STEADMAN PHILIPPON RESEARCH INSTITUTE

Science Finding Cures
Medicine Enhancing Lives

Olympian Tommy Ford, United States Ski Team (Photo: John Kelly)

2016-2017 ANNUAL REPORT

THE YEAR IN REVIEW

Dear Friends,

On behalf of all of us at the Steadman Philippon Research Institute, we wish to thank you for your continued support. The years of 2016 and 2017 are two of the most exciting and remarkable years in our 29-year history!

Thanks to philanthropy and our partnership with the Vail Valley Medical Center, we moved in January into new and expanded research and clinical office facilities housing surgical skills, biomechanical, robotics, regenerative medicine and biomotion labs. This new space represents a 36 percent growth, totaling more than 26,000 square feet. The new and renovated facilities will allow for increased collaboration between physicians, scientists and SPRI staff members, which will advance bench-to-bedside clinical applications and improve patient care.

In 2016, we established two unique research networks, bringing together some of the top scientists and clinicians in the world. Research teams from Mayo Clinic, Northwestern University and University of Wisconsin are working with SPRI to improve platelet-rich plasma as an effective treatment for muscle damage. This three-year study is made possible through a generous gift from Mike and Mary Sue Shannon.

The second network is with the University of California-San Francisco. Joint injuries are among the most disabling and costly conditions suffered by Americans. Thanks to financial support from Steven Read, scientists from SPRI and University of California-San Francisco are exploring new ways to improve joint regeneration.

We continue to focus our resources on the patient through personalized medicine and predictive analytics. With the SPRI data covering more than 33,000 surgeries stored in our Center for Outcomes-Based Orthopaedic Research's database, new predictive modeling applications are being developed to add to the quality of personalized medicine. Using this data, SPRI's researchers are on the verge of being able to better predict the development of osteoarthritis—the most common joint disorder in the United States. These analytic tools are being used to educate and prepare patients for future health developments and to help doctors make well-informed decisions regarding treatment of their patients. It can also assist patients in taking charge of their health.

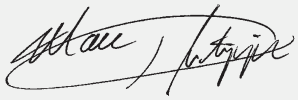
We have always emphasized collaboration with other research organizations and institutions to achieve the goal of advancing science, health care and injury prevention. That tradition of collaboration continued with two major events—the Second Annual Vail Scientific Summit in August of 2016 and the first-ever Conference on the Prevention of Injury and Illness in Sport held earlier in 2017 with the United States Olympic Committee. These conferences and research collaborations are designed for health care professionals, whose combined efforts will ultimately unlock the secrets of healing, find cures, prevent injuries and improve patient care.

Our life-changing research would not exist without the visionary support of individuals like you. On behalf of our dedicated trustees and researchers, we wish to thank you, our other benefactors, corporate sponsors and foundations. We look forward to your continued support and to updating you on exciting advances from the Steadman Philippon Research Institute.

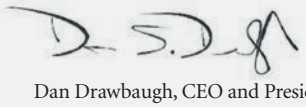
With your help, we are making a difference.

Respectfully yours,

J. Richard Steadman, M.D., Co-Chairman



Marc J. Philippon, M.D., Co-Chairman



Dan Drawbaugh, CEO and President

Johnny Huard, Ph.D., Chief Scientific Officer

MISSION

Building our legacy of excellence in orthopaedic sports medicine, SPRI is unlocking the secrets of healing, finding cures and enhancing lives through global leadership in regenerative medicine, scientific research, innovation and education.

CONTENTS

Dr. Marc J. Philippon, SPRI co-chairman

Photo: John Kelly

TOGETHER—THE CAMPAIGN FOR A HEALTHY, ACTIVE TOMORROW

$75 million campaign funds SPRI research and VVMC renovation

Photos: John Kelly

Vail Valley Medical Center (VVMC) and Steadman Philippon Research Institute (SPRI) have combined efforts to raise $75 million in their first-ever joint capital campaign. Gifts to this five-year campaign are funding VVMC's comprehensive hospital renovation and expansion, as well as SPRI's leading-edge research.

Campaign gifts are helping fund the complete transformation of the Vail campus. With the recent expansion, the west wing has increased by 72,000 square feet. The larger footprint includes additional patient rooms, expanded Howard Head Sports Medicine and a new fourth floor—the new home of SPRI and The Steadman Clinic.

Demolition of the current east wing will begin in late 2017. This wing will be replaced with a new 350,000 square foot structure, highlights of which include a new main entrance, state-of-the-art Level III Trauma Center, an underground garage and an on-site helipad.

The campaign is also advancing SPRI's trailblazing research in adult stem cells, biomotion and biomedical engineering. In addition, philanthropic dollars will support SPRI's Center for Outcomes-Based Orthopaedic Research and development of the next generation of imaging technology.

SPRI PHILANTHROPY BY THE NUMBERS

STATISTICS FOR 2016
$3,804,460.75 raised
789 gifts
619 benefactors
215 new benefactors

MORE SPACE, MORE STUDIES, MORE DISCOVERIES

New SPRI labs help further research and patient care

State-of-the-art facilities. Latest technology. Enhanced research. These are just a few of the many benefits of Steadman Philippon Research Institute's new home at Vail Valley Medical Center (VVMC).

SPRI moved to the newly constructed fourth floor atop VVMC's west wing earlier this year. The Steadman Clinic is also located on this floor. Together, the research institute and the clinic have 30 percent more square footage than in their previous locations.

In addition, patients, visitors and staff now access SPRI and the clinic through the wing's new main lobby. Only steps from the front doors, an express elevator takes them directly to the fourth floor. All of these changes provide greater convenience for everyone.

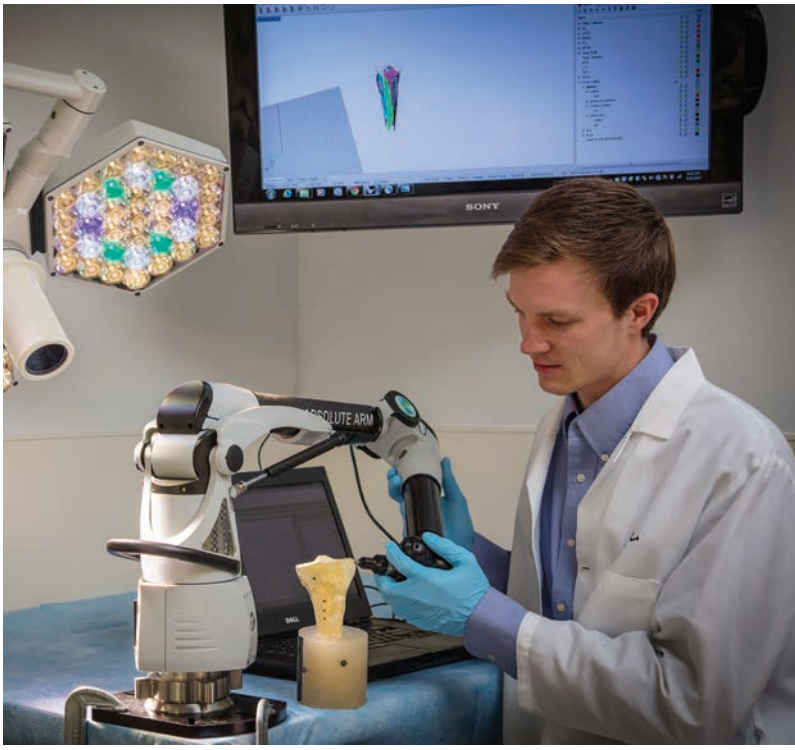
The new floor is part of VVMC's comprehensive remodel and expansion, which is being funded in part through benefactors' generous gifts to Together-The Campaign for a Healthy, Active Tomorrow. This capital campaign is a joint effort of SPRI and VVMC.

"Over the course of four years, I spent over 300 hours in attending planning and design meetings for our new space. I believed that it was essential that the surgical skills labs and bioengineering labs be adjacent to the physicians and fellows to maximize access and collaboration. Obviously, this format has initially been proven to be very successful. I am looking forward to the physicians and researchers being able to work even more closely together and bring research to a new level in our new space," said Robert LaPrade M.D., Ph.D.

SPRI's new space, which also includes much of the wing's first floor, houses:

1st floor:
- BioMotion Lab
- Center for Regenerative Sports Medicine
- Imaging Research
- Research staff offices

4th floor:
- Surgical Skills Lab
- Robotic Biomechanics Lab
- Center for Outcomes-Based Orthopaedic Research (COOR)
- Machine shop
- Administrative and research staff offices



GREATER COLLABORATION MOVES RESEARCH TO NEW LEVEL

Another huge benefit of SPRI's new location is its proximity to The Steadman Clinic.

