Massachusetts General Hospital
2015 Chief’s Report

Harry E. Rubash, MD

It is a great pleasure to once again share that the MGH is ranked #1 in the annual U.S. News & World Report “Best Hospitals” list for 2014-2015. We are pleased to be at the top of an incredible list of institutions around our country. It is an honor to join hospital leadership in congratulating other specialty areas for their outstanding rankings. Orthopaedics was ranked fourth in the nation, and has been in the top five orthopaedic departments for the last two decades. We are proud of our continued national presence in the field of Orthopaedic Surgery.

EPIC Go-live
We began this year with preparation for MGH’s conversion to the EPIC electronic medical record in April of 2015. Marilyn Heng, MD acted as a super-user for the EPIC Go-live at BWH, and was appointed “Epic Czar” for the department. She worked with the MGH e-Care team to redevelop the training curriculum for our orthopaedic providers. Sean Hazzard, PA, and Dr. Heng were certified as Epic peer educators, and 21 service chiefs and advanced practitioners were designated “super-users.” Training began in January 2016, and we are ready for the go-live!

Professional Development Committee
The Professional Development Committee held a series of evening “faculty socials” at the Liberty Hotel. These events were well attended and a highlight for socialization. We met informally as a faculty to restore esprit de corps and bolster morale at a time when we were unfairly maligned by the Boston Globe. We met four times in 2015, and each time more faculty members attended. What we all rediscovered was our genuine affection for each other and our common affinity for surgery and fellowship within this department. The professional expectation of performance, citizenship and fellowship continues to soar!

New Faculty
Mark Price, MD, PhD
It is a pleasure to welcome Mark Price, MD, PhD, to our Sports Medicine Center at MGH. Mark earned his bachelor’s degree at Northwestern University, received his medical degree from Harvard Medical School, and completed his PhD at Massachusetts Institute of Technology. He was an outstanding resident in the Harvard Combined Orthopaedic Residency Program, and in 2009, completed a fellowship in Sports Medicine and Shoulder Surgery at MGH. Prior to returning to MGH, Mark was an Assistant Professor of Orthopaedics and Physical Rehabilitation in the Division of Sports Medicine at the University of Massachusetts Medical School and UMass Memorial Medical Center in Worcester, MA, where he was an active clinician, educator, and scientist.

Mark is also a member of the United States Navy Medical Corps Reserves. In 2012, as Officer in Charge, he led an eight-man surgical trauma team treating war injuries and performing humanitarian surgery in northern Afghanistan in support of Operation Enduring Freedom. In 2013, he received a Bronze Star Medal for his service, an award given to members of the United States Armed Forces for either meritorious achievement or service in a combat zone. Mark received the prestigious Herodicus
Society Travelling Fellowship in 2009, and he visited the American Sports Medicine Institute in Birmingham, AL, and the Hospital for Special Surgery in New York, NY.

We are pleased to have Mark back at MGH joining the Sports Medicine Service. We look forward to his many contributions.

**Saechin Kim, MD, PhD**

We welcomed Saechin Kim, MD, PhD, to the MGH Pediatric Orthopaedic Service. Saechin earned his Bachelor's degree from the Massachusetts Institute of Technology (MIT) in 1986, graduated from the MD and PhD program at Harvard Medical School, and earned a PhD in Molecular Genetics from MIT in 1994. After a successful residency with the Harvard Combined Orthopaedic Residency Program, Saechin completed an Orthopaedic Trauma Fellowship at Beth Israel Deaconess Medical Center. In 2001, he also completed the Maurice E. Muller North American Orthopaedic Fellowship in Inselspital in Bern, Switzerland.

Saechin has been a Partners faculty member since 2001, and in 2015, moved to a full-time role on the Spine and Pediatric Orthopaedic services. He will continue his research in improving surgical techniques to correct scoliosis and the molecular processes involved in an animal model of avascular necrosis of the femoral epiphyses, which may be a model for Legg-Calve-Perthes disease.

We are honored to have Saechin at MGH as a full-time faculty member, and look forward to his contributions to our department.

**New England Patriots**

This year the New England Patriots returned to the desert for Super Bowl XLIX, and it was an unlikely hero who made the play of the game. The Patriots beat the Seattle Seahawks, 28-24, to reclaim the title of NFL champions, thanks to an amazing end-zone interception by rookie cornerback Malcolm Butler!

The interception capped an impressive second-half comeback by the Patriots. New England became the sixth franchise in NFL history to win at least four Super Bowls, joining the Pittsburg Steelers (my old team), Dallas Cowboys, New York Giants, Green Bay Packers, and San Francisco 49ers.

**Primary Care Orthopaedics Course**

This year’s annual MGH Primary Care Orthopaedics Course, under the direction of Drs. David Ring and A. Holly Johnson, along with Co-Directors Drs. Louis Jenis and R. Malcolm Smith, was held in May at the Harvard Club on Commonwealth Avenue in the Back Bay. The MGH Department of Orthopaedic Surgery has offered this Harvard Medical School accredited program for over two decades. Through interactive sessions, the course teaches the fundamentals of musculoskeletal medicine to primary care providers. These sessions include presentations, case discussions, and a casting and splinting workshop run by John Burns. This year’s program was a great success. We will return to the Harvard Club in May 2016 with another outstanding offering.
In 2015, our clinical and research faculty gathered on the third weekend in June at the beautiful Chatham Bars Inn in Chatham, MA for our 10th annual Departmental Retreat. The theme of our retreat was “Strategy and Synergy,” inspired by our faculty’s desire to focus on innovation and clinical growth.

During our mini-retreats, we asked our faculty to address four objectives: (1) review and update your service’s strategy for clinical growth and recruitment; (2) focus on development of innovative activities that span across two or more of our services; (3) develop service-level opportunities in Population Health Management that can improve clinical efficiency; and (4) look for opportunities to reduce the administrative burden for our doctors.

Drs. Kevin Raskin and Holly Johnson shared their 2015-16 goals with the Professional Development committee, and our faculty was receptive and eager to be involved. Dr. David Ting, Chief Medical Information Officer of the Massachusetts General Physicians Organization (MGPO), and Dr. Cassandra Kelleher, MGH eCare Surgical Champion, prepared us for our department’s implementation of Epic (April 2, 2016).

