, O'Holleran JD, Hawkins RJ.**
Reliability, validity, and responsiveness of the ASES shoulder scale in patients with shoulder instability, rotator cuff disease, and glenohumeral arthritis. *American Academy of Orthopaedic Surgeons 72nd Annual Meeting,* Washington, DC, Feb 2005.

**Krastins B, Kho A, Sarracino D, Chase M, Millett PJ, Gobezie R.**
Identification of a protein biomarker profile for osteoarthritis in knees using proteomic analysis. Abstract, *Cambridge Healthtech Institute Biomarker Discovery Summit,* Philadelphia, Sept 2005.

**Krastins B, Kho A, Sarracino D, Chase M, Millett PJ, Gobezie R.**
Identification of a protein biomarker profile for osteoarthritis in knees using proteomic analysis. Poster, *The Proteome Society Annual Meeting,* Washington, DC, Oct 2005.

**Martin RL, Irrgang JJ, Philippon MJ.**
Evidence of validity for the hip outcome score (HOS). Poster, *American Physical Therapy Association Combined Sections Meeting,* New Orleans, Feb 2005.

Evidence of validity for the hip outcome score. Poster, *Arthroscopy Association of North America Annual Meeting,* Vancouver, British Columbia, May 2005.

**Millett PJ.**
Management of complex deformities of shoulder prosthetics adaptable in three dimensions. *Zimmer 19th Annual Vail Orthopaedic Symposium,* Vail, Jan 2005.

Surgical demonstrations. *Zimmer 19th Annual Vail Orthopedic Symposium,* Vail, Jan 2005.

Complex and revision shoulder instability surgery. *New England Shoulder and Elbow Society Annual Meeting,* Jay Peak, Vermont, Feb 2005.

Total shoulder arthroplasty: Complications. *Harvard Combined Orthopaedic Surgery Residency Program,* Boston, 2005.

The thrower's shoulder. *Sports Medicine Grand Rounds Massachusetts General Hospital,* Boston, 2005.

Advanced techniques in arthroscopic rotator cuff repair. *5th Advanced Course on Shoulder Arthroscopy,* Val D'Isere, France, Jan 2005.

Advanced techniques in the arthroscopic treatment of shoulder instability. *5th Advanced Course on Shoulder Arthroscopy,* Val D'Isere, France, Jan 2005.

Management of complex deformities of the shoulder with a prosthesis adaptable in three dimensions. *Orthopaedic Update 2005: Shoulder, Elbow, Hip and Knee,* Vail, 2005.

Reinforced suture passing techniques in rotator cuff repair. *International Shoulder and Knee Surgeons' Meeting,* Naples, Fla, 2005.

Advanced techniques in shoulder surgery: Shoulder update for the practicing orthopaedist. *International Shoulder and Knee Surgeons' Meeting,* Naples, Fla, 2005.

Evaluation and treatment of common shoulder disorders. *Orthopaedics and Spine Lecture Series, Steadman◆Hawkins Research Foundation,* Vail, Nov 2005.

Technique for reliable glenoid exposure: How to see it every time. *Zimmer Orthopaedic Learning Center, Shoulder and Elbow Workshop,* Chicago, Dec 2005.

**Millett PJ, Ponce BA, Ahluwalia RS, Mazzocca AD, Santangelo SA, Warner JJP.**
Mechanical and clinical analysis of a novel subscapularis repair technique for shoulder arthroplasty. Abstract, *American Academy of Orthopaedic Surgeons,* Washington, DC, Feb 2005.

Subscapularis dysfunction after total shoulder arthroplasty: Biomechanical and clinical analysis of a novel lesser tuberosity osteotomy repair technique. Scientific Exhibit, *American Academy of Orthopaedic Surgeons,* Washington, DC, Feb 2005.

Subscapularis dysfunction after total shoulder arthroplasty: Biomechanical and clinical analysis of a novel lesser tuberosity osteotomy repair technique. Abstract, *19th Congress, European Society for Surgery of the Shoulder and the Elbow,* Rome, Italy, Sept 2005.

**Millett PJ, Neumann G, Yoshioka CS, Winalski CS Carrino J, Lang P.**
Articular cartilage in the shoulder: Correlation of MR arthrography and surgical arthroscopy. Poster, *American Academy of Orthopaedic Surgeons,* Washington, DC, Feb 2005.

MR Arthrography of the shoulder: Cartilage loss associated with labral tears and bone marrow edema. Poster, *American Academy of Orthopaedic Surgeons,* Washington, DC, Feb 2005.

**Noonan TJ.**
The biomechanics of throwing. Injury Prevention and Treatment Techniques, *Baseball Medicine Conference,* Denver, Jan 2005.

Degenerative biceps lesions in throwing athletes. Injury Prevention and Treatment Techniques, *Baseball Medicine Conference,* Denver, Jan 2005.

Toradol use in professional athletes. *Major League Baseball Team Physicians Association Annual Meeting,* Dallas, Dec 2005.

Pulmonary embolism in a professional baseball pitcher. *Major League Baseball Team Physicians Association Annual Meeting,* Dallas, Dec 2005.

**Pacheco I, Gobezie R, Tsaniklides N, Krastins B, Millett PJ.**
AC joint reconstruction with CA ligament transfer using the docking technique. Abstract, *19th Congress, European Society for Surgery of the Shoulder and the Elbow,* Rome, Italy, Sept 2005.

**Philippon MJ.**

The role of labral repair and capsular plication in hip injury and instability. Instructional Course Lecture on Hip Arthroscopy, *American Academy of Orthopaedic Surgeons Annual Meeting,* Washington, DC, Feb 2005.

Iliofemoral ligament and hip instability. *International Hip Arthroscopy Course,* São Paulo, Brazil, Mar 2005.

The ligamentum teres and the iliofemoral ligament. *International Hip Arthroscopy Course,* São Paulo, Brazil, Mar 2005.

Labral and ligamentum teres repair. *International Hip Arthroscopy Course,* São Paulo, Brazil, Mar 2005.