"With the surgeons just around the corner, we have greater access and interaction with them. This facilitates more in-depth conversations, better problem solving and greater collaboration," says Travis Turnbull, Ph.D., deputy director of BioMedical Engineering. "The result has been advanced research, which asks and answers the most challenging orthopaedic questions and will lead to improved patient outcomes."

He adds that the labs' more efficient and strategically planned layouts are enhancing research findings. For example, scientists can now position X-ray equipment to capture complete images of joints as they are manipulated in the Robotic Biomechanics Lab to simulate clinical stress examinations. These images help surgeons develop better-informed treatment plans for patients.

Thanks to philanthropy, SPRI researchers have more than just a new home. They now have the facilities to translate their high-quality, award-winning research from bench to bedside more efficiently, benefiting patients worldwide.

NEXUS OF KNOWLEDGE

Networks foster research collaboration across U.S.

"Many ideas grow better when transplanted into another mind than the one where they sprang up."

— OLIVER WENDELL HOLMES

This is the idea behind the new research networks established by Steadman Philippon Research Institute. Scientists from across the U.S. are collaborating to advance discoveries in regenerative medicine.

"Networks bring together a unique combination of scientists, clinicians and philanthropists," says Johnny Huard, Ph.D., chief scientific officer. "These collaborations are producing uncompromised science quality."

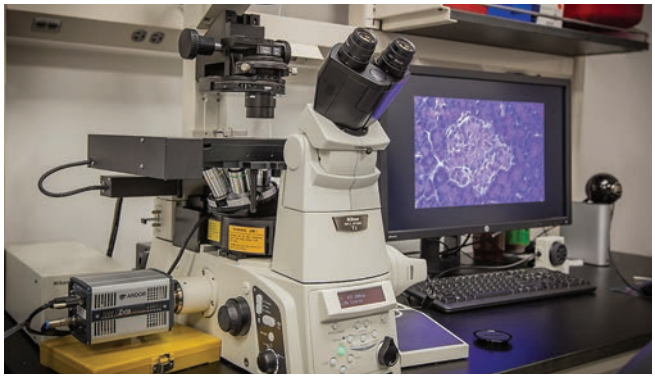
ENHANCING PLATELET-RICH PLASMA TO REPAIR TISSUE

Platelet-rich plasma (PRP) has proven to be an effective treatment for muscle damage. But what if there was a way to make this treatment even better? SPRI has joined forces with scientists from Mayo Clinic, Northwestern University and University of Wisconsin to answer this question.

Their study involves removing or blocking certain detrimental factors in PRP while increasing the release of beneficial factors. The teams are testing whether modifying PRP promotes tissue regeneration.

In addition, this study will help scientists better understand the biological nature of PRP. This could lead to innovative approaches that would greatly improve the effectiveness of PRP treatments.

The network's researchers expect to find that customizing each patient's PRP will improve the repair of muscle tissue and bones.



Highly sophisticated microscopic equipment used to image cells and tissue sections.

"We believe this study will help unlock the power of regenerative medicine. Pairing such groundbreaking research with leading-edge treatments is the future of medicine. It's the level of medicine we want for you and your family."

- MIKE SHANNON, PRP Network Benefactor

This three-year study is made possible through a generous gift from Mike and Mary Sue Shannon.

"We believe this study will help unlock the power of regenerative medicine," Shannon says. "Pairing such groundbreaking research with leading-edge treatments is the future of medicine. It's the level of medicine we want for you and your family."

"Without benefactor support of our networks, certain medical advancements and technology innovations wouldn't be possible," Dr. Huard explains.

STUDYING JOINT CROSSTALK TO REGENERATE MUSCLES

Joint injuries are among the most disabling and costly conditions suffered by Americans. Even with the most up-to-date treatments, these injuries can take weeks or even months to heal. And often, total joint function never returns.

Thanks to financial support from Steven Read, scientists from SPRI and the University of California-San Francisco are exploring new ways to improve joint regeneration. They believe the key lies in better understanding the interaction between the joint's bones and muscles, known as crosstalk. The goal of this two-year study is to identify new ways to restore healthy joint crosstalk. Researchers expect to discover that enhancing this crosstalk speeds cartilage regeneration and promotes whole joint function.

Another new research network teams up researchers from SPRI and UTHealth. They are conducting studies similar to those of the Read network. However, they are focused on using a microfracture technique to regenerate cartilage in animals.

"Networks create a great opportunity to share world-class expertise and support new ideas, technologies and hypotheses, leading to the ultimate in patient care," Dr. Huard adds. "Networks bring brilliant minds together."

SPRI STRENGTHENS ITS COMMITMENT TO COLLABORATION WITH RESEARCH PARTNERS AROUND THE WORLD

Throughout its 29-year history, the Steadman Philippon Research Institute has emphasized collaboration with other research organizations and institutions to achieve its goal of advancing science, health care and injury prevention.

That tradition of collaboration has recently been illustrated by two major events—the Second Annual Vail Scientific Summit in August of 2016 and the first-ever Conference on the Prevention of Injury and Illness in Sport held earlier this year.

VAIL SCIENTIFIC SUMMIT

"The goal of the Scientific Summit was to encourage new collaborations and to build on existing ones," according to Dan Drawbaugh, CEO of The Steadman Clinic and SPRI.

That's exactly what happened when more than 40 of the best minds in regenerative medicine and cellular therapies came together in Vail to share findings, provide insights and discuss possible collaborations with fellow researchers, scientists and physicians.

"It's just amazing what is being done here," says Dr. Marc Philippon, SPRI co-chairman. "The scientific summit is a great example of multiple minds being better than one."

The three-day conference included speakers from throughout the United States, representing universities and medical institutions such as the Mayo Clinic, Harvard, Northwestern University, University of Pittsburgh, University of Texas Health Science Center at Houston and Carnegie Mellon.

Commenting on the need for collaboration between the scientific and medical communities, SPRI Chief Scientific Officer and Summit Co-Chair Dr. Johnny Huard said, "I dream that we can do science that translates to the clinic. Surgeons and scientists need to work together—to be a team that can make big things happen."

If the exchange of ideas at the 2016 Vail Scientific Summit is an indication of game-changing collaboration in the future, the Steadman Philippon Research Institute will have reinforced its position as an innovative leader in the world of regenerative medicine.

The Third Annual Vail Scientific Summit is scheduled for August 23-26, 2017.

Dr. Bill Moreau, U.S. Olympic Committee managing director of Sports Medicine, addressing medical professionals at the Conference on the Prevention of Injury and Illness in Sport.

New collaborations were encouraged at the Vail Scientific Summit.

> **"It's just amazing what is being done here. This is a great example of multiple minds being better than one."**
>
> **- DR. MARC J. PHILIPPON, SPRI co-chairman**

CONFERENCE ON THE PREVENTION OF INJURY AND ILLNESS IN SPORT

The first-ever Conference on the Prevention of Injury and Illness in Sport was jointly hosted by SPRI and the U.S. Olympic Committee.

The event, attended by more than 60 sports medicine professionals, addressed current research and clinical applications for sustaining the health of athletes through sports and exercise medicine, with a particular emphasis on adolescents and young adults.

"The Steadman Philippon Research Institute is proud to have hosted this unique event," said Dr. Marc Philippon, SPRI's co-chairman. "Dr. Bill Moreau of the U.S. Olympic Committee has been a huge proponent of this conference, and we are grateful to him and the USOC for their partnership."

Dr. Moreau, USOC's managing director of Sports Medicine, commented, "This conference was groundbreaking. We were happy to see so many come and join the seminar to learn and contribute to the sports medicine community that is focused on preserving and improving the health of athletes."

The target audience for the conference was physicians and other health care providers engaged in the care of patients with sports-related injuries. The objectives were for those who attended to be better prepared to:

- recognize injury patterns of specific sports
- identify sport-specific injuries and how to reduce them and
- implement standard screening programs among high-risk populations

IMPROVING PATIENT CARE

These conferences and research collaborations, as well as those that will follow, are designed for health professionals whose combined efforts will ultimately unlock the secrets of healing, find cures and improve patient care.

The Conference was focused on preserving and improving the health of athletes.

CRSM CENTER FOR REGENERATIVE SPORTS MEDICINE

Johnny Huard, Ph.D., Director and SPRI Chief Scientific Officer

Photo: John Kelly

Orthopaedic surgeons and CRSM scientists looking at cellular differentiation.

The focus of the Center for Regenerative Sports Medicine is to understand basic stem cell biology and translate that knowledge to the clinic to aid in the healing and regeneration of a variety of tissues. We are concentrating on gene therapy, tissue engineering and regenerative medicine applications based on the use of muscle-derived stem cells (MDSCs).

CRSM

In 2016, under the direction of Dr. Huard, CRSM team members produced more than 100 articles, posters and research presentations, some in collaboration with other physicians and departments within the Institute.