On Friday night our families joined the faculty for our traditional clambake with a beachside bonfire and live music under the stars. It is always wonderful to celebrate a successful retreat with our faculty and family members. Another outstanding event!
Clinical Subspecialties Updates

Adult Reconstructive Surgery

The Adult Reconstructive Surgery Service at the MGH, under the direction of Dr. Andrew Freiberg, Service Chief and Department Vice-Chair, had a successful year with remarkable gains in clinical activity and research productivity. The Service continues to be a leader in the orthopaedic community, delivering the most up-to-date surgical techniques for hip and knee arthroplasty, the evaluation of problem joint replacements, including treatment of metal-on-metal implant failures, and advanced treatments for infection and peri-prosthetic fractures. We also continue our studies of minimally invasive techniques, rapid recovery protocols, and partial tibio-femoral and patello-femoral arthroplasty.

The service continues to be a model for focused care redesign at MGH. Surgical volumes continue to grow, length of stay has decreased due to our EXCElerated recovery program, and patient satisfaction scores have improved significantly. These achievements will allow us to provide better patient access and enable us to meet increasing demand for lower extremity arthroplasty. We are indebted to the work of Lauren Hoogendyk, Administrative Director for the Foot and Ankle and Podiatry Service, and Greg Pauly, Chief Operating Officer of the Massachusetts General Physicians Organization, as well as to Emily Mulla, NP, and Lauren Swisher, PA, for the tremendous success of our inpatient NP Program. We are in the process of developing bundled payments to prepare for both federal and private insurance initiatives.

We had a wonderful year in terms of increased productivity and efficiency, performing more than 2,500 hip and knee arthroplasties. In addition, our colleagues at Newton-Wellesley Hospital, in collaboration with the Kaplan Center for Joint Replacement, continue to thrive. Dr. William Healy, our newest faculty member, has fully integrated into the program and adds the capability of anterior hip replacement techniques and a broad knowledge of and experience in clinical care, education, and program organization.

The MGH Center for Metal-on-Metal Total Hip Replacement is a national and international resource for patients seeking consultation and surgery. This advanced clinical work has given us many new research avenues and substantial headway in orthopaedic advances. An example of this leading work is Dr. Young-Min Kwon’s national leadership in formulating treatment guidelines. The guidelines have wide clinical and educational implications and acknowledge our expertise in providing advanced care for these complex patients.

Dr. Hany Bedair has become recognized as a leader in the diagnosis and treatment of peri-prosthetic infection. We greatly benefit from our continued clinical association with the Infectious Disease Service, especially Dr. Sandra Nelson. Dr. Nelson was promoted to Assistant Professor at Harvard Medical School in part because of her clinical excellence and dedication to work with Orthopaedics.

Boasting more than 50 national and international presentations, the Adult Reconstructive Surgery Service had another outstanding year at the annual meetings of the Orthopaedic Research Society, The Knee Society, The Hip Society, the American Academy of Orthopaedic Surgeons, the American Orthopaedic Association, and the American Academy of Hip and Knee Surgeons. Our group had a plethora of podium and poster presentations at these meetings, and it was rewarding to see the academic successes and the presence of so many former fellows. Many of our faculty and fellows presented important clinical and scientific information in different countries including Great Britain, Singapore, India, Japan, Korea, Denmark, Sweden, Brazil, and China.

Congratulations to Dr. Andrew Freiberg, who was elected to The Knee Society in recognition of his scientific and clinical contributions to the field of knee arthroplasty. A great honor, and well done!
Congratulations to Dr. Harry Rubash, who was elected President of the prestigious Hip Society. Harry has contributed so much to the field of hip and arthroplasty surgery and deserves this great honor. The closed meeting of The Hip Society will be hosted by Dr. Rubash and the Boston members of The Hip Society from October 27-29, 2016 at the wonderful Liberty Hotel. In addition, Dr. Rubash’s 3rd edition of The Adult Hip was published this year. Another great contribution!

Under the direction of Dr. Guoan Li, collaboration with the Bioengineering Laboratory is ongoing as we do the groundwork to study new robotic techniques and implants that can be applied to hip and knee surgery. We are confident that these exciting discoveries will translate into a new major clinical program. In addition, researchers in the Harris Orthopaedic Laboratory continue to work on major clinical outcomes studies including the ASR/DePuy Study and the Persona Total Knee Outcomes Study. We continue to focus on the extensive evaluation of retrieved cross-linked liners from hip and knee replacement patients.

Our service has contributed a significant number of cases to the National Total Joint Registry and continues to work with our colleagues at the Mayo Clinic to make this Registry successful. In addition, we have finally incorporated the NWH Registry into our larger Harris Registry.

This year marks our 53rd Fellowship Class and the second with Dr. Young-Min Kwon as Fellowship Director and Dr. Hany Bedair as Director of Arthroplasty Fellowship Education. These faculty members have provided new energy and abilities. Our fellows this year were: Dr. Brian Burroughs, who has joined an outstanding orthopaedic group in Worcester, MA; Dr. Ken Urish, who is now an Assistant Professor in Orthopaedic Surgery at the University of Pittsburgh; Dr. Eric Eisemon, who joined Kaiser outside of San Francisco; Dr. Michael Stoesz, who joined Aurora Advanced Healthcare in Summit, Wisconsin; and Dr. Horim Choi, who is doing a Sports Medicine Fellowship at the University of Minnesota. We wish them all great success as they enter practice or continue their training.

Hand and Upper Extremity Service

Jesse Jupiter, MD, currently serves as President of the American Society of Shoulder and Elbow Surgeons. He was also named the first recipient of the A. Lee Osterman Award for Lifetime Excellence in Education from the American Society for Surgery of the Hand and the American Foundation for Surgery of the Hand. Chaitanya Mudgal, MD, was honored at the inaugural annual CS Mudgal Hand Surgery Forum at Guaiang City People’s Hospital in the People’s Republic of China. He also serves as a member of the AO North America Hand Education Committee.

Dr. Jesse Jupiter receiving the A. Lee Osterman Award


We graduated our eighth, ninth, and tenth Dutch PhDs: Wendy Bruinsma, Arjan Bot, and Stephanie Becker. Wendy was our first PhD through Trauma Surgery at the Academic Medical Center under Professor Carol Goslings, and Stephanie was the first PhD through Plastic Surgery at the Academic Medical Center with Professor Chantal van der Horst.
The MGH Hand and Upper Extremity Fellowship program continues to flourish. After a highly successful and stable tenure, Dr. Mudgal passed the reins to Dr. Neal Chen as Program Director and Kyle Eberlin, MD, from Plastic Surgery as Associate Program Director. Sang-Gil Lee, MD, Jonathan Winograd, MD, and Curt Cetrulo, MD, manage busy and complex hand practices while still allowing time to mentor our fellows.

The 26th annual Smith Day Oration was given by Graham King, MD, and this year’s Jupiter International Forum Orator was Michael McKee, MD, MPH. We are pleased to host next year’s Orators, Joseph Upton, MD, and Milan Stevanovic, MD, respectively.