Arthroscopic partial surface replacement. *International Hip Arthroscopy Course,* São Paulo, Brazil, Mar 2005.

Results and complications of hip arthroscopy in the professional athlete. *International Hip Arthroscopy Course,* São Paulo, Brazil, Mar 2005.

The role of hip arthroscopy in the treatment of femoroacetabular impingement. Instructional Course Lecture on Hip Arthroscopy, *International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine,* Miami, Apr 2005.

Hip arthroscopy, live surgical demonstration. *International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine,* Miami, Apr 2005.

My approach to labral tears. *International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine,* Miami, Apr 2005.

Biomechanics of injury. Masters Course, *Arthroscopy Association of North America,* Chicago, Apr 2005.

My approach to labral tears. Masters Course, *Arthroscopy Association of North America,* Chicago, Apr 2005.

The modified supine approach. Masters Course, *Arthroscopy Association of North America,* Chicago, Apr 2005.

Management of capsular lesions and the ligamentum teres. Masters Course, *Arthroscopy Association of North America,* Chicago, Apr 2005.

Emerging trends in hip arthroscopy. *Orthopaedics & Spine Lecture Series*, *Steadman◆Hawkins Research Foundation* Vail, Jun 2005.

Prevention and treatment of hip injuries in golfers. *Howard Head Community Lecture Series,* Vail, Jun 2005.

Hip arthroscopy. Live Surgical Demonstration, *Canadian Orthopaedic Association,* London, Ontario, Jun 2005.

Labral injuries in the athlete. *4th Symposium on Joint Preservation and Minimally Invasive Surgery of the Hip,* Los Angeles, Jun 2005.

Femoroacetabular impingement. *2nd Annual Sports Medicine Conference,* Akron, Jun 2005.

The modified supine position. *2nd Annual Sports Medicine Conference,* Akron, Jun 2005.

Microfracture of the hip. *Vail Cartilage Symposium, Steadman◆Hawkins Research Foundation,* Vail, Aug 2005.

Biomechanics of injury. Masters Course, *Arthroscopy Association of North America*, Chicago, Aug 2005.

My approach to labral tears. Masters Course, *Arthroscopy Association of North America,* Chicago, Aug 2005.

The modified supine approach. Masters Course, *Arthroscopy Association of North America,* Chicago, Aug 2005.

Management of capsular lesions and the ligamentum teres. Masters Course, *Arthroscopy Association of North America*, Chicago, Aug 2005.

Hip arthroscopy. *State of Art in Nordic Arthroscopy,* Oslo, Norway, Sept 2005.

A novel approach to subchondral acetabular cyst. *State of Art in Nordic Arthroscopy,* Oslo, Norway, Sept 2005.

Evaluation of the professional and high level athlete with hip pain. *Smith & Nephew Hip Arthroscopy Course,* San Francisco, Sept 2005.

The function of the labrum and illiofemoral ligament. *Smith & Nephew Hip Arthroscopy Course,* San Francisco, Sept 2005.

Arthroscopic surgery for AVN. *Smith & Nephew Hip Arthroscopy Course,* San Francisco, Sept 2005.

Arthroscopic surgery for labral repair. *Smith & Nephew Hip Arthroscopy Course,* San Francisco, Sept 2005.

Rationale and repair of the ligamentum teres. *Smith & Nephew Hip Arthroscopy Course,* San Francisco, Sept 2005.

Outcomes from arthroscopic surgery in the professional athlete. *Smith & Nephew Hip Arthroscopy Course,* San Francisco, Sept 2005.

Second look arthroscopy following microfracture of the acetabulum. *Smith & Nephew Hip Arthroscopy Course,* San Francisco, Sept 2005.

Emerging trends in hip arthroscopy. *Western Colorado Orthopaedic Association,* Glenwood Springs, Oct 2005.

Physical exam of the hip and associated arthroscopic treatment. *Vail Valley Medical Center Grand Rounds,* Vail, Oct 2005.

Hip arthroscopy: What can you see? What can you do? *Ontario Orthopaedic Association,* Toronto, Ontario, Nov 2005.

Chondral defects of the hip: Diagnosis and treatment. *Ontario Orthopaedic Association,* Toronto, Ontario, Nov 2005.

Diagnosis and treatment of labral tears and femoroacetabular impingement. *Mini Symposium, A Day of Live Hip Surgery,* Copenhagen, Nov 2005.

Labral repair and postoperative rehabilitation. *Mini Symposium, A Day of Live Hip Surgery,* Copenhagen, Nov 2005.

Arthroscopy for anterior hip pain in dancers. *15th Annual International Association for Dance Medicine and Science Conference: Doctors Day for Orthopaedic Surgeons,* Stockholm, Nov 2005.

Loose bodies and lesions of the ligamenturm teres, *24th Arthroscopy Association of North America Fall Course,* Phoenix, Dec 2005.

Labral resection versus repair. Point/counter point: Labral repair. *24th Arthroscopy Association of North America Fall Course,* Phoenix, Dec 2005.

**Philippon MJ, Martin RL, Kelly BT.**
A classification system for labral tears of the hip. Poster, *American Physical Therapy Association Combined Sections Meeting,* New Orleans, Feb 2005.

A classification of labral tears of the hip. *Arthroscopy Association of North America Annual Meeting,* Poster, Vancouver, British Columbia, May 2005.

**Ponce BA, Ahluwalia RS, Mazzocca AD, Santangelo SA, Warner JJP, Millett PJ.**
Mechanical and clinical analysis of a novel subscapularis repair technique for shoulder arthroplasty. Abstract, *American Academy of Orthopaedic Surgeons,* Washington, DC, Feb 2005.

**Ponce BA, Millett PJ, Ahluwalia RS, Mazzocca AD Santangelo SA, Warner JJP.**
Mechanical and clinical analysis of a novel subscapularis repair technique for shoulder arthroplasty. Abstract, *American Academy of Orthopaedic Surgeons,* Washington, DC, Feb 2005. [Selected for Best Scientific Award of AAOS Annual Meeting, 2005]

**Ramappa AJ, Steadman JR, Bollom TS, Fein M, Maxwell RB, Briggs KK.**
Kellgren-Lawrence (K-L) scores and arthroscopic findings in the degenerative knee. Poster, *2005 International Society of Arthroscopy, Knee Surgery, & Orthopedic Sports Medicine Congress,* Miami, Apr 2005.