Photo: John Kelly

Johnny Huard, Ph.D., CRSM director and SPRI chief scientific officer.

The MDSCs that have been isolated by the CRSM lab are currently undergoing clinical trials for the treatment of urinary stress incontinence and myocardial infarction. As of this date, more than 400 patients in Canada and the United States have volunteered for this stem cell therapy.

Much of the work involving stem cells to treat musculoskeletal conditions is still in the experimental stage. In addition to musculoskeletal conditions, the research team plans to explore the use of adult stem cells to treat heart disease, Duchenne muscular dystrophy and aging. Dr. Huard also plans to look at stem cell therapies for neurological conditions such as concussions.

FACILITIES/TECHNOLOGY

Since completion of the new CRSM lab on the first level of the Vail Valley Medical Center, we now have three separate rooms in which to work. The incubator room lets us better maintain the sterility of our workspace with four Class-II biological safety cabinets and eight incubators.

A highly equipped microscope room allows us to use the microscopes with the lights off without having to manage a curtain and other machines that require light to operate. The room has a bioreactor that allows us to image live cells by time-lapse camera to study biophysiological properties of stem cells.

We have protein profiling MagPix and traditional blotting apparatus. We have added bench space, freezers to bank RNA/DNA/protein and liquid nitrogen tanks to bank stem cells.

RESEARCH HIGHLIGHTS

The primary focus of the Center for Regenerative Sports Medicine is on translational regenerative medicine, where multiple projects are being developed, including:

- platelet-rich plasma optimization
- bone marrow aspirate characterization and delivery of stem cells and
- multi-disciplinary initiatives involving basic science studies, clinical translation of MDSCs and adipose-derived stem cells (ADSCs) with implications for orthopaedics and healthy aging

CLINICAL OUTCOMES

Dr. Huard's team studies clinical outcomes and anatomical biomechanical factors, many of which involve hip arthroscopic surgeries, as well as the best diagnosis and treatment for the patients with hip joint problems.

ANTI-FIBROSIS AGENTS

The center has been investigating a variety of agents (losartan, suramin, relaxin, decorin, γ-interferon) to prevent the formation of fibrosis (scarring) and promote muscle fiber regeneration following injuries and disease.

PLATELET-RICH PLASMA, BONE MARROW ASPIRATE CONCENTRATE

CRSM studies how platelet-rich plasma (PRP) and bone marrow aspirate concentrate aid healing and repair of an injury and the potential applications for the regeneration of soft tissue and cartilage. CRSM also investigates ways to inhibit factors within PRP that may have negative effects on tissue regeneration and repair. These investigations

of biologic applications (derived from natural sources) are conducted with patient outcomes in mind in order to develop more effective treatment methods.

URINARY INCONTINENCE, MYOCARDIAL INFARCTION, LIFE SPAN

MDSCs can be isolated from skeletal muscle of humans or mice regardless of age, sex or disease state, although the yield of MDSCs varies with age and health. MDSCs are currently being tested for treatment of urinary incontinence and myocardial infarction. MDSCs have also been demonstrated to extend life span and health span in mouse models.

ISCHEMIC HEART DISEASE

Dr. Huard's team investigated the therapeutic potential of an injectable, heparin-based substance co-delivering an angiogenic factor (development of blood vessels) for the treatment of ischemic heart disease.

Myocardial infarction (MI) causes myocardial necrosis, triggers chronic inflammation and leads to pathological remodeling. Controlled delivery of a combination of angiogenic and immunoregulatory proteins may be a promising therapeutic approach for MI.

DUCHENNE MUSCULAR DYSTROPHY

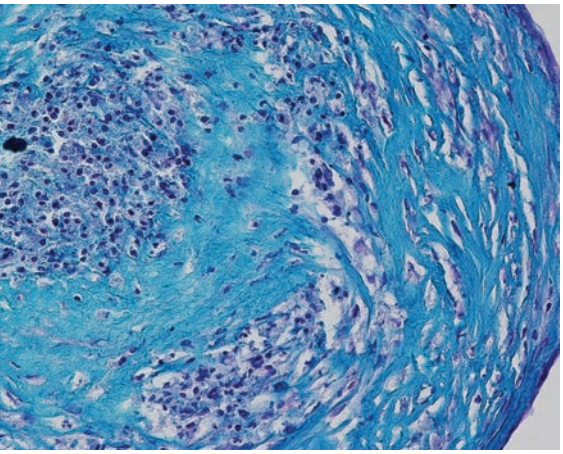
Duchenne muscular dystrophy (DMD) patients lack dystrophin from birth. However, muscle weakness becomes apparent only at 35 years of age, which coincides with the depletion of the muscle progenitor cell (MPC) pools. MPCs isolated from older DMD patients demonstrate impairments in

Photo: John Kelly

CRSM Director Dr. Huard supervising research assistant Jill King on PRP and BMAC studies.

CRSM

The generous support of our benefactors has enabled us to expand the scope of our research to include the healing power of regenerative medicine, helping patients heal better and faster, and remain active longer.



Muscle-derived stem cells differentiating (transforming) into cartilage cells

myogenic potential. Dr. Huard's team showed in an animal model that alleviating MPC depletion could represent an approach to delay the onset of tissue disease associated with DMD patients.

LIFE SPAN, HEALTH SPAN

Muscle-derived stem/progenitor cells (MDSPCs) isolated from accelerated-aged animal models show an impaired capacity for cell differentiation. The mammalian target of rapamycin (mTOR) is a critical regulator of cell growth in response to nutrient, hormone and oxygen levels. Dr. Huard's team showed in an animal model that the inhibition of the mTOR pathway extends the life span and health span of several species.

MECHANICAL STIMULATION (FLEXING)

Researchers at CRSM have observed that mechanical stimulation alleviated the defect observed in progeria MDSCs. Mechanical stimulation (flexing) of the muscle stem cells could partially compensate for the progeria phenotypes and protect cells from entering senescence (deterioration with age).

Flexing appears to prime the cells so that they are more resistant to stressors such as hydrogen peroxide. Preliminary results indicate that mechanical stimulation may rejuvenate and rescue the cells from defects in anti-oxidative stress and anti-aging capacity. Based on these results, flexing cells *in vitro* may improve the quality and outcome of stem cells to be implanted into patients, especially in older donors.

ACHIEVEMENTS

The Center for Regenerative Sports Medicine excelled in publications, presentations and grants, as well as hosting the second annual Vail Scientific Summit. Following is a summary of those achievements.

PUBLICATIONS

In 2016, Dr. Huard and his team members produced nearly 100 articles, posters and research presentations.

GRANTS

Department of Defense, "Development of Biological Approaches to Improve Functional Recovery After Compartment Syndrome Injury," $487,091.

National Institutes of Health, "Cell Autonomous and Non-Autonomous Mechanisms of Stem Cell Defects with Aging," $1,117,731.

National Institutes of Health, "Bone Abnormalities & Healing Defect in Muscular Dystrophy," $1,250,000.

National Institutes of Health, "Biomimetic Coacervate Delivery of Muscle Stem Cell to Improve Cardiac Repair," $279,616.

AOSSM/Sanofi Biosurgery Osteoarthritis Grant, "Cartilage Repair with Mesenchymal Stem Cells (MSCs) Delivered in a Novel Chondroitin Sulfate/Polyethylene Glycol Hydrogel in an Equine Animal Model," $50,000.

PROJECTIONS

CRSM will be receiving a new autoclave (an apparatus used for chemical reactions, sterilizations, and other processes

Photo: John Kelly

CRSM research assistant preparing slides for microscopic imaging.

using high pressure and high temperatures) from Vail Valley Medical Center, which will be much larger and more efficient than our current one. In 2017, the Center anticipates getting a ducted fume hood, which is not only safer than the current one, but will provide us with the space we need to use hazardous chemicals and perform staining/dehydration at the same time.

The CRSM team is continuing to work with Robert Hardie on securing Department of Defense grants.

Finally, the Center for Regenerative Sports Medicine will host the 2017 Vail Scientific Summit. In 2016, CRSM initiated an effort to include vendors as sponsors to defray costs. The first year brought 11 sponsors. With the success of the conference, we expect even more vendors in the future.

SPRI's long-term orthopaedic research has led to new and less-invasive repair and rehabilitation therapies. Most recently, the generous support of our benefactors has enabled us to expand the scope of our research to include the healing power of regenerative medicine, helping patients heal better and faster, and remain active longer.

COOR CENTER FOR OUTCOMES-BASED ORTHOPAEDIC RESEARCH

Grant Dornan, M.S., Director, Center for Outcomes-Based Orthopaedic Research

Dr. Marc Philippon and team

The Center for Outcomes-Based Orthopaedic Research patient database is celebrating its silver anniversary—25 years of tracking and studying patient outcomes. More than 34,000 surgeries are being followed and more than 133,000 patient-centered outcomes surveys have been collected.