We are looking forward to an exciting 2016 with continued clinical research in conjunction with our international colleagues and the development of kinematics studies on the wrist in our Biomechanics laboratory with Guoan Li, PhD.

Foot and Ankle Service
Last year was marked by meaningful ongoing development of the MGH Foot and Ankle Service. Growth was seen in many areas of this program as it continues to support a commitment to excellence and refine its clinical, educational, research, and overall healthcare mission in the Departments of Orthopaedic Surgery at MGH and Newton-Wellesley Hospital (NWH).

In the first quarter of 2015, the new MGH-NWH Foot and Ankle Center (FAC) opened in the Orthopaedic Clinics at MG West, Waltham. At its core, this comprehensive care center has the goal of becoming a world-class model for value-driven musculoskeletal care in the field of foot and ankle. With thoughtful guidance, we envision this site as the primary referral source for foot and ankle patients in New England and beyond.

Staffing at MGH-NWH FAC is at an all-time high, as we continue to attract and recruit outstanding candidates for ancillary, technological, and patient care services in Waltham.

Coordination of foot and ankle care across five different facilities throughout Boston is neither typical nor easy for any orthopaedic service in our department; however, our center director, Lauren Hoogendyk, has certainly made it look easy. Representation of one program at nine sites is unique to our service, and doing it successfully has been challenging at times. Her vision, dedication, and connections within the MGH and NWH systems have been invaluable for our growth and development as a service.

2015 ushered in a finalized space allocation and an early architectural rendering of our planned Foot and Ankle Retail Store in Waltham. This exciting new project is expected to open within the next 12-18 months and will offer relevant accessories to meet the non- and peri-operative needs of our patients. As part of this project, we have also begun working with Nancy Ferullo, MGH’s longtime in-house orthotist, to develop a full-service orthotic program. As part of this, we intend to create a rational, sustainable financial model for orthotic implementation and revision.

In support of MGH’s commitment to population health management, we have begun collecting data on the diabetic/neuropathic population at MGH who typically require intensive foot and/or ankle care. Given the ever expanding size of this group, we have formalized a national search to hire a Charcot/neuropathic expert over the next six months. The position will necessitate building a close working relationship with our colleagues in wound care, vascular, plastics, infectious disease, medicine, podiatry, and emergency care.
Following this hire, we anticipate we will quickly begin the recruitment of an additional podiatrist with non-operative expertise in this area who would also be based primarily at MGH.

Another important hallmark of 2015 has been the significant expansion of our research team. This past year has seen the organization and hiring of multiple international researchers, including five from the Netherlands, one from Egypt, one from Chile, and one from Iran, as well as two college students (Dartmouth and Harvard). Combined, this group has facilitated weekly research meetings, multiple grant applications, and numerous accepted abstracts and publications in leading educational forums. We are in the process of hiring a promising PhD post-doc to lead the development of our lab.

Our lab has also seen the development of many other cutting-edge projects in 2015, including studies of the syndesmosis, 5th metatarsal, peroneals, arthroscopy, total ankle arthroplasty, VTED, and more. We have also secured the first-ever approval of a new RPDR for service quality improvement in the field of foot and ankle at Partners. Ultimately, our goal is to secure funding to create and sustain a novel “MGH Foot and Ankle Research and Innovation Lab.” We are working with various individuals in administration, compliance, development, and legal to identify a framework for fundraising. This is a potentially promising new direction for the service, and, if successful, would enhance our research and innovation mission, including the development of an annual international research fellowship in foot and ankle.

Faculty development and camaraderie continue to grow thanks to the dedicated service of the faculty members—Drs. Guss, Johnson, and DiGiovanni. Our younger faculty members have significantly expanded their roles in the regional and national scenes, including committee involvement, podium presence, production of peer-reviewed papers, and sports team influence. In recognition of her mentoring work with students, Dr. Johnson was awarded the MGH Orthopaedic Eleanor Shore Fellowship by the Dean of the Harvard Medical School.

As of 2015, we are also the representative F/A consultants for Boston College (in addition to Harvard and some of the US Olympic teams, especially hockey and skiing), and are poised to foster new and expanded relationships with our Sports Medicine Service.

Our Foot and Ankle Fellowship program also continues to receive applications from across North America, and has quickly become recognized as one of the best in the country. We are consistently matched with our top candidates, despite an increasingly high demand for competitive applicants each year.

Excellence in patient care is perhaps the main component of our mission at MGH. Much of what we do every day is steeped in ensuring the delivery of the highest quality of care. Over the past year, we have assimilated numerous new quality improvements in our service, including providing better patient access, offering 24/7 ED foot and ankle care at NWH, ensuring that patients of the MGH medical walk-in practice can gain same-day access in Boston, developing an opioid pain prescription program for our patients, continuing the standardization of foot and ankle instrumentation, establishing hand-off protocols with our ancillary providers while we are offsite providing care each week, improving multiple new F/A technologies for in-clinic access, and maximizing “one-stop shopping” for patients who are seen and require testing at the MGH-NWH FAC. We are increasingly viewed as “the place to go for all things below the knee” in Boston and beyond, and we expect this reputation to continue to grow.

Another cornerstone mission of our service remains the education, mentorship, and leadership of our trainees—the future of our specialty and our profession of medicine. Our faculty, conferences, mentorship, bioskills labs, and research opportunities are all heralded by our students as some of the best experiences they have in their HCORP training. Further, the involvement of our frontline staff in these educational activities, training, and mentorship in clinic and beyond, has been a major attraction to young professionals looking to build their careers. Of the last several employees hired,
most hold undergraduate degrees and are preparing to move on to advanced degrees within a few years. This career ladder trajectory empowers our team to perform at levels that exceed the requirements of their specific roles.

**Podiatry**

In March 2015, the Podiatry Service officially merged with the Foot and Ankle Service. This created a new and exciting beginning for the service as we move forward with the combined vision to create a world-class, integrated foot and ankle center at MGH. As an integral part of the Foot and Ankle Service, Podiatry’s role in the non-operative care of foot and ankle pathology will become paramount in 2016.

In July 2015, we hired Satwinder Gosal, DPM, our graduating resident, to join the podiatric staff. Her enthusiasm for patient care and her desire to incorporate new treatment modalities to the list of services offered by Podiatry is exhilarating. To that end, Dr. Gosal has become our go-to person for Extracorporeal Shock Wave Therapy, a treatment option previously not offered by Podiatry. Dr. Gosal is also continuing her training in other, newer treatment modalities. We look forward to expanding the scope of treatment options available to our patients.