Kellgren-Lawrence (K-L) scores and arthroscopic findings in the degenerative knee. *7th European Federation of National Associations of Orthopaedics and Traumatology Congress,* Lisbon, Portugal, Jun 2005.

Kellgren-Lawrence (K-L)scores and arthroscopic findings in the degenerative knee. Poster, *10th World Congress on Osteoarthritis, Osteoarthritis Research Society International,* Boston, Dec 2005.

**Rodkey WG.**
The surgical treatment of articular cartilage defects of the knee: Microfracture technique. Instructional Course Lecture, *American Academy of Orthopaedic Surgeons,* Washington, DC, Feb 2005.

Articular cartilage thickness of species used in preclinical studies compared to human knees. *7th Congress of the European Federation of National Associations of Orthopaedics and Traumatology (EFORT 2005),* Lisbon, Portugal, Jun 2005.

Evaluation of extracorporeal shock wave therapy for osteoarthritis. *7th Congress of the European Federation of National Associations of Orthopaedics and Traumatology (EFORT 2005),* Lisbon, Portugal, Jun 2005.

An animal model to study calcified cartilage and its effects on healing of chondral defects treated with microfracture. Instructional Course Lecture, *American Orthopaedic Society for Sports Medicine Annual Meeting,* Keystone, Jul 2005.

Articular cartilage: In sickness and in health. *Vail Cartilage Symposium, Steadman◆Hawkins Research Foundation,* Vail, Aug 2005.

Microfracture: Basic science, patient selection, technique, and results in competitive athletes. *Sportsmedizin Gardasee 2005,* Riva di Garda, Italy, Sept 2005.

Patellar tendinosis and tendinitis in athletes. *Sportsmedizin Gardasee 2005,* Riva di Garda, Italy, Sept 2005.

Collagen meniscus implants: Tissue engineering approach to meniscus regeneration. *Sportsmedizin Gardasee 2005,* Riva di Garda, Italy, Sept 2005.

Microfracture: Our first option for treatment of chondral defects. *Orthopaedic Summit on Minimally Invasive Surgery,* University of Colorado School of Medicine, Keystone, Sept 2005.

Collagen meniscus implants: Tissue engineering approach to meniscus regeneration. *Orthopaedic Summit on Minimally Invasive Surgery,* University of Colorado School of Medicine, Keystone, Sept 2005.

ACL reconstruction: The 2-incision technique. *Orthopaedic Summit on Minimally Invasive Surgery, University of Colorado School of Medicine,* Keystone, Sept 2005.

Collagen meniscus implants: Tissue engineering approach to meniscus regeneration. *International Cartilage Repair Society Surgical Skills Course,* Vienna, Austria, Sept 2005.

Microfracture. *International Cartilage Repair Society Surgical Skills Course,* Vienna, Austria, Sept 2005.

CMI: Latest US clinical results. *International Collagen Meniscus Implant Meeting,* Varese, Italy, Nov 2005.

**Rodkey WG, Briggs KK, Kocher MS, Steadman JR.**
Reliability, validity, and responsiveness of the Lysholm knee score and Tegner activity scale for meniscus injuries of the knee. *7th European Federation of National Associations of Orthopaedics and Traumatology Congress,* Lisbon, Portugal, Jun 2005.

**Rudman DP, Schlegel TF, Boublik M, Hawkins RJ, Keller J, Antonopulos S.**
On-field evaluation and treatment of cervical spine injuries. Video, *American Orthopaedic Society for Sports Medicine Annual Meeting,* Washington, DC, Feb 2005.

**Schlegel TF, Boublik M, Antonopulos S.**
Adductor ruptures. *National Football League Physicians Society Annual Scientific Meeting,* Indianapolis, Feb 2005.

**Schlegel TF, Martin LP, Keller J, Boublik M, Hawkins RJ.**
The use of corticosteroid injections for acute acromioclavicular joint separations: A ten year experience. *American Orthopaedic Society for Sports Medicine Annual Meeting,* Keystone, Jul 2005.

**Schlegel TF, Boublik M, Hawkins RJ.**
Grade III acromioclavicular separations in NFL quarterbacks. *American Orthopaedic Society for Sports Medicine Annual Meeting,* Keystone, Jul 2005.

**Shelburne KB.**
Seminar in bioengineering and life sciences. *Colorado School of Mines,* Golden, Oct 2005.

Seminar in biomedical engineering. *Colorado State University,* Fort Collins, Nov 2005.

Seminar in mechanical engineering. *Boise State University,* Boise, Nov 2005.

**Simovitch R, Gobezie R, Millett PJ, Warner JJP.**
The anatomic total shoulder prosthesis: Outcomes in the 60 years and younger population. Abstract, *International Society for Shoulder Arthroplasty,* Paris, France, Apr 2005.

**Steadman JR.**
Treatment of chondral defects of the knee. *2005 Baseball Team Medical Conference,* Denver, Jan 2005.

Microfracture. Instructional Course Instructor, *American Orthopaedic Society for Sports Medicine Annual Meeting,* Keystone, Jul 2005.

Microfracture. *Vail Cartilage Symposium, Steadman◆Hawkins Research Foundation,* Vail, Aug 2005.

Arthroscopic treatment in degenerative joint disease. *Vail Cartilage Symposium, Steadman◆Hawkins Research Foundation,* Vail, Aug 2005.

Microfracture surgical demonstration. *Vail Cartilage Symposium, Steadman◆Hawkins Research Foundation,* Vail, Aug 2005.

Microfracture update. *14th Annual Current Issues of MRI in Orthopedics & Sports Medicine,* San Francisco, Aug 2005.

Concepts of managing ACL injury. *Sports Knee Surgery 2005,* Warwick, UK, Oct 2005.

Meniscal reconstruction. *Sports Knee Surgery 2005,* Warwick, UK, Oct 2005.