At the end of 2016, COOR Director Karen Briggs moved into a role focused on hip research. In 2017, Grant Dornan, SPRI's chief biostatistician for the past five years, was named the new director of COOR.

2016 was a successful year in COOR, with 62 publications cited in PubMed, including a diverse set of patient outcome papers, systematic reviews and studies of surgical techniques. Examples of studies on the hip, shoulder, ankle and knee are summarized below.

HIP RESEARCH

SURVIVORSHIP AND OUTCOMES 10 YEARS FOLLOWING HIP ARTHROSCOPY FOR FEMOROACETABULAR IMPINGEMENT: LABRAL DEBRIDEMENT COMPARED TO LABRAL REPAIR

Femoroacetabular impingement (FAI) is a disorder of the hip that has been increasingly recognized and can cause pain, decreased function and osteoarthritis. Hip arthroscopy can be an effective treatment, but there are limited data on the outcomes.

Purpose
The purpose was to evaluate 10-year patient-reported outcomes scores and survivorship (of the repair) following hip arthroscopy to treat FAI. Patients who had labral debridement (surgical removal) were compared with patients who had labral repair.

Results
A total of 154 patients met the inclusion criteria. Seventy-nine had labral repair and 75 had labral debridement. The repair group had an increased rate of acetabular microfracture and combined-type FAI compared to the debridement group.

The results demonstrated that patients with 2 mm of joint space or greater had an increased survivorship and decreased rate of requiring a subsequent total hip replacement in both groups. The average survivorship for both groups in this case was 9.9 years. Patients who underwent labral debridement had a higher risk of progressing to total hip replacement compared to those who underwent labral repair.

This study will be published in an upcoming issue of the *Journal of Bone and Joint Surgery.*

PREDICTORS OF LENGTH OF CAREER AFTER HIP ARTHROSCOPY FOR FEMOROACETABULAR IMPINGEMENT IN PROFESSIONAL HOCKEY PLAYERS

Overuse injuries of the hip in ice hockey players are common due to the repetitive forces seen during skating. Hip arthroscopy to treat femoroacetabular impingement (FAI) can be helpful to return the players to their prior level of play.

Purpose
The purpose was to determine the prevalence of professional hockey players who continued to play at the professional level for a minimum of five years following hip arthroscopy to treat FAI and to determine factors associated with length of career.

Results
Those who had microfracture were older and had longer careers than those who did not. For the number of years played after surgery, there was no difference between those who had microfracture and those who did not.

Overuse injuries of the hip in ice hockey players are common due to the repetitive forces seen during skating. Hip arthroscopy to treat femoroacetabular impingement can be helpful to return the players to their prior level of play.

The average number of years played after hip arthroscopy was 5.9. All players returned to the NHL for a least one season. The average length of career was 13.7 years. All but two players had a career length of at least five years. Sixty-seven percent continued to play professionally for a minimum of five years following hip arthroscopy. Players who played at least five years after hip arthroscopy were significantly younger than those who did not.

This study demonstrated that professional hockey players who underwent arthroscopy surgery for FAI were able to continue playing at the professional level. The study research was published in the September 2016 edition of the *American Journal of Sports Medicine.*

Photo: John Kelly

SHOULDER RESEARCH

ARTHROSCOPIC BANKART REPAIR TWO-YEAR OUTCOMES

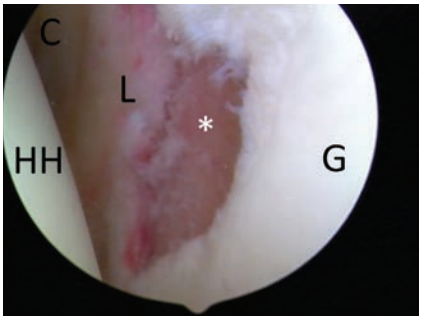
A study conducted by Dr. Peter Millett and his team evaluated the outcomes of patients with recurrent shoulder instability (dislocation). Shoulder instability is common in young, active patients, particularly men. The most frequent cause is trauma, such as an accident while skiing, biking, etc. Without surgical intervention, young patients with instability are very likely to experience repeated episodes of shoulder dislocation throughout their lives.

Purpose
The study followed 72 patients who underwent arthroscopic surgery to stabilize the joint with the goal of preventing future dislocations. Patients were followed for a minimum of two years after surgery to evaluate the status of their shoulder.

Results
Almost 90 percent of the patients experienced significant improvement, demonstrating the positive effects of the surgical intervention. Ten patients experienced recurrent episodes of instability.

The research team analyzed factors increasing a patient's risk of recurrent instability after surgery. They found that patients with a particular finding called a GLAD lesion (glenoid labral articular disruption) were at higher risk of recurrent dislocation (figure 1).

This finding will help shoulder surgeons identify patients with a higher risk for dislocation in the future. This knowledge will inform patients about appropriate post-operative rehabilitation and future treatment.



Our study showed people with a GLAD lesion in their shoulder joint (shown here) had greater risk of recurrent dislocation after repair surgery.

ARTHROSCOPIC DOUBLE-ROW ROTATOR CUFF REPAIR FIVE-YEAR OUTCOMES

Rotator cuff tears are common, especially in middle-aged to elderly adults. While many tears are completely symptom-free, some cause disabling pain and dysfunction that require surgical intervention.

Purpose
This study followed 259 patients for a minimum of five years after arthroscopic rotator cuff repair using Dr. Millett's double-row repair technique to evaluate the outcomes.

Results
Patients experienced significant improvement in pain and function. Only five percent of patients required revision rotator cuff repair surgery, which is about 33 percent lower than the rate of 7.5 percent reported in similar studies. This finding demonstrates the long-term strength and reliability of the double-row repair technique.

ANKLE RESEARCH

DO OUTCOMES DIFFER FOLLOWING MICROFRACTURE WITH BIOLOGIC AUGMENTATION VS. MICROFRACTURE ALONE FOR THE TREATMENT OF ARTICULAR CARTILAGE LESIONS OF THE ANKLE?

Cartilage lesions of the ankle account for up to 50 percent of ankle sprains in the U.S. More severe cartilage lesions of the ankle are usually treated with surgery. The first line of surgery for treating lesions has been primarily through microfracture, which has demonstrated significant overall improvement in function and activity level after surgery. While short-term results after microfracture have been good, it is unclear whether increased function and decreased pain are maintained over time.

Purpose
The purpose was to determine if there is a significant difference in activity level and function after surgery in patients who undergo microfracture with biocartilage augmentation, as opposed to microfracture alone, to treat a talar or mortise chondral lesion of the ankle articular cartilage.

Results
Overall, there were no significant differences in function between the microfracture only versus microfracture with biocartilage groups. Chondral lesion size was a significant predictor of function, and body mass index was a significant predictor of activity level. It is possible that the full advantages of using biocartilage are not seen until long-term follow-up.

This study is important because it is unclear at which point in time the

addition of biocartilage affects outcome scores. Further research is needed to determine the full effects of biological treatments and determine whether these biologics are able to aid in the maintenance of cartilage repair.

This study also concluded that chondral lesion size affects functional scores at a minimum of two years follow-up. Body mass index had a significant effect on activity level. By identifying predictors of decreased function and activity level, physicians are better able to counsel patients regarding expectations of treatment.

KNEE RESEARCH

POSTERIOR MENISCAL ROOT REPAIRS: OUTCOMES OF AN ANATOMIC TRANSTIBIAL PULL-OUT TECHNIQUE

The two meniscal roots anchor the inside and outside menisci, which are cartilage-like structures that act as shock absorbers, to the top part of the tibia.

Meniscal root tears lead to altered contact pressures and contact areas in the knee, which have a negative effect on functional capabilities. If left untreated, patients may experience increased pain and overall long-term knee dysfunction due to progressive degenerative changes, and that could lead to early degenerative joint disease.

Due to an increased understanding of the consequences of injury at or near the meniscus root attachments, greater emphasis has been placed on preserving the meniscus.

A technique called the transtibial pull-out repair for posterior medial and lateral meniscus root tears is designed to restore meniscal function (figure 2).

Outcomes following both medial and lateral meniscus root repair remain unclear, emphasizing the need to document how patients are doing after surgery.

Purpose

The purpose of this study was to report outcomes in patients who underwent meniscus-preserving surgical repair. The primary focus was to compare outcomes in patients younger than 50 years versus patients 50 years and older. Outcomes were also assessed in patients with medial versus lateral meniscus root repairs.

Results

The most important finding of this study was that patients who underwent meniscal root repairs had significantly improved outcomes and a high level of patient satisfaction with the outcome.