In October, Norman A. Wortzman, DPM, accepted the position of Lead Podiatrist. With the assistance of Dr. DiGiovanni, Dr. Wortzman identified a number of projects that will expand and improve the services offered by the Podiatry.

As we look toward the future, we hope to hire additional Podiatric staff, as we anticipate an increased need for Podiatric services in all venues including the main campus, the FAC in Waltham, and the health centers in Chelsea, Charlestown, and Revere.

We will work with the Vascular, Endocrine, and Infectious Disease services to develop a comprehensive diabetic wound clinic. We look forward to developing a Podiatric fellowship in diabetic wound care as well.

**Orthopaedic Oncology Service**

The Orthopaedic Oncology Service includes Francis J. Hornicek, MD, PhD; Kevin A. Raskin, MD; Joseph H. Schwab, MD; and Santiago Lozano-Calderon, MD, PhD. Dr. Raskin leads the fellowship, which recently underwent successful ACGME review. Dr. Lozano-Calderon continues to split his clinical time between the MGH, Beth Israel Deaconess, and Boston Children’s.

At the MGH the Orthopaedic Oncology, General Surgery/Surgical Oncology, Medical Oncology, Radiation Oncology Services, and the members of Pathology and Radiology form the Center of Sarcoma and Connective Tissue Oncology, offering specialized multidisciplinary patient care. This facility provides comprehensive care for children and adults with bone and soft-tissue tumors, and is a regional, national, and international referral center for these complex tumors. The service has been focusing on a multidisciplinary sarcoma database and collecting quality of life measures.

In the Molecular Sarcoma Laboratory Dr. Hornicek and Zhenfeng Duan, MD, PhD, are involved in ongoing multiple collaborative efforts to study tumor multidrug resistance and develop novel drugs to treat cancer. They are working with researchers at Northeastern University on nanoparticle delivery of drugs and imaging agents, which have in the past resulted in a NIH U01 grant. Collaboration with Chinese investigators at First Hospital of Zhengzhou University has been fruitful and hopefully will continue to expand. They are also involved in a unique sarcoma SPORE grant with the cooperative group SARC. Dr. Schwab and Dr.
Soldano Ferrone continue to focus on immunotherapy for sarcomas and related tumors, working together with the Surgical Oncology Division of General Surgery.

The Stephan L. Harris Chordoma Center continues to grow and has secured funding for the next five years. Collaboration with Memorial Sloan Kettering and the Mayo Clinic has grown to include other institutions and completed quality of life projects. Francis Hornicek, MD, PhD was promoted to Professor of Orthopaedic Surgery at Harvard Medical School.

**Pediatric Orthopaedic Surgery**

Pediatric Orthopaedics at the MassGeneral Hospital for Children (MGH/C) remains clinically and academically active. Service Chief Brian Grottkau, MD, continues to provide an outstanding patient experience for our diverse patient population with the assistance of Maurice Albright, MD, Director of the fellowship program; Gleeson Rebello, MBBS; Saechin Kim, MD, PhD; and Jeff Kreher, MD. They are assisted by their new fellow, Chondra Boddu, MBBS, who completed a knee fellowship at the Lenox Hill Hospital, and the numerous and outstanding HCORP residents who they are privileged to have rotate through the service.

Yonggang Pang, MD, PhD, continues to co-direct the Pediatric Orthopaedic Laboratory for Tissue Engineering and Regenerative Medicine. The focus of the lab is to discover and develop minimally invasive therapies for pediatric orthopaedic ailments. A number of exciting and significant discoveries continue to be made with the assistance of their lab manager, visiting scholars, and students.

A new initiative has been launched to provide pediatric orthopaedic services at the Shriners Hospitals for Children-Boston. While pediatric orthopaedics has been a presence at the Shriners Hospitals since its inception, it has always been provided in a support capacity to the burn mission. This past year, the Shriners Hospitals-Boston developed a five-year business plan and committed extensive resources to building pediatric orthopaedics at the hospital. Orthopaedics was the founding core mission for the Shriners Hospitals system, and this has been a natural fit. The surgeons of the Division of Pediatric Orthopaedics have been chosen to develop and operate this initiative. We are excited to participate and look forward to the synergistic growth we anticipate at the MGH/C.

**Shoulder Service**

The Shoulder Service, under the direction of Jon J.P. Warner, MD, has continued to advance care through clinical quality initiatives, research, and teaching. At the MGH, much of Dr. Warner’s strategic agenda has focused on patient-centric care delivery initiatives. Central to this philosophy has been the implementation of a web-based shoulder registry, which lets patients report their recovery after surgery. This has allowed us to generate “recovery curves” for multiple procedures. Early analysis has demonstrated that patients recover much faster after shoulder arthroplasty than rotator cuff repair; in the case of the former, pain is almost completely resolved by two weeks after surgery. These insights will allow us to further improve upon the patient’s process of recovery. This work will be incorporated into some of the educational programs at Harvard Business School, according to Professor Michael Porter, an expert in Value-Based Care.

Dr. Larry Higgins and Dr. Warner continue to systematically analyze all patient outcomes, which are published on the patient website, [www.bosshin.com](http://www.bosshin.com) as “Quality Measures.”

Dr. Neal Chen, who recently joined the Hand and Upper Extremity Service, has played a key role on the Shoulder Service in the management of complex reconstruction surgeries. He has worked closely with our fellows, teaching and assisting them with both complex shoulder surgery and elbow reconstructions.

Dr. Luke Oh continues to serve a dual role on the Shoulder (and Elbow) Service and the Sports Medicine Service. Dr. Thomas Holovacs continues to manage a busy practice and teach the Harvard residents.

After ten years of collaboration and fruitful research, we said farewell to Daniel Massimini,
PhD, who had been the research workhorse for the MGH Shoulder Biomechanics Laboratory. He has accepted a position working in cardiothoracic research for Boston Scientific Company in Minneapolis, MN.

This year four fellows graduated from our postgraduate program. Amit Sood, MD, has joined a busy private practice in New Jersey; Gregory Mallo, MD, has begun private practice in Long Island, New York; Gil Freeman, MD, has joined private practice in Green Bay, Wisconsin; and Jeremy Axe, MD, has returned to private practice, joining his father’s practice in Delaware.