The athroscopic DJD package and microfracture. *Sports Knee Surgery 2005,* Warwick, UK, Oct 2005.

Knee degenerative joint disease. *Collagen Meniscus Implant Meeting,* Varese, Italy, Nov 2005.

When not to do microfracture. *Collagen Meniscus Implant Meeting,* Varese, Italy, Nov 2005.

Criteria for returning to sports after ACL reconstruction. *9th International Conference on Orthopaedics, Biomechanics & Sports Rehabilitation,* Assisi, Italy, Nov 2005.

Microfracture: When not to do it. 9th *International Conference on Orthopaedics, Biomechanics & Sports Rehabilitation,* Assisi, Italy, Nov 2005.

Arthroscopic surgery and osteoarthritis. *9th International Conference on Orthopaedics, Biomechanics & Sports Rehabilitation,* Assisi, Italy, Nov 2005.

Current perioperative ACL pain management. *Orthopedics Today: NY 2005,* New York, Nov 2005.

Postoperative ACL rehabilitation. *Orthopedics Today: NY 2005,* New York, Nov 2005.

Bracing the ACL deficient knee and reconstructed knee. *Orthopedics Today: NY 2005,* New York, Nov 2005.

ACL reconstruction, panel discussion. *Orthopedics Today: NY 2005,* New York, Nov 2005.

**Steadman JR, Ramappa AJ, Bollom TS, Briggs KK, Rodkey WG.**
Outcomes of an arthroscopic treatment regimen for severe osteoarthritis of the knee. Poster, *2005 International Society of Arthroscopy, Knee Surgery, & Orthopedic Sports Medicine Congress,* Miami, Apr 2005.

**Steadman JR, Ramappa AJ, Bollom TS, Briggs KK, Rodkey WG.**
Outcomes of an arthroscopic treatment regimen for severe osteoarthritis of the knee. Poster, *Arthroscopy Association of North America 2005 Annual Meeting,* Vancouver, British Columbia, May 2005.

**Steadman JR, Ramappa AJ, Briggs KK, Rodkey WG.**
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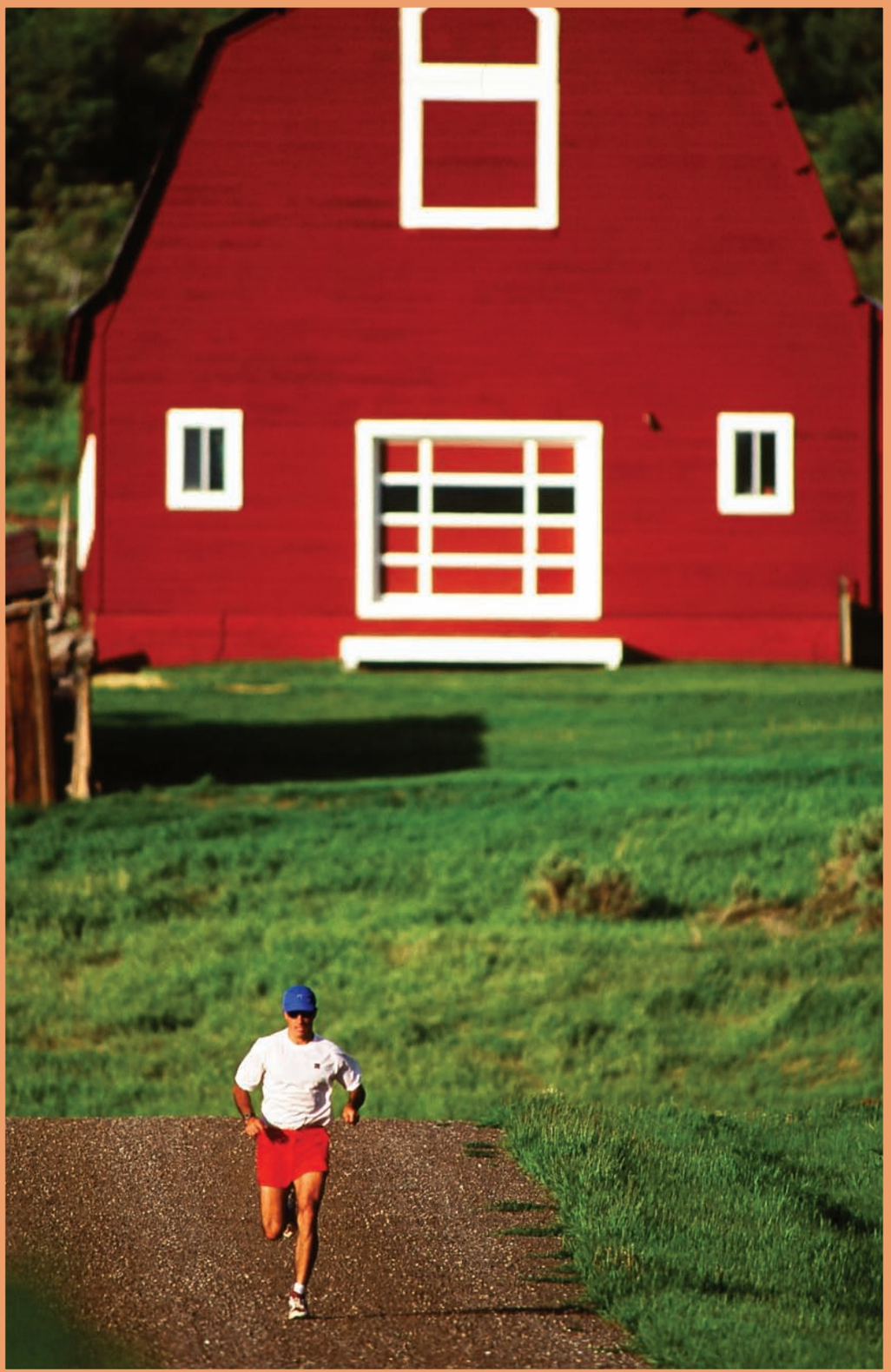

# In The Media

## OLDER KNEES NOW HAVE A NEW OPTION

By Vicky Lowry, *New York Times*
This article appeared in the April 5, 2005, edition of the *New York Times* and is reprinted with permission.