Patient satisfaction was high, regardless of age and meniscus location. Overall, this technique of meniscal root repair resulted in significant improvement in function, symptoms of pain and activity level.

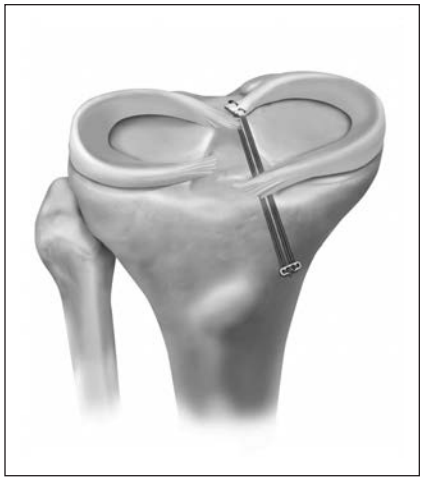


Illustration of a transtibial pull-out repair for a posterior medial meniscal root tear. Reproduced with permission from LaPrade CM, LaPrade MD, Turnbull TL, Wijdicks CA, LaPrade RF. Biomechanical evaluation of the trastibial pull-out technique for posterior medial meniscus root repairs using 1 and 2 transtibial bone tunnels.

Photo: John Kelly

Dr. Robert LaPrade

The findings suggest that patients 50 and over should not be excluded purely based on age. Other factors such as osteoarthritis, high body mass index and the ability to follow the postoperative rehabilitation program may be more useful in guiding the management of the condition.

The Steadman Philippon Research Institute could not carry out its mission without the philanthropy of its friends. Since our founding in 1988, gifts have helped SPRI emerge as one of the most productive and respected centers of its kind. The discoveries and pioneering surgical techniques made possible by benefactor support have profoundly impacted the quality of treatments available throughout the world.

BME DEPARTMENT OF BIOMEDICAL ENGINEERING

Scott Tashman, Ph.D., Director, Department of BioMedical Engineering
Travis Turnbull, Ph.D., Deputy Director, Department of BioMedical Engineering

Scientifically proven injury prevention and restoration techniques are the focus of the Department of BioMedical Engineering. Our team of intelligent, creative and passionate researchers diligently tests new and innovative repair techniques, investigates injury pathologies and analyzes human movement mechanics.

These research activities are conducted with the goal of helping patients heal faster and get back to the activities they love, while lessening their chance of experiencing additional problems or reinjury. This collaborative research environment, involving not only assorted testing modalities but also a diverse knowledge base, produces quality research that has immediate application in orthopaedic sports medicine.

The results of our research studies are published in top-tier, peer-reviewed journals, giving physicians in The Steadman Clinic and around the world the confidence to perform scientifically validated surgeries and giving patients the assurance they are receiving the best care available.

FACILITIES/TECHNOLOGY

In conjunction with the Vail Valley Medical Center expansion, the Department of BME now occupies new laboratory spaces on the first floor (BioMotion Lab) and fourth floor (Robotics Lab).

The new fourth floor places researchers of the Department of BME and other SPRI departments immediately adjacent to The Steadman Clinic physicians. The increased proximity has facilitated immediate communication and interaction between researchers and surgeons, which keeps both groups on the cutting edge of orthopaedic sports medicine research and patient care.

Through philanthropy, new robotics software was installed and will allow us to study the biomechanics of joints that have not previously been investigated at SPRI. The new BioMotion Lab, outfitted with state-of-the-art equipment, will be used to capture and analyze 3-D human movements in real time.

Photo: John Kelly

ACCOMPLISHMENTS

Success in the Department of BioMedical Engineering is measured by awards, presentations at conferences, publications in high-impact, peer-reviewed journals, and community involvement. Among our accomplishments during the past year are:

- Receiving the 2016 AOSSM Excellence in Research Award presented by the American Orthopaedic Society for Sports Medicine
- 15 podium and 19 poster presentations at national and international conferences
- Continued involvement with the SPRI Education and Public Outreach Committee (EPOC) through interactive tours of BME laboratories, middle school science fairs, presentations at schools and one-on-one mentorship for students in SPRI's high school Science Club
- 22 publications in peer-reviewed journals, including studies on the hip, shoulder, knee and ankle conducted by Drs. Marc Philippon, Peter Millett, Robert LaPrade and Thomas Clanton, respectively, and their teams. Following are the titles of four studies conducted and/or published in 2016/2017, brief summaries of their findings and their impact on doctors and patients.

HIP CAPSULAR CLOSURE: A BIOMECHANICAL ANALYSIS OF FAILURE TORQUE

In this biomechanical study, several capsule closure suture configurations were analyzed. Dr. Philippon and SPRI researchers learned that two sutures provided torsional strength equivalent to that of three sutures. Fewer sutures reduce operative time and the potential for suture irritation of surrounding muscle tissue.

The BME team will continue to pursue multidisciplinary collaborations among all SPRI departments, with a focus on maintaining the research prowess for which SPRI is known and, ultimately, keeping people active through orthopaedic research and education.

Photo: John Kelly

L-R, Travis Turnbull, Ph.D., deputy director, Kimi Dahl, M.Sc., research scientist and Scott Tashman, Ph.D., director, Department of BioMedical Engineering.

BME

Photo: John Kelly

The robotic equipment at SPRI is extremely useful to researchers and provides a means to investigate and answer research questions through a testing medium capable of reproducing the natural movement of joints.

The Steadman Philippon Research Institute could not carry out its mission without the philanthropy of its friends. Since our founding in 1988, gifts have helped SPRI emerge as one of the most productive and respected centers of its kind. The discoveries and pioneering surgical techniques made possible by benefactor support have profoundly impacted the quality of treatments available throughout the world.

QUANTITATIVE AND COMPUTED TOMOGRAPHY ANATOMIC ANALYSIS OF GLENOID FIXATION FOR SUPERIOR CAPSULE RECONSTRUCTION: A CADAVERIC STUDY

This study, conducted by Dr. Millett and his research team, represents the first in a series of research investigations of the newly developed superior capsule reconstruction (SCR) technique. The SCR surgery is performed in younger patients, or those wishing to maintain a very active lifestyle, who have an irreparable rotator cuff tear. The SCR technique saves or delays patients from undergoing a more invasive shoulder replacement surgery.

ANATOMIC ANTEROLATERAL LIGAMENT RECONSTRUCTION OF THE KNEE LEADS TO OVERCONSTRAINT AT ANY FIXATION ANGLE

Dr. LaPrade conducted this study and determined anterolateral ligament (ALL) reconstruction should be used with caution because the procedure often resulted in tightness of the knee joint relative to the healthy knee mechanics. The clinical impact of this research project was acknowledged with the receipt of the 2016 AOSSM Excellence in Research Award.

ANKLE SYNDESMOSIS: ANATOMY AND RECONSTRUCTION

Dr. Clanton and his colleagues published four studies in 2016 related to the anatomy and reconstruction of the ankle syndesmosis joint. The four-part study included an anatomy study, which defined the pertinent surgical anatomy, and three reconstruction studies, which investigated various repair devices and techniques. This series of research projects and associated published journal articles will inform surgeons of the relevant anatomy, best devices and procedures for surgical interventions involving the ankle syndesmosis.

IR IMAGING RESEARCH

Charles Ho, M.D., Ph.D., Director, Imaging Research

The Department of Imaging Research at SPRI develops and evaluates non-invasive imaging techniques, with an emphasis on joint health. Imaging Research complements and enhances the clinical relevance of research conducted by other departments, including the Center for Regenerative Sports Medicine, the Center for Outcomes-Based Orthopaedic Research and the Department of BioMedical Engineering.

IR

The Steadman Philippon Research Institute could not carry out its mission without the philanthropy of its friends. Since our founding in 1988, gifts have helped SPRI emerge as one of the most productive and respected centers of its kind. The discoveries and pioneering surgical techniques made possible by benefactor support have profoundly impacted the quality of treatments available throughout the world.

The Skyra 3.0 T MRI scanner allows Imaging Research to perform state-of-the-art research and apply imaging tools to improving patient outcomes. With improved and accurate 3T imaging, Dr. Ho and his staff can give accurate diagnoses for injuries that involve the meniscus, labrum, cartilage, ligaments or tendons.

As a result, Imaging Research can assist the treating physician with his or her diagnosis and treatment plan. 3T imaging is also a method of monitoring treatment and response to treatment. The goal is to be aware of all the associated injuries in order to get a comprehensive idea of what issues the patient is having and how to treat them.

The Skyra 3T imaging system provides higher resolution and greater speed than lower field scanners. The higher the resolution, the more accurate the evaluation.

Long exams often not only make the patient uncomfortable, but also make it more likely that they will move during the procedure. Movement results in compromised images and evaluation, which decreases the kind of detailed information the treating doctor wants and deserves.