Orthopaedic Spine Service
In February 2015, Louis G. Jenis, MD, assumed the role of Chief of the Spine Service at MGH and Director of the Orthopaedic Spine Center. He joined an accomplished group of talented surgeons including Thomas Cha, MD; Joseph Schwab, MD; Fred Mansfield, MD; Brian Grottkau, MD (Chief of Pediatric Orthopaedics); Saechin Kim, MD; Frank Pedlow, MD, and Kirkham Wood, MD. The service provides comprehensive treatment for a multitude of spinal disorders including cervical, thoracic and lumbar degenerative, pathologic and traumatic conditions. In collaboration with our rehabilitation medicine specialists, anesthesia pain service, physical therapists, and nursing and case management staff, we deliver care focused on a multidisciplinary team approach.

The MGH Orthopaedic Spine Service experienced significant growth in 2015. Surgical volume increased by 29% (in-patient procedures) while outpatient surgeries increased by 77%. The number of patients evaluated in the Spine Center also rose by 48%. Access to our spine specialists has improved with clinics at the Newton-Wellesley, Foxboro, Waltham, and Danvers.

The Spine Service has placed great emphasis on identifying and improving care processes and operational efficiencies. Preoperative optimization projects have included applying indices to stratify risk assessment, coordinating postoperative discharge destination by risk assessment prediction tools, and enhancing education with patient guides, website information and videos. Fast Track and High Risk/Complex Spine surgery pathways have been developed to standardize treatment with a patient-centric approach.

Additional redesign efforts have focused on postoperative means to reduce the risk of readmission and return to the emergency room by creating tools to maintain communication with the patient. These methods include a callback program, initiated by our nurse practitioners, as well as an innovative text-based informational system providing instant feedback between the patient and his/her surgical team.

Resident and fellow education and training remain high priorities for the Spine section. One Harvard Orthopaedic resident (PGY-4) on a three-month rotation and three Harvard Combined Spine Surgery fellows (rotating between MGH and BWH) participate in an active educational experience. In addition to their clinical duties, each fellow contributes to numerous research projects and presentations.

Drs. Jenis, Cha, Schwab, Hornicek and Wood participated in the 5th Annual International Spine Symposium hosted by MGH and the Peking Medical Center 3rd People’s Hospital in Beijing in November. In addition, presentations by faculty were given at the American Academy of Orthopaedic Surgeons, North American Spine Society, Cervical Spine Research Society, Lumbar Spine Research Society, and Orthopedic Research Society.
Our Spine fellows in 2015 were Dr. Kevin Park, who is now in private practice at OrthoAtlanta in Atlanta, GA, and Dr. Ravi Patel, who joined a private practice at the Brain and Spine Institute of California in Newport Beach. We are confident they will find great success in the future!

**Sports Medicine Service**

During the third year under its Chief, Dr. Matthew T. Provencher, the MGH Sports Medicine Service has grown and developed into an exceptional clinical, educational and research group that attends to and investigates the most complex sports-related and orthopaedic conditions. The Sports Medicine Service’s continued effort towards providing patient-centric care with a strong focus on research has also developed within the Service. The work done by the sports division, whether in clinic or research, is rooted in the division’s collective dedication to providing excellent care, outstanding medical education to students, residents and fellows, and leading research efforts that immediately benefit our patients. Our team is diverse in training and is composed of multiple disciplines including non-operative sports providers, an expert sports-specific physical therapy and training group, and sports surgeons with expertise in shoulder, elbow, hip and knee, and lower extremity surgery. Aside from this productivity, the promise of our program has also surged considerably through the installation of 3D printing projects investigating bony lesions of the shoulder. Moreover, research in knee injuries and prevention has also become a developing strength of the sports medicine team. Following the establishment of the ACL Center of Excellence, a growing collaborative approach has been taken effect, which spans the arenas of research, education, outreach, and development. As a result of the collective effort of our 50-member team, the Sports Medicine Center continues to work towards developing a national standard for all aspects of ACL injury and care, ranging from radiology, basic science and biomechanics to sports performance and physical therapy.

Through the leadership of Scott Waugh, PT, the sports medicine physical therapy team has developed both clinically and academically with the overall focus of providing exemplary education. This education not only centers on the interaction between patient and PT, but between PT and PT residency as well. After the providing this care and values our relationships with these organizations. Accordingly, the service has made an effort to strengthen our relationships with these teams through participation in other mutually beneficial work. In addition, under the leadership of Dr. Pete Asnis, the medical care of the Boston Bruins has grown to an NHL-recognized entity of the highest caliber in the NHL. Under the direction of Drs. Larry Ronan and Pete Asnis, the Boston Red Sox have greatly expanded the scope of sports medicine to one that is recognized as among the best in Major League Baseball. This relationship has also cultivated the Homebase Wellness Program, which the MGH and Boston Red Sox co-sponsor to improve the health and wellness of our wounded military warriors.

The Sports Medicine Research program has grown in productivity over the past year with the recent addition of an ACL study group under the leadership of Dr. Pete Asnis. Multiple research projects relating to glenoid bone reconstruction in young active patients, proper alignment of CT scans for shoulder diagnosis, bipolar bone loss characterization in glenohumeral joint, and 3D modeling are ongoing. Aside from this productivity, the promise of our program has also greatly expanded the scope of sports medicine to one that is recognized as among the best in Major League Baseball. This relationship has also cultivated the Homebase Wellness Program, which the MGH and Boston Red Sox co-sponsor to improve the health and wellness of our wounded military warriors.
establishment of the Northeast’s first sports physical therapy residency, the importance of educating both patients and future PTs has steadily grown over the past year. With this residency program, the MGH sports physical therapy team has not only increased in number, but, more importantly, in strength. The program is now fully certified and one highly coveted position. Our team of physical therapists offers top sports-centric physical therapy for patients undergoing non-operative and post-operative care. In partnership with Northeastern University, our service is also responsible for educating and training future physical therapists. Our new website also provides fundamental therapy protocols for our patients by offering perpetually accessible care, which was made possible through the efforts of our PTs. Lastly, our weekly conferences continue to provide our physical therapists, students, and surgeons with active discourse concerning injuries and treatments in order to learn from one another.

During this academic year, the MGH Sports Medicine Service hosted a number of visiting faculty speakers from around the world. We were honored to host Dr. Jo Hannafin of the Hospital for Special Surgery this past year as our 8th Augustus Thorndike lecturer.

A highly regarded leader in the field of sports medicine, Dr. Hannafin gave a wonderful lecture that was well received by all of us at MGH Sports. In line with our goal of granting topnotch education to our students, residents, and fellows, a number of hands-on cadaveric and plastic model labs were organized where national experts provided dissection and procedure-specific training. In addition, we hosted world-renowned shoulder and elbow expert Dr. Buddy Savoie from Tulane, and Dr. Michael Axe from Delaware. All of these learning experiences gave our many trainees invaluable instruction.