For active people in their 30's and 40's who are starting to experience knee pain from years of running, skiing, or basketball, the sports pages may point to a solution. Microfracture surgery is commonly performed on the knees of professional athletes to regenerate cartilage eroded from overuse or sheared off from injury.

The treatment has prolonged the careers of many professionals, including Jason Kidd of the New Jersey Nets, who had the operation in July. But it is also gaining in popularity among people who do not earn a living in sports.

The surgery was pioneered by Dr. Richard Steadman of the Steadman-Hawkins Clinic in Vail, Colorado, who estimates he has performed it 2,700 times since he developed it in the early 1990's.

The surgery is performed using an arthroscope and takes 20 to 35 minutes, said Dr. Kevin Plancher, an orthopaedic surgeon in Greenwich, Conn., who often performs the operation. First, the area of cartilage erosion — imagine a divot on an ice rink — is scraped with a curet to remove any calcified cartilage remnants that could interfere with the formation of new cartilage. ''The cleaner the surface, the more potential there is for regrowth,'' Dr. Steadman said.

Next, tiny holes, called microfractures, are punched into the bone with an awl resembling a small curved ice pick. These tiny perforations allow stem cells to escape from the marrow cavity, starting the formation and growth of repair tissue that is similar to the original cartilage.

A video of a microfracture surgery that also featured two follow-up observations illustrated the effects of the procedure. A month after the surgery, blood gathered in the area of the picks, and new cartilage had started to mature. Six months later, islands of new cartilage filled in the gaps.

Dr. William Rodkey, director of basic science research at the Steadman◆Hawkins Research Foundation, said that patients were required to be on crutches up to eight weeks and to spend at least six hours a day with a machine that moves the knee in a continuous passive motion. The tissue remains delicate during maturation, which takes at least a year.

"For reasons we don't know, passive motion, which rocks your knee like a cradle, promotes healthy growth cells and promotes a more durable tissue," said Dr. Nicholas DiNubile, an orthopaedic consultant for the Philadelphia 76ers and the Pennsylvania Ballet.

The longer recovery period compared with other arthroscopic knee procedures, which typically allow patients to walk out of the hospital without crutches, can pay off. A long-term evaluation of 72 cases, led by Dr. Steadman and published last year in the journal *Arthroscopy*, found that 80 percent of patients 45 and younger who had the microfracture procedure showed major improvement in function and experienced less pain. The benefits extended, on average, at least 11 years after surgery.

In 2003, a study of 25 pro football players treated with microfracture documented that 19 of them (76 percent) returned to play the season after surgery and continued to play for an average of 4.6 additional seasons.

Older knees, however, may not fare as well. "Patients over 65 may have more problems with the crutch-walking and the rehab," Dr. Rodkey said. "And, in general, one would expect younger patients to have more stem cells in their marrow, and, therefore, do better.'' Arthritic knees with major cartilage degeneration are not ideal candidates, either. "The threshold size of the defect seems to be around 2.5 centimeters," said Dr. David Altchek of the Hospital for Special Surgery in Manhattan, who operated on Jason Kidd's left knee.

"Defects larger than this have marginal response," Dr. Altchek said, because if the surrounding cartilage is too worn down, it cannot contain the blood clot.

Many surgeons will not perform the procedure on people with markedly bowed legs or knock-knees, conditions that can put too much pressure on the area that has cartilage defect, so that new cartilage will probably just wear down again.

Being overweight is also an obstacle. "The fact is that obesity not only causes arthritis, but it makes it more likely to progress," Dr. DiNubile said. "We have the technology to repair potholes on the joint surface, but we can't repave the road."

# Associates

The Steadman◆Hawkins Research Foundation is proud to recognize its team of associates, who carry out the Foundation's research and educational mission in Vail. The staff has been selected for its diverse training and background in biomechanics, engineering, clinical research, veterinary science, and computer science. Together, the staff members take a multidisciplinary approach to their work in solving orthopaedic sports medicine problems.

## ADMINISTRATION

**Norm Waite, Jr.**
*Chief Executive Officer and President*

**John Welaj, MBA**
*Chief Operating Officer*

**Amy Ruther**
*Human Resources Manager*

**Karyll Nelson**
*BioSkills Laboratory Director and Executive Assistant*

## DEVELOPMENT

**John G. McMurtry, M.A., M.B.A.**
*Vice President for Program Advancement*

**Rachele Palmer**
*Development Coordinator*

## BASIC SCIENCE

**William G. Rodkey, D.V.M.**
*Director*

## CLINICAL RESEARCH

**Karen K. Briggs, M.B.A., M.P.H.**
*Director*

**Marilee Horan**
*Research Associate*

**Lauren Matheny**
*Research Associate*

**Mara Schenker**
*Research Intern*

**David Kuppersmith**
*Research Intern*

**Anna Fay**
*Research Intern*

## BIOMECHANICS RESEARCH LABORATORY

**Michael Torry, Ph.D.**
*Director*

**Kevin B. Shelburne, Ph.D.**
*Senior Staff Scientist*

**J. Erik Giphart, Ph.D.**
*Staff Scientist/Motion Laboratory Director*

**Takashi Yanagawa, M.A.**
*Staff Scientist/Senior Programmer*

## EDUCATION

**Greta Campanale**
*Coordinator*

**Dina Proietti**
*Educational/Development Assistant*

## INFORMATION SYSTEMS

**Jean Claude Moritz**
*Manager*

## VISUAL SERVICES

**Joe Kania**
*Coordinator*

## Independent Accountants' Report

Board of Directors
Steadman◆Hawkins Research Foundation
Vail, Colorado

We have audited the accompanying statements of financial position of Steadman◆Hawkins Research Foundation as of December 31, 2005 and 2004, and the related statements of activities, cash flows and functional expenses for the years then ended. These financial statements are the responsibility of the Foundation's management. Our responsibility is to express an opinion on these financial statements based on our audits.