With the enhanced speed of the 3T scanner, examinations can be performed at a faster rate that allows for greater patient comfort and tolerance. The 3T scanner system can reduce the time required for a scan by 10-15 minutes or more.

RESEARCH INITIATIVES

Imaging Research continues to conduct research on quantitative magnetic imaging. One of the specific goals is to gain a better understanding of tissue properties. Once a distinct tear has occurred, it can be very difficult to provide long-term treatment.

By obtaining images before there is a macroscopic tear (large enough to be seen by the unaided eye), Imaging Research is able to determine if there has been prior degradation or tissue injury. Recognizing the injury process at an earlier stage might make the condition more treatable, either by slowing down the process or reversing it.

Imaging Research continues to screen junior league hockey players. For the past six years, IR has examined, screened and scanned more than 30 athletes to better understand the development of hip injuries and disorders, and their relationship to the movements executed in hockey.

Imaging findings indicate that the longer the subjects participate in sports such as hockey, the more likely they are to display imaging findings and symptoms of hip disorders. The injuries appear to be associated with repetitive use and overuse, which is what most

sports involve. That pattern of use and overuse stresses the body, which can lead to a degenerative process.

This ongoing study will help researchers, physicians, coaches, parents and athletes identify the injury risk associated with sports such as hockey and assist in the development of early intervention and treatment.

Research conducted by IR resulted in three national and international presentations and eight articles published in scientific journals such as *Magnetic Resonance Imaging in Medicine; Orthopaedic Journal of Sports Medicine; Arthroscopy; Foot & Ankle International; and Knee Surgery, Sports Traumatology, Arthroscopy.*

COLLABORATIVE INITIATIVES

IR has increased its involvement with other departments at SPRI by introducing imaging as a tool for noninvasive diagnosis and treatment. IR is now focusing on ways imaging research can be applied to regenerative medicine and to research being conducted in the BioMotion Lab. IR continues to cooperate with all departments regarding clinical work and research.

Collaborative efforts also continue with the University of Queensland and the Commonwealth Scientific and Industrial Research Organization in Australia. Current projects include the knee meniscus, cruciate ligaments, (hip) labrum, articular cartilage and the bony morphology of the hip, knee and shoulder. An important component of the collaboration with the two entities in Australia is in the area of automatic segmentation (partitioning) and modeling of various tissues within the joint images.

Photo: John Kelly

Charles Ho, M.D., Ph.D., directs Imaging Research at SPRI. His work is leading to better diagnosis and treatment plans.

SPORTS MEDICINE FELLOWSHIP AND INTERNATIONAL SCHOLARS PROGRAM

Robert F. LaPrade M.D., Ph.D., diretor, International Scholars Program and co-director, Sports Medicine Fellowship Program

Each year, as many as eight young orthopaedic surgeons are selected from a field of more than 160 applicants to participate in 12 months of vigorous training in the Steadman Philippon Sports Medicine Fellowship Program. "We train the best of the best," says Dr. LaPrade.

The goal is to prepare them to be leaders in the field of orthopaedic sports medicine for the remainder of their careers. Many go on to hold high-level faculty positions at top medical schools.

In addition, between eight and 10 surgeons from around the globe come to SPRI as International Scholars.

In addition to their clinical responsibilities, the fellows and visiting scholars have a unique opportunity to perform research in their respective areas of interest, including biomechanics research, clinical research, imaging research and basic science research. Both groups spend 12 months refining their skills in orthopaedic surgery and investigating the causes, prevention and cure of degenerative diseases, as well as the treatment and prevention of joint injuries.

Not only are SPRI's fellows and scholars advancing their own knowledge and expertise, they are improving the patient care provided by orthopaedists around the world through their groundbreaking research.

These physicians also have the opportunity to hone their skills further in SPRI's Surgical Skills Lab and through on-site care for the US Ski Team.

The institute currently maintains a network of more than 220 fellows in communities around the world who often serve in academic positions at leading universities and in private practices.

Photo: John Kelly

SPRI Sports Medicine Fellows working in the Surgical Skills Laboratory.

FOUNDATION OF ORTHOPAEDIC EXCELLENCE

The knowledge and skills gained at SPRI propel these surgeons to the top of their fields. One such physician is Mininder Kocher, M.D.

A 2000 SPRI Fellow, he is one of *U.S. News & World Report's* America's Top Doctors. He is the associate director of the Sports Medicine Division at Boston Children's Hospital and a professor of Orthopaedic Surgery at Harvard Medical School.

Dr. Kocher says he wanted to continue his education at SPRI because of the breakthrough research and surgical innovations for which it is known.

"Besides enhancing my surgical skills, the greatest benefit of coming to SPRI was learning how to be a great doctor," Dr. Kocher says. "Working with Dr. Richard Steadman, I learned the importance of developing a personal relationship with my patients. I have applied this philosophy throughout my career. And as I train young doctors, I spread Dr. Steadman's philosophy by teaching them the importance of listening and truly caring about their patients."

A highly recognized orthopaedic surgeon and researcher, Dr. Kocher has authored hundreds of textbooks, book chapters and peer-reviewed journal articles. He also has lectured at over 250 meetings and conferences worldwide. Dr. Kocher continues to be involved at SPRI as a member of its Research Advisory Committee.

2016-17 SPORTS MEDICINE FELLOWS

SALVATORE J. FRANGIAMORE, M.D.

Dr. Frangiamore graduated from John Carroll University in Ohio with a bachelor's degree in biology and earned his medical degree at the University of Toledo. He studied orthopaedics at the Cleveland Clinic and researched shoulder and elbow injuries in baseball pitchers. This research earned him the 2015 Charles S. Neer Award. He completed his residency with the Ohio Orthopaedic Society and provided physician coverage for the Cleveland Indians.

ANDREW GEESLIN, M.D.

Dr. Geeslin earned his bachelor's and medical degrees at the University of Minnesota. He completed his residency at Western Michigan University, where he provided sports coverage for the university and U.S. Tennis Association's national championships. Dr. Geeslin has published several research papers, including one on multi-ligament knee injuries, joint pathology and biologic orthopaedic treatments, in several orthopaedic journals.

JON GODIN, M.D., M.B.A.

Dr. Godin graduated from Johns Hopkins University with a bachelor's degree in neuroscience. He received his medical degree from the University of Michigan Medical School and completed a residency at Duke University Medical Center. He provided physician coverage for the North Carolina Central University and Duke athletic teams. He has presented his research of pediatric ligament injuries, shoulder instability and bone-tendon healing internationally.

PATRICK KANE, M.D.

Dr. Kane earned a bachelor's degree in biology at Villanova University. He received his medical degree from Thomas Jefferson University in Philadelphia, where he also did his residency in orthopaedic surgery. He provided physician coverage for the Philadelphia Phillies, St. Joe's University and Villanova. His research interests include ACL reconstruction graft selection, biceps tenodesis and recurrent shoulder instability.

GEOF LEBUS, M.D.

Dr. Lebus received his bachelor's degree from Harvard University and his medical degree from the University of Texas Southwestern Medical School. He completed his residency in orthopaedic surgery at Vanderbilt University Medical Center, where he provided sports coverage for the university. His research interests include shoulder instability and other traumatic and degenerative shoulder conditions.

2016-17 SPORTS MEDICINE FELLOWS (CONT.)

SANDEEP MANNAVA, M.D., Ph.D.

Dr. Mannava earned his medical degree from State University of New York. He completed his orthopaedic surgery residency at Wake Forest University, where he also earned a Ph.D. Dr. Mannava invented a surgical device that has been patented and authored more than 70 abstracts presented at national and international conferences. He also published over 45 manuscripts and book chapters. His research focus is regenerative medicine.

2016-17 INTERNATIONAL SCHOLARS

IONNA BOLIA, M.D.

Dr. Bolia comes to SPRI from the University of Athens School of Medicine, Department of Orthopedic Surgery. She received her medical degree from Aristotle University of Thessaloniki School of Health Sciences, as well as a master's degree in molecular and applied physiology. Her research focus is hip arthroscopy. She is preparing for the U.S. Medical Licensing Examination and plans to apply for a medical residency in the U.S.

JORGE CHAHLA, M.D.

Dr. Chahla completed his residency at the Buenos Aires British Hospital in Argentina and a research fellowship at the Hospital for Special Surgery in New York. His research focus is translational regenerative medicine and cartilage and joint preservation procedures. Dr. Chahla has recently completed his Ph.D. research through the Catholic University of Argentina. He will begin a sports medicine fellowship at Santa Monica Orthopaedic Group at Cedars-Sinai Medical Center in July.

MARCIO FERRARI, M.D.