Under the direction of Fellowship Director Dr. Matthew Provencher and Associate Program Director Dr. Luke Oh, the MGH Sports Medicine fellowship continues to thrive. The match process for fellows starting in 2015 recruited one of the best fellowship classes. The sports fellowship provides world-class education in sports medicine and surgery, and all fellows work synergistically with the Shoulder Division under the direction of Dr. Jon J.P. Warner. Over the past year, our fellows have continued to work closer with the Physical Medicine and Rehabilitation fellow in an effort to not only provide more well-rounded care to our patients, but more well-rounded education to all fellows across the Sports Medicine Center. In addition, our fellows will continue to have high-level exposure to disorders of the knee, foot and ankle, as well as sports medicine injuries, with future plans for hip arthroscopy and joint preservation.

The MGH, as well as the MGH Sports Medicine Service and its physicians, garnered a number of recent honors. U.S. News & World Report, as well as Boston Super Doctors, and Patients’ Choice Awards, recognized many of the doctors in our service as Top Doctors in America. Dr. Matthew Provencher received several recognitions as one of the top shoulder and knee surgeons in the US. His research projects were accepted at multiple national and international society meetings.

Luke S. Oh, MD, was selected as one of three 2015 Traveling Fellows by the Asia-Pacific Knee Arthroscopy and Sports Medicine Society (APKASS) and the American Orthopaedic Society for Sports Medicine (AOSSM). During a three-week timeframe, Luke visited six countries and delivered seven lectures at grand rounds at various hospitals in Singapore, Hong Kong and Macao, regional arthroscopy and sports medicine conferences in Putrajaya, Kuala Lumpur and Shenzhen, as well as at the annual APKASS meeting in Taipei. Luke gave talks in the Thrower’s Shoulder and Elbow, Biceps/Triceps injuries, Osteochondritis Dissecans, and Elbow Arthroscopy. After his return, he has been active in the Magellan Society of Sports Medicine Traveling Fellows and co-hosted the Traveling Fellows from Europe last year and will co-host
the group from Asia next year with Andreas Gomoll, MD, from Brigham and Women’s Hospital.

The Sports Medicine Service would like to hire a hip arthroscopist and joint restoration specialist, as well as an additional knee and shoulder surgeon by mid-to-late 2016. The service looks forward to continued success and growth in clinic and research. We remain dedicated to providing top-notch care to our patients along with outstanding education to our students, residents, and fellows in a collaborative and collegial manner.

**Orthopaedic Trauma Service**

The Trauma Service, under the direction of Mark Vrahas, MD, continues its tradition of excellence in clinical care. Every three years the MGH Trauma Program is evaluated by the American College of Surgeons (ACS) for verification as a Level I trauma center. This year’s ACS review once again singled out the Orthopaedic Trauma Service as a strength of the program.

Our Geriatric Inpatient Fracture Service (GIFTS), under the direction of geriatrician Esteban Franco Garcia, MD, remains robust. He is embedded on the Orthopaedic Trauma Service and directs the care of fracture patients over the age of 65. Our most recent data shows full-day reduction in length of stay compared to pre-GIFTS data, as well as a reduction in time to OR and in variable costs. More importantly, we all believe the collaboration has greatly improved the quality of our care. Working with Dr. Franco Garcia, our faculty and residents have developed a much greater appreciation of the unique medical and social needs of elderly patients. Working in conjunction with the Harvard Orthopaedic Trauma initiative, the GIFTS program is contributing to our research efforts. Dr. Alvarez Nebreda, a geriatrician from Spain, has joined us for a year as a research fellow. He is conducting several studies we hope will contribute to the general knowledge of how to better care for these patients.

Our research program, in collaboration with the Harvard Orthopaedic Trauma Initiative, continues to grow. The recent AAOS meeting included 31 presentations from the Harvard Orthopaedic Trauma Initiative. This year we added a full-time research director, Michael McTague, as well as a second full-time research assistant to manage our research efforts. Our research infrastructure provides support and direction for residents and medical students working on projects, and insures full compliance with all federal and state mandates.

Under the direction of Suzanne Morrison, we created a summer research experience for undergraduate students. The program’s popularity has far exceeded our expectations. This year we had over 400 applicants from universities around the country for seven spots. We involve the students in ongoing projects, and additionally give them a chance to experience the operating room and the general routine of clinical care. Our only disappointment is that we have to turn away so many students.

Paracelsus University in Austria has funded an opportunity for their medical students to spend time working with our orthopaedic trauma research program. Four students a year will spend two months with us working on projects. Our first two visitors have hit the ground running. We expect the opportunity to be valuable for us as well as for the visitors.

The Trauma Service continues to reach out beyond just our service. Dr. Mark Vrahas has taken a major role working with Partners Population Health Management to guide population health initiatives. Soon all services will routinely collect Patient Reported Outcome
Measures (PROM), as well as data for risk stratification and appropriateness. Marilyn Heng, MD, working as the EPIC Orthopaedic Czar, has done a great job preparing the orthopaedic physicians and their staff for the coming of eCare in April. R. Malcolm Smith, MD, is working with MGH Global Health to develop an initiative in Uganda. The New England Trauma Summit, a CME course for regional orthopaedic surgeons, started by Drs. Vrahas and Jesse Jupiter, celebrated its 15th anniversary this year. The course has sold-out attendance every year since its inception. Dr. Smith has taken over as chairman of the New England Fracture Forum, a program dedicated to resident education, and we expect another good turnout this year.

Dr. Vrahas was the guest editor for the December 2015 special orthopaedic trauma issue of Operative Techniques in Orthopaedic Surgery. Eleven of the contributing authors were either current faculty or alumni of the trauma program. Dr. Vrahas was also one of the editors of the 4th edition of the classic text, Fractures of the Pelvis and Acetabulum.

Finally, Dr. Vrahas achieved the academic rank of Professor at Harvard Medical School and was named the Robert W. Lovett Professor of Orthopedic Surgery at a wonderful ceremony at the Paul S. Russell, MD, Museum of Medical History and Innovation.

Orthopaedic Research Laboratories

Please see selected references at the end of the report.

Sarcoma Molecular Biology Laboratory

The Sarcoma Molecular Biology Laboratory (SMBL) is under the direction of Zhenfeng Duan, MD, PhD, and Orthopaedic Oncology Service Chief Francis J. Horinek, MD, PhD. The focus of the laboratory’s work is to analyze the molecular biology of sarcoma, examine the mechanisms of multidrug resistance (MDR), identify small molecules and targets to reverse drug resistance, and understand the molecular mechanisms governing the growth and proliferation of human sarcoma cells.