We conducted our audits in accordance with auditing standards generally accepted in the United States of America. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management as well as evaluating the overall financial statement presentation. We believe that our audits provide a reasonable basis for our opinion.

In our opinion, the financial statements referred to above present fairly, in all material respects, the financial position of Steadman◆Hawkins Research Foundation as of December 31, 2005 and 2004, and the changes in its net assets and its cash flows for the years then ended in conformity with accounting principles generally accepted in the United States of America.

BKD, LLP

March 29, 2006
Colorado Springs, Co

## STATEMENTS OF FINANCIAL POSITION

*DECEMBER 31, 2005 AND 2004*

### ASSETS

| | 2005 | 2004 |
|---|---|---|
| Cash | **$ 915,096** | $ 892,598 |
| Accounts receivable | **149,965** | 88,752 |
| Accounts receivable, related party | **1,633** | 12,721 |
| Investments | **3,119,858** | 2,517,302 |
| Contributions receivable | **291,054** | – |
| Contributions receivable, related party | **5,750** | 1,900 |
| Prepaid expenses and other assets | **56,740** | 26,667 |
| Property and equipment, net | **214,577** | 242,219 |
| Total assets | **$ 4,754,673** | $ 3,782,159 |

### LIABILITIES AND NET ASSETS

| | | |
|---|---|---|
| **Liabilities** | | |
| Accounts payable | **$ 108,358** | $ 47,519 |
| Accrued expenses | **88,936** | 91,046 |
| Deferred revenue | **134,500** | – |
| Total liabilities | **331,794** | 138,565 |
| **Net Assets** | | |
| Unrestricted | **3,835,466** | 3,446,661 |
| Temporarily restricted | **587,413** | 196,933 |
| Total net assets | **4,422,879** | 3,643,594 |
| Total liabilities and net assets | **$ 4,754,673** | $ 3,782,159 |

See Notes to Financial Statements

## STATEMENTS OF ACTIVITIES

*YEAR ENDED DECEMBER 31, 2005*

| | Unrestricted | Temporarily Restricted | Total |
|---|---|---|---|
| **REVENUES, GAINS AND OTHER SUPPORT** | | | |
| Corporate partner support | $ 520,000 | $ – | $ 520,000 |
| Contributions | 832,853 | 386,881 | 1,219,734 |
| Grants | 5,000 | 768,554 | 773,554 |
| Fundraising events, net of $136,052 of expenses | 335,768 | – | 335,768 |
| Fellows and other meetings | 10,050 | – | 10,050 |
| Video income | 11,915 | – | 11,915 |
| Other income | 28,815 | – | 28,815 |
| Net assets released from restrictions | 764,955 | (764,955) | 0 |
| Total revenues, gains and other support | 2,509,356 | 390,480 | 2,899,836 |
| **EXPENSES** | | | |
| Biomechanics research program | 443,245 | – | 443,245 |
| Basic science program | 165,622 | – | 165,622 |
| Clinical research program | 319,967 | – | 319,967 |
| Education program | 438,099 | – | 438,099 |
| Office of Information Services | 171,755 | – | 171,755 |
| Management and general | 415,810 | – | 415,810 |
| Fundraising | 431,440 | – | 431,440 |
| Total expenses | 2,385,938 | – | 2,385,938 |
| **OTHER INCOME** | | | |
| Investment income | 265,387 | – | 265,387 |
| **CHANGE IN NET ASSETS** | 388,805 | 390,480 | 779,285 |
| **NET ASSETS, BEGINNING OF YEAR** | 3,446,661 | 196,933 | 3,643,594 |
| **NET ASSETS, END OF YEAR** | $ 3,835,466 | $ 587,413 | $ 4,422,879 |

See Notes to Financial Statements

## STATEMENTS OF ACTIVITIES

*YEAR ENDED DECEMBER 31, 2004*

| | Unrestricted | Temporarily Restricted | Total |
|---|---|---|---|
| **REVENUES, GAINS AND OTHER SUPPORT** | | | |
| Corporate partner support | $696,750 | $3,000 | $699,750 |
| Contributions | 887,413 | 216,438 | 1,103,851 |
| Grants | 12,754 | 46,052 | 58,806 |
| Fundraising events, net of $257,969 of expenses | 312,121 | – | 312,121 |
| Fellows and other meetings | 11,025 | – | 11,025 |
| Video income | 39,565 | – | 39,565 |
| Other income | 13,231 | – | 13,231 |
| Net assets released from restrictions | 436,485 | (436,485) | 0 |
| Total revenues, gains and other support | 2,409,344 | (170,995) | 2,238,349 |
| **EXPENSES** | | | |
| Biomechanics research program | 389,090 | – | 389,090 |
| Basic science program | 222,085 | – | 222,085 |
| Clinical research program | 314,403 | – | 314,403 |
| Education program | 204,176 | – | 204,176 |
| Office of Information Services | 174,797 | – | 174,797 |
| Management and general | 414,875 | – | 414,875 |
| Fundraising | 442,434 | – | 442,434 |
| Total expenses | 2,161,860 | – | 2,161,860 |
| **OTHER INCOME** | | | |
| Investment income | 297,816 | – | 297,816 |
| **CHANGE IN NET ASSETS** | 545,300 | (170,995) | 374,305 |
| **NET ASSETS, BEGINNING OF YEAR** | 2,901,361 | 367,928 | 3,269,289 |
| **NET ASSETS, END OF YEAR** | $3,446,661 | $196,933 | $3,643,594 |