Dr. Ferrari completed his medical residency at Hospital Cristo Redentor in Porto Alegre in Brazil and a knee fellowship at Hospital de Clinicas de Porto Alegre. He is conducting knee and shoulder research at SPRI as he pursues a master's degree in surgical sciences at Universidade Federal do Rio Grande do Sul. Dr. Ferrari is the 2016 recipient of the Jorge Paulo Lemann Mentored Scientific Award.

RENATO LOCKS, M.D.

Dr. Locks earned his medical degree from Peolatas Federal University in Brazil and completed his residency in orthopaedics and traumatology at Cristo Redentor Hospital. He recently completed a fellowship in hip surgery at the Pontifical Catholic University of Parana. Dr. Locks has presented his studies at many international medical conferences and has been a frequent contributor to research journals. Dr. Locks is also the 2016 recipient of the Jorge Paulo Lemann Mentored Scientific Award.

GILBERT MOATSHE, M.D.

Dr. Moatshe received his medical degree from University of Tromsø, Norway. He is focusing on research in arthroscopy and sports medicine, with an emphasis on treating knee injuries. He completed his residency at Oslo University Hospital and is working on a Ph.D. in collaboration with SPRI and Oslo University. He was recently awarded the Achilles Sports Medicine Award through ISAKOS, representing the best paper presented at the meeting in Shanghai, for his research.

JONAS POGORZELSKI, M.D.

Dr. Pogorzelski specializes in sports orthopaedics with an emphasis on rotator cuff pathologies and treatments. Before joining SPRI, he worked at Technical University of Munich in the Department of Sports Orthopedics. Having recently completed a master's degree in health business administration, he is pursuing his Ph.D. while at SPRI.

JIMMY UTSUNOMIYA, M.D., Ph.D.

Dr. Utsunomiya specializes in stem cell research, in particular, using shoulder stem cells to treat rotator cuff tears. He is assisting Dr. Johnny Huard, SPRI's chief scientific officer, with his regenerative medicine research.

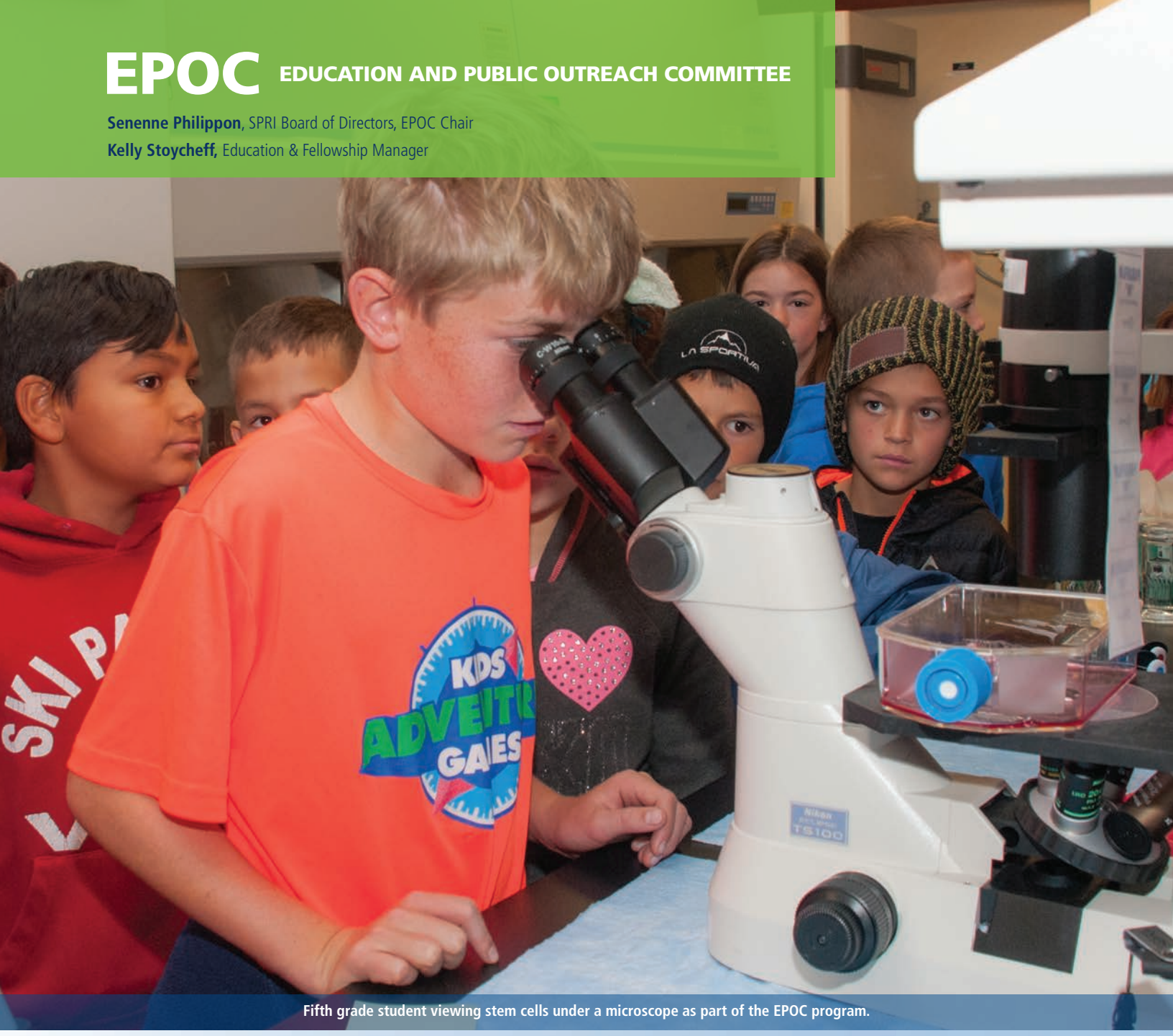
CHANGING MEDICAL CARE WORLDWIDE

Not only are SPRI's fellows and scholars advancing their own knowledge and expertise, they are improving the patient care provided by orthopaedists around the world through their groundbreaking research.

SPRI has been committed to training tomorrow's orthopaedic leaders for decades. Because of your support, hundreds of SPRI alumni are spreading medical excellence around the world—helping patients heal better and faster, and remain active longer.

EPOC EDUCATION AND PUBLIC OUTREACH COMMITTEE

Senenne Philippon, SPRI Board of Directors, EPOC Chair
Kelly Stoycheff, Education & Fellowship Manager



Fifth grade student viewing stem cells under a microscope as part of the EPOC program.

In 2016-2017, the Education and Public Outreach Committee (EPOC) completed its sixth year of programs. EPOC was established in 2011 to inspire next generation scientists through exposure to STEM (science, technology, engineering and math).

The program focuses on students at three stages of their academic lives. From August 2016 through April 2017:

- EPOC engaged 247 students in seven elementary schools through SPRI laboratory tours
- 300 6th-8th grade students in four schools who invited SPRI scientists and researchers to their classrooms, lecture halls and science fairs; and
- 10 students from five high schools who were selected by their respective science teachers to participate in the Science Club.

The 11th and 12th grade students participated in teams mentored by their high school science teachers and SPRI staff members. SPRI's engineers and researchers are an integral part of the program, and their commitment makes EPOC possible.

RESEARCH INITIATIVES

Among the research initiatives conducted by Science Club members during the past year were:

- The effects of ACL reconstruction bone tunneling on the structural integrity of the tibia
- A measurement system for mental toughness and its effect on skiing performance and injury rate
- ACL injury recurrence rates in males and females after reconstruction
- Analysis of high tibial osteotomy
- Biomechanical analysis of minimum hip angle and knee extension at toe-off between sprinters and distance runners at equal and maximum speeds

Senior Engineer and Scientist Travis L. Turnbull, Ph.D., introduces Science Club final presentations.

Since its inception, EPOC has impacted more than 2,300 students in the Vail Valley, including 40 in the Science Club.

EPOC GRADUATES NOW IN COLLEGE

Students who have participated in the EPOC programs at various levels are now studying at some of the most prestigious colleges and universities in the country, including Johns Hopkins, Stanford, Georgia Tech, Cal Poly, Florida State, Baylor and University of Denver.

EPOC continues to evolve as it meets the needs of students in the Vail Valley community. New requests from schools and professional organizations are being made to participate in EPOC programs.

Since its inception, EPOC has impacted more than 2,300 students in the Vail Valley, including 40 in the Science Club.

2016-2017

SPRI is leading the way with groundbreaking research in regenerative medicine that affects almost every system of the body. The advances are reflected in new initiatives by the Center for Regenerative Sports Medicine, the departments of BioMedical Engineering, Imaging Research and the Center for Outcomes-Based Orthopaedic Research. Following are some of the accomplishments during the past year.

Center for Regenerative Sports Medicine (CRSM)

Photo: John Kelly

CRSM senior research scientist, Sudheer Ravuri, PhD working on growth factor analysis.