The overall objective of the laboratory is to explore biological mechanisms of tumors arising in bone and other soft tissues. One major focus is to elucidate the mechanisms of the development of drug resistance in cancer. Previously, we found multidrug resistance could be partially reversed by siRNA targeting of ABCB1 (MDR1) or by a combination of nanoparticles with chemotherapy drugs. We have identified two small molecules that can overcome drug resistance in vitro and in vivo. Another significant aim of the research is to define the essential kinases responsible for the proliferation and survival of human sarcoma cells. We have discovered that several kinases are essential in tumor cell growth and survival. In addition, translational research into new treatment options for patients is underway.

The Sarcoma Molecular Biology Laboratory published several articles pertaining to sarcoma and multidrug resistance in human cancer. One paper of note is “Nsc23925 prevents the development of paclitaxel resistance by inhibiting the introduction of P-glycoprotein and enhancing apoptosis,” which was published in the International Journal of Cancer. The major limitation to the success of chemotherapy in osteosarcoma is the development of multidrug resistance (MDR). Preventing the emergence of MDR during chemotherapy treatment has been a high priority of clinical and investigational oncology, but it remains an elusive goal. The NSC23925 has been identified as a novel and potent MDR reversal agent. Therefore, this study
aims to evaluate the effects of NSC23925 on prevention of the development of MDR in osteosarcoma. We observed that tumor cells selected with increasing concentrations of paclitaxel alone developed MDR with resistance to paclitaxel and other Pgp substrates, whereas cells cultured with paclitaxel-NSC23925 did not develop MDR and cells remained sensitive to chemotherapeutic agents. Our findings suggest that NSC23925 may prevent the development of MDR by specifically preventing the over-expression of Pgp. Given the significant incidence of MDR in osteosarcoma and the lack of effective agents for prevention of MDR, NSC23925 and derivatives hold the potential to improve the outcome of cancer patients with poor prognosis due to drug resistance.

“The roles and therapeutic potential of cyclin-dependent kinases (CDKs) in sarcoma” was published in *Cancer and Metastasis Reviews*. Many patients with metastatic or recurrent osteosarcoma show poor prognosis with current chemotherapy agents. Therefore, it is important to improve the general condition and overall survival rate of patients with osteosarcoma by identifying novel therapeutic strategies. Our results demonstrate that CRISPR-Cas9 system is a useful tool for the modification of endogenous CDK11 gene expression, and CRISPR-Cas9 targeted CDK11 knockout may be a promising therapeutic regimen for osteosarcoma treatment.

Research projects have received funding from a variety of sources including the National Institutes of Health, foundations, corporate sponsors, and other benefactors.

**Laboratory for Musculoskeletal Tissue Engineering**

The Laboratory for Musculoskeletal Tissue Engineering, under the direction of Mark Randolph, focuses on cartilage repair and regeneration of the knee. The laboratory’s mission is to conduct cutting-edge research in tissue engineering and regenerative medicine for repairing and regenerating musculoskeletal tissues to restore normal function to patients. The research program explores tissue engineering approaches to repair and regenerate damaged musculoskeletal tissues following traumatic sports-related injuries, particularly in the knee. The laboratory provides training in research methodology to undergraduates, medical students, and postdoctoral research fellows. Programs have been developed in three primary areas: 1) articular cartilage repair and regeneration; 2) meniscal repair and replacement; and, 3) photochemical tissue bonding to promote healing.

A primary area of investigation seeks to develop novel approaches for the repair and regeneration of damaged articular cartilage. One strategy employs the use of hydrogel polymers for delivering chondrocytes or chondrogenic precursor cells directly into cartilage defects. The expected outcome is that new cartilage matrix is formed as the polymer biodegrades. In vivo results have been published using fibrin polymer, poly (ethylene glycol), and hyaluronic acid gels. In collaboration with Robert Redmond, PhD, from the MGH Wellman Center for Photomedicine, and Kristi Anseth, PhD, a chemical engineer at the University of Colorado, ongoing work sponsored by the US Department of Defense is focused on developing photochemically cross-linked hydrogels for cartilage repair and regeneration in a preclinical large animal swine model. Previous studies have demonstrated that collagen hydrogels can be photochemically cross-linked to encapsulate chondrocytes, facilitating new cartilage matrix formation in nude mice. In collaboration with the Anseth group, projects are underway to chemically synthesize PEG norbornene gels and perform modifications to the polymers to enhance cartilage forming abilities. With greater understanding of cell polymer interactions and the possible incorporation of growth, it may be feasible to engineer cartilage that resembles native cartilage in every parameter. The aim is to move this technology toward clinical application.

In collaboration with Stephanie Bryant, PhD, at the University of Colorado, another aspect of hydrogel development is exploring the rational design of patient-specific hydrogels for cartilage repair. In work funded by the NIH, we are using computational methods to model desirable attributes of the materials to compose photochemically crosslinkable hydrogels for...
cartilage repair. The predictive modeling is compared to the experimental results using the gels to validate the models. Ultimately, the goal is to have patient-specific inputs to include in the computational models and design appropriate gels for repair and regeneration of the cartilage.

The cartilage repair program is also exploring the source and utility of chondrogenic precursors for cartilage repair. In work funded by the Department of Defense, we are collaborating with Hong Mei, MD, and David Scadden, MD, in the MGH Center for Regenerative Medicine on identifying the source of stem cells involved in cartilage repair. We are using genetically modified mice in which the stem cell populations can be labeled and followed in a pulse-chase fashion. Following cartilage injury, this will permit the identification of stem cells and stem cell niches that are involved in the repair. If these cell populations can be identified, isolated and optimized, they could become valuable sources for cell-based therapy of cartilage injury.

We have developed a light-activated tissue sealing method that rapidly and securely seals coaptation sites and leads to improved outcomes in peripheral nerve repair in simple pre-clinical models. In Photochemical Tissue Bonding (PTB), a photoactive dye is applied to the tissue surfaces, which are brought into contact and illuminated with low power green light to form an immediate water-tight seal. The dye used is Rose Bengal (RB), which is FDA-approved for diagnosis of ocular surface defects. RB associates strongly with the collagen-rich surfaces of tissues and biomaterials so that chemical cross-linking of structural proteins across the interface forms a strong water-tight bond. No additional solder or adhesive is used and the process does not cause increases in temperature of the tissues. We have published numerous reports on the use of PTB where nerve transection sites are wrapped with thin amnion wraps and bonded to promote peripheral nerve regeneration. A recent report in Plastic and Reconstructive Surgery has extended these findings to treating gaps in peripheral nerves with nerve grafts and PTB with amnion wraps. Large animal studies are now underway to treat five-centimeter gaps in the ulnar nerve of swine.