See Notes to Financial Statements

## STATEMENTS OF CASH FLOWS

*YEARS ENDED DECEMBER 31, 2005 AND 2004*

| | 2005 | 2004 |
|---|---|---|
| **OPERATING ACTIVITIES** | | |
| Change in net assets | **$ 779,285** | $ 374,305 |
| Items not requiring (providing) cash | | |
| Depreciation | **93,470** | 83,314 |
| Realized and unrealized gains on investments | **(203,739)** | (262,249) |
| In-kind contributions of investments | **(43,717)** | (116,309) |
| Changes in | | |
| Accounts receivable | **(50,125)** | 257,028 |
| Contributions receivable | **(294,904)** | 145,433 |
| Prepaid expenses and other assets | **(30,073)** | 13,156 |
| Accounts payable | **60,839** | 27,252 |
| Accrued expenses | **(2,110)** | 23,175 |
| Deferred revenue | **134,500** | (18,900) |
| Net cash provided by operating activities | **443,426** | 526,205 |
| **INVESTING ACTIVITIES** | | |
| Purchase of property and equipment | **(65,828)** | (11,564) |
| Purchases of investments | **(1,055,100)** | (131,800) |
| Sales of investments | **700,000** | 254,005 |
| Net cash provided by (used in) investing activities | **(420,928)** | 110,641 |
| **INCREASE IN CASH** | **22,498** | 636,846 |
| **CASH, BEGINNING OF YEAR** | **892,598** | 255,752 |
| **CASH, END OF YEAR** | **$ 915,096** | $ 892,598 |

See Notes to Financial Statements

# STATEMENTS OF FUNCTIONAL EXPENSES

*YEAR ENDED DECEMBER 31, 2005*

| | Programs | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Biomechanics Research | Basic Science | Clinical Research | Education | Office of Information Services | Total | Management and General | Fundraising | Total |
| Salary and benefits | $301,547 | $ 22,589 | $224,553 | $110,176 | $ 81,860 | $ 740,725 | $266,348 | $187,477 | $1,194,550 |
| Payroll taxes | 18,911 | 1,610 | 15,363 | 7,446 | 5,858 | 49,188 | 18,941 | 11,378 | 79,507 |
| Travel | 7,858 | 4,977 | 4,569 | 36,670 | 4,487 | 58,561 | 12,755 | 1,846 | 73,162 |
| Utilities | 4,997 | 3,103 | 3,447 | 2,955 | 5,417 | 19,919 | 7,006 | 2,216 | 29,141 |
| Telephone | 2,831 | 202 | 2,105 | 472 | 1,875 | 7,485 | 3,441 | 1,655 | 12,581 |
| Consulting and contract labor | 13,968 | 111,369 | 14,837 | 250 | 2,430 | 142,854 | 40,301 | 70,047 | 253,202 |
| Legal and accounting | 8,460 | 752 | 6,522 | 1,505 | 2,259 | 19,498 | 4,767 | 3,970 | 28,235 |
| Postage and freight | 4,405 | 814 | 5,055 | 2,789 | 1,909 | 14,972 | 3,549 | 4,578 | 23,099 |
| Exhibits and meetings | 1,590 | – | 1,160 | 245,725 | – | 248,475 | 45 | – | 248,520 |
| Research projects | 50,000 | – | 10,457 | 5,087 | – | 65,544 | – | – | 65,544 |
| Facility rent | 8,323 | 4,226 | 5,839 | 4,115 | 7,435 | 29,938 | 9,817 | 3,872 | 43,627 |
| Promotion | 2,000 | – | 579 | 90 | 219 | 2,888 | 750 | 37,534 | 41,172 |
| Repair, maintenance and equipment | 20 | 3 | 23 | 5 | 11,945 | 11,996 | 198 | 36 | 12,230 |
| Dues, subscriptions, books and journals | 1,327 | 11 | 91 | 7,509 | 32 | 8,970 | 67 | 1,857 | 10,894 |
| General insurance | 693 | 54 | 668 | 134 | 399 | 1,948 | 13,217 | 321 | 15,486 |
| Printing | 3,463 | 416 | 5,766 | 679 | 844 | 11,168 | 5,524 | 75,800 | 92,492 |
| Supplies | 7,241 | 5,646 | 7,091 | 2,947 | 9,156 | 32,081 | 5,021 | 7,352 | 44,454 |
| Program support | 198 | 22 | 212 | 47 | 89 | 568 | 146 | 4,217 | 4,931 |
| Depreciation | 5,282 | 8,937 | 11,630 | 9,308 | 35,541 | 70,698 | 10,427 | 12,345 | 93,470 |
| Other | 131 | 891 | – | 190 | – | 1,212 | 13,490 | 4,939 | 19,641 |
| | $443,245 | $165,622 | $319,967 | $438,099 | $171,755 | $1,538,688 | $415,810 | $431,440 | $2,385,938 |

See Notes to Financial Statements

# STATEMENTS OF FUNCTIONAL EXPENSES

*YEAR ENDED DECEMBER 31, 2004*

| | Programs | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Biomechanics Research | Basic Science | Clinical Research | Education | Office of Information Services | Total | Management and General | Fundraising | Total |
| Salary and benefits | $301,345 | $ 23,067 | $229,704 | $ 95,819 | $ 97,750 | $ 747,685 | $282,912 | $177,011 | $1,207,608 |
| Payroll taxes | 19,002 | 1,711 | 15,391 | 6,151 | 6,535 | 48,790 | 19,572 | 10,840 | 79,202 |
| Travel | 6,381 | 1,824 | 4,364 | 15,253 | 5,857 | 33,679 | 6,831 | 25,591 | 66,101 |
| Utilities | 3,578 | 2,880 | 2,688 | 2,304 | 4,224 | 15,674 | 3,891 | 1,728 | 21,293 |
| Telephone | 3,271 | 243 | 2,139 | 586 | 1,519 | 7,758 | 3,586 | 1,772 | 13,116 |
| Consulting and contract labor | 15,413 | 89,658 | 15,304 | – | – | 120,375 | 6,866 | 60,098 | 187,339 |
| Legal and accounting | 5,540 | 429 | 5,334 | 935 | 2,960 | 15,198 | 3,711 | 2,994 | 21,903 |
| Postage and freight | 2,825 | 226 | 3,887 | 1,231 | 2,162 | 10,331 | 1,543 | 3,666 | 15,540 |
| Exhibits and meetings | 935 | – | 110 | 46,978 | 100 | 48,123 | 244 | 200 | 48,567 |
| Research projects | 800 | 80,000 | 454 | 8,345 | – | 89,599 | – | – | 89,599 |
| Facility rent | 10,460 | 5,203 | 4,950 | 4,156 | 7,566 | 32,335 | 7,320 | 3,059 | 42,714 |
| Promotion | – | – | – | 90 | 228 | 318 | 25,000 | 45,005 | 70,323 |
| Repair, maintenance and equipment | 3,737 | 442 | 2,384 | 545 | 2,454 | 9,562 | 1,561 | 1,322 | 12,445 |
| Board and SAC meeting | – | – | – | 5,403 | – | 5,403 | – | 685 | 6,088 |
| Dues, subscriptions, books and journals | 869 | – | – | 8,440 | 20 | 9,329 | 100 | 1,101 | 10,530 |
| General insurance | 918 | 71 | 883 | 177 | 530 | 2,579 | 27,539 | 424 | 30,542 |
| Printing | 1,431 | 65 | 4,504 | – | 520 | 6,520 | 735 | 61,054 | 68,309 |
| Supplies | 8,088 | 7,314 | 11,974 | 407 | 8,751 | 36,534 | 4,417 | 5,563 | 46,514 |
| Program support | 201 | 15 | 193 | 39 | 116 | 564 | 116 | 18,726 | 19,406 |
| Depreciation | 4,171 | 8,937 | 10,116 | 7,317 | 33,491 | 64,032 | 10,428 | 8,854 | 83,314 |
| Other | 125 | – | 24 | – | 14 | 163 | 8,503 | 12,741 | 21,407 |
| | $389,090 | $222,085 | $314,403 | $204,176 | $174,797 | $1,304,551 | $414,875 | $442,434 | $2,161,860 |