The Center for Regenerative Sports Medicine excelled in publications, presentations, awards and grants, as well as hosting the second annual Vail Scientific Summit.

In 2016, under the direction of Dr. Huard, CRSM team members produced more than 100 articles, posters and research presentations, some in collaboration with other physicians and departments within the Institute.

Center for Outcomes-Based Orthopaedic Research (COOR)

2016 was a successful year, with 62 publications cited in PubMed, including a diverse set of patient outcome papers, systematic reviews and studies of surgical techniques. An example of a study on the hip, is summarized below.

"Survivorship and Outcomes 10 Years Following Hip Arthroscopy for Femoroacetabular Impingement: Labral Debridement Compared to Labral Repair," was a study conducted by Dr. Marc Philippon, former SPRI Fellow Travis Menge, M.D. and the COOR team. For his role in the study, Dr. Menge was named winner of the Nicola's Foundation Young Researcher Award at the 17th European Society of Sports Traumatology, Knee Surgery & Arthroscopy meeting in Barcelona, Spain.

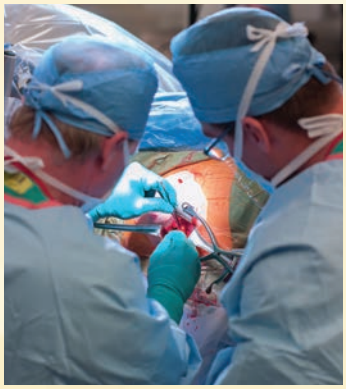


Photo: John Kelly

Was a Ground-Breaking, Award-Winning Year for SPRI

Dr. Robert LaPrade—Clinician and Scientist

Photo: John Kelly

Robert LaPrade, M.D., Ph.D.

Congratulations to Dr. Robert LaPrade, whose leadership and mentorship contributed to four major awards for SPRI during 2016-2017.

Researchers under the direction of Dr. LaPrade, were recognized as follows:

- **Excellence in Research Award**
- **Cabaud Memorial Award**
- **Best Scientific Award**
- **Achilles Orthopaedic Sports Medicine Award**

In addition, Dr. LaPrade was responsible for 68 peer reviewed publications in 2016.

BioMedical Engineering (BME)

Success in BioMedical Engineering is measured by awards, presentations at conferences, publications in high-impact, peer-reviewed journals and community involvement. Among our accomplishments during the past year are:

- **Excellence in Research Award**, Awarded to Jason Schon, "Anatomic Anterolateral Ligament Reconstruction of the Knee Leads to Overconstraint at any Fixation Angle," *American Orthopaedic Society for Sports Medicine* (AOSSM), Colorado Springs, Colorado
- **Cabaud Memorial Award**, awarded to Robert F. LaPrade M.D., Ph.D., "Use of Platelet-Rich Plasma Immediately Post-injury to Accelerate Ligament Healing Was Not Successful in an In Vivo Animal Model," AOSSM, Toronto, Canada.

Photo: John Kelly

L-R, Kimi Dahl, M.Sc., research scientist and Scott Tashman, Ph.D., director, Department of BioMedical Engineering.

- **Best Scientific Award**, Awarded to Gilbert Moatshe, M.D., "Optimization of Tunnel Position and Orientation in Complex Multiple Knee Ligament Reconstructions: Preoperative Planning and Intraoperative Techniques," *American Academy of Orthopaedic Surgeons* Annual Meeting, San Diego, California

Ground-Breaking, Award-Winning Year for SPRI (cont.)

- **Achilles Orthopaedic Sports Medicine Award**, awarded to Gilbert Moatshe, MD, "The lateral meniscus posterior root and meniscofemoral ligaments are stabilizing structures in the ACL deficient knee." The Achilles award recognizes the researchers who performed the most outstanding research in the field of sports medicine. *11th Biannual Congress of the International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine* (ISAKOS), Shanghai.
- 15 podium and 19 poster presentations at national and international conferences
- Continued involvement with the SPRI Education and Public Outreach Committee (EPOC) through interactive tours of BME laboratories, middle school science fairs, presentations at schools and one-on-one mentorship for students in SPRI's high school Science Club
- 22 publications in peer-reviewed journals, including studies on the hip, shoulder, knee and ankle conducted by Drs. Marc Philippon, Peter Millett, Robert LaPrade and Thomas Clanton, and their teams, respectively

Imaging Research

Research conducted by Imaging Research resulted in three national and international presentations and eight articles published in scientific journals such as *Magnetic Resonance Imaging in Medicine; Orthopaedic Journal of Sports Medicine; Arthroscopy; Foot & Ankle International;* and *Knee Surgery, Sports Traumatology, Arthroscopy.*

Dr. Marc Philippon Receives McCarthy Award for Achievement

Photo: John Kelly

Dr. Marc J. Philippon, center

Dr. Marc Philippon, co-chairman of the Steadman Philippon Research Institute, received the inaugural Joseph C. McCarthy Award for Achievement in Advancing Knowledge and Scholarship in Hip Joint Preservation.

The award was presented during the Annual Meeting of the International Society for Hip Arthroscopy in San Francisco (ISHA) September 17, 2016. It was given in recognition of Dr. Philippon's innovation, research and teaching in hip arthroscopy.

The award carries the name of the renowned Massachusetts General hospital (MGH) orthopaedic surgeon and founding member of ISHA, Dr. Joseph McCarthy.

"We are proud of Dr. Philippon's many achievements and his contributions to orthopaedic sports medicine," says Dan Drawbaugh, president and chief executive officer of Steadman Philippon Research Institute.

"His pioneering research and clinical expertise have improved the lives of patients around the world."

Dr. Philippon is internationally known for his joint preservation techniques. Using the various instruments he has designed, he has improved arthroscopic hip surgery for treating painful joint injuries.

Dr. Philippon is often recognized as the preeminent authority in the arthroscopic treatment of femoroacetabular impingement (FAI), a condition in which abnormally shaped bones of the hip cause damage to the labrum and articular cartilage.

In 2012, Dr. Philippon received the American Academy of Orthopaedic Surgeons Achievement Award in recognition of his outstanding contributions to the orthopaedic surgery field. He is recognized by his peers in *U.S. News and World Report* as being among the top one percent in the nation in his specialty.

Financial Summary

2016 OVERVIEW

total assets
$12,632,915

total liabilities
$2,464,574

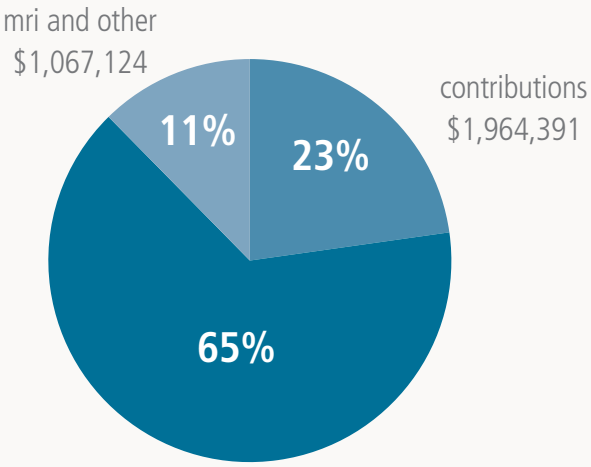
total unrestricted net assets
$1,513,453

total change in net assets
$(464,207)

cash and cash equivalents year-end
$2,370,072

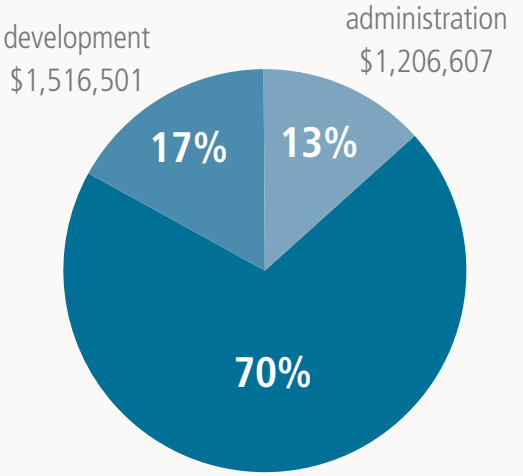
A copy of our latest financial report may be obtained by writing to Steadman Philippon Research Institute, 181 West Meadow Drive, Suite 1000, Vail, CO 81657 or by calling (970) 479-5781.

2016 INCOME BY TYPE



Total Income by Type $8,629,367

2016 EXPENDITURES BY FUNCTION



Total Expenditures by Function $8,982,615

181 West Meadow Drive, Suite 1000
Vail, Colorado 81657
970-479-5781
www.sprivail.org

STEADMAN PHILIPPON RESEARCH INSTITUTE

A 501(c)(3) nonprofit organization