See Notes to Financial Statements

## NOTES TO FINANCIAL STATEMENTS

*YEARS ENDED DECEMBER 31, 2005 AND 2004*

### NOTE 1: NATURE OF OPERATIONS AND SUMMARY OF SIGNIFICANT ACCOUNTING POLICIES

#### Nature of Operations
Steadman◆Hawkins Research Foundation (the Foundation) is a not-for-profit foundation located in Vail, Colorado that is organized for educational and scientific purposes to advance medical science and research. The Foundation's primary sources of support are public donations, grants and corporate partners.

#### Corporate Partners
The Foundation has agreements with several corporations where the Foundation's research and product development is provided to the corporation in exchange for an annual payment to the Foundation. These agreements are recorded as income in the year payment is due.

#### Contributions
Gifts of cash and other assets received without donor stipulations are reported as unrestricted revenue and net assets. Gifts received with a donor stipulation that limits their use are reported as temporarily or permanently restricted revenue and net assets. When a donor-stipulated time restriction ends or purpose restriction is accomplished, temporarily restricted net assets are reclassified to unrestricted net assets and reported in the statements of activities as net assets released from restrictions.

Gifts of land, buildings, equipment and other long-lived assets are reported as unrestricted revenue and net assets unless explicit donor stipulations specify how such assets must be used, in which case the gifts are reported as temporarily or permanently restricted revenue and net assets. Absent explicit donor stipulations for the time long-lived assets must be held, expirations of restrictions resulting in reclassification of temporarily restricted net assets as unrestricted net assets are reported when the long-lived assets are placed in service. Unconditional gifts expected to be collected within one year are reported at their net realizable value. Unconditional gifts expected to be collected in future years are reported at the present value of estimated future cash flows. The resulting discount is amortized using the level-yield method and is reported as contribution revenue.

#### Cash
At various times during the year, the Foundation's cash accounts exceeded federally insured limits.

#### Accounts Receivable
Accounts receivable are stated at the amount billed to customers. The Foundation provides an allowance for doubtful accounts, which is based upon a review of outstanding receivables, historical collection information and existing economic conditions. Accounts receivable are ordinarily due 30 days after the issuance of the invoice. Accounts past due more than 120 days are considered delinquent. Delinquent receivables are written off based on individual credit evaluation and specific circumstances of the customer.

#### Property and Equipment
Property and equipment are depreciated on a straight-line basis over the estimated useful life of each asset. Leasehold improvements are depreciated over the shorter of the lease term plus renewal options or the estimated useful lives of the improvements.

#### Investments and Investment Return
Investments in equity securities having a readily determinable fair value and all debt securities are carried at fair value. Investment return includes dividend, interest and other investment income and realized and unrealized gains and losses on investments carried at fair value. Investment return is reflected in the statements of activities as unrestricted or temporarily restricted based upon the existence and nature of any donor or legally imposed restrictions.

#### Use of Estimates
The preparation of financial statements in conformity with accounting principles generally accepted in the United States of America requires management to make estimates and assumptions that affect the reported amounts of assets and liabilities and disclosure of contingent assets and liabilities at the date of the financial statements and the reported amounts of revenues, expenses, gains, losses and other changes in net assets during the reporting period. Actual results could differ from those estimates.

#### Income Taxes
The Foundation is a qualifying organization under Section 501(c)(3) of the Internal Revenue Code and a similar provision of state law. Consequently, no provision for income taxes has been made in the financial statements.

#### Reclassifications
Certain reclassifications have been made to the 2004 financial statements to conform to the 2005 financial statement presentation. These reclassifications had no effect on the change in net assets.

### NOTE 2: INVESTMENTS AND INVESTMENT RETURN

Investments at December 31 consist of the following:

| | 2005 | 2004 |
|---|---|---|
| Stock and equity funds | **$ 2,773,831** | $ 2,230,729 |
| Equity securities | **40,137** | – |
| Fixed income funds | **194,750** | 185,806 |
| Money market funds | **111,140** | 100,767 |
| | **$ 3,119,858** | $ 2,517,302 |

At December 31, 2005 and 2004, approximately 90% and 89%, respectively, of the Foundation's investments consisted of equity securities and equity mutual funds.
Investment income during 2005 and 2004 consists of the following:

| | 2005 | 2004 |
|---|---|---|
| Interest and dividend income | **$ 61,648** | $ 35,567 |
| Net realized and unrealized gains on investments | **203,739** | 262,249 |
| Investment income | **$ 265,387** | $ 297,816 |