**Bioengineering Laboratory**

The Bioengineering Laboratory, under the direction of Guoan Li, PhD, has entered its 15th year and is a leader in the field of musculoskeletal engineering and biomechanics. The laboratory continues to make significant contributions to several subspecialty areas including arthroplasty, spine biomechanics, and sports medicine.

Under the collaboration of Drs. Ring, Chen, Hosseini, and Li, the lab initiated studies of the in vivo biomechanics of the hand joint by investigating the hand kinematics of patients with Carpal Tunnel Syndrome and evaluating the alteration in carpal biomechanics in an open carpal tunnel release technique vs. an endoscopic carpal tunnel release technique.

Drs. Hosseini and Kim have continued their focus on studying the biochemical structure of patellofemoral joint (PFJ) using MRI T2 signals as a prognostic tool for joint degeneration. They evaluated patient-specific PFJ cartilage status of ACL-reconstructed knees at three years’ postoperatively by comparing their T2 relaxation times and with those of their uninjured contralateral knees to determine changes in the cartilage tissue related to osteoarthritis.

Dr. Tsai concentrated on in vivo hip and knee kinematics using fluoroscopic imaging systems with Drs. Kwon, Rubash and Li. In collaboration with Jeffrey DeClaire, MD, from the DeClaire LaMacchia Orthopaedic Institute, an investigation on in vivo joint function of bi-cruciate retaining total knee arthroplasty has been initiated and the in vivo dynamic behavior of the BCR total knee arthroplasty is being analyzed. The research team celebrated 15 journal publications, which successfully accessed in vivo kinematics of the native hip/knee and total hip/knee replacements during various physiological activities.

Jing-Sheng Li, the lab’s core bioengineer, continues to pursue his PhD at Boston University’s Health Science Department. Under
the supervision of Dr. Li and Dr. David Felson of Boston University Medical Center, he is conducting his thesis research on the prevention of OA in obese patients.

Sean Driscoll, the lab’s former core bioengineer, investigated in vivo intervertebral motion characteristics of the cervical spine. This work, in close collaboration with Thomas Cha, MD, MBA, is aimed at providing insights into innovative surgical implants and techniques. Also, in collaboration with Martin Torriani, MD, from the Department of Radiology, the spine research group is using quantitative MRI techniques to investigate intervertebral cervical disc composition. Dr. Yu Yan, from Shanghai, China, an attending spine surgeon at the Tong Ji Hospital of Tong Ji University in China, has recently joined the spine research team to help Dr. Cha in the study of lumbar and cervical spine biomechanics. Dr. Zhan Liu, an associate professor of Biomechanical Engineering from Sichuan University in China, also continues to excel in spine research and is investigating in vivo lumbar disc loading using a combined DFIS and 3D finite element method.

There have also been other new additions to the laboratory. Dr. Seung-Hoon Baek came from Yonsei University Hospital in Seoul, Korea to investigate knee biomechanics after total knee arthroplasty. Dr. Lin Lin and Dr. Peng Yin from Beijing, China joined the Laboratory to examine ACL impingement issues and the indications to ACL reconstruction and cruciate retaining TKAs.

The lab published a series of studies using advanced imaging techniques to determine in vivo spinal disc deformation, and hip/knee articular motion. These studies demonstrated the capability to accurately measure 6DOF motion of joints in the knee, hip, spine and joint arthroplasty during dynamic functional activities such as gait, step-up and sit-to-stand. With this exciting technique, we have secured several research grants to investigate the in vivo functional performance of spine, TKA and THA. This project is aimed at revealing in vivo function of the retained ACL and PCL and improving the longevity of the prosthesis.

The team published 32 papers in prestigious peer-reviewed journals in the areas of arthroplasty, spine, sports medicine, and biomechanics. In addition, the team secured several competitive grants from the NIH and other foundations to study the biomechanical intricacies of hip/knee arthroplasty, spine pathology, and ACL reconstruction.

**Musculoskeletal Genetics and Regenerative Biology Laboratory**

The Musculoskeletal Genetics and Regenerative Biology Laboratory (MGRBL), under the direction of Jenna Galloway, PhD, entered its third year with the Center for Regenerative Medicine and the Department of Orthopaedic Surgery. In this past year, the lab was very productive and significant advances were made in research projects on tendon and ligament repair and regeneration.

Using human stem cells and mouse and zebrafish genetic models, the laboratory gained a greater understanding of tendon cell behaviors during development, maturation, maintenance, and injury. The laboratory also developed and performed a high-throughput screen using transgenic zebrafish and identified cartilage and tendon promoting drugs. By combining these interdisciplinary approaches, the lab hopes to expand our understanding of tendon and ligament biology and impact the way we treat these injuries in humans. In addition, the lab hosted an undergraduate from Harvard University, Grant Sprow, who is writing his senior thesis. Grant received the HSCI summer research program fellowship, which sponsored his research in the lab last summer.

The lab was also successful at securing funding from the Arthritis National Research Foundation, the American Federation of Aging Research, the Hood Foundation, and an R03 from the NIH. Dr. Galloway was invited to speak at the Zebrafish Disease Model Meeting, ZDM8, an international conference spotlighting zebrafish models of human disease. In addition to this, the laboratory published two papers in the *Journal of Orthopaedic Research* and *Current Molecular Biology Reports*. We look forward to another exciting and enriching year!
Harris Orthopaedic Laboratory
The Harris Orthopaedic Laboratory (HOL) has over five decades of experience addressing problems in adult reconstructive surgery by innovating new surgical techniques, devices, joint implant designs, and joint implant materials. Notably, this laboratory developed several clinical implant formulations of highly cross-linked ultrahigh molecular weight polyethylene (UHMWPE), stabilized by re-melting or vitamin E, for large scale usage in implant manufacturing. Currently, several million patients are using implants developed in this laboratory. The core cross-linking technology in these implants has changed the landscape of joint replacement by reducing the number of wear particles and instances of osteolysis associated with total joint implants.

Under the direction of Orhun Muratoglu, PhD, the laboratory’s current focus area of the pre-clinical material development team is improving the longevity of joint implants through advancing material development and treating diseases associated with implants by using material technology. The materials research team collectively brings experience in material and polymer science, polymer chemistry, biomaterials and biomechanics testing, and bench-to-clinic implant development, as well as follow-up testing of explanted devices to analyze in vivo effects. The team welcomes collaboration in all areas of orthopaedics.

Another major focus is follow-up and analysis of clinical implant performance to provide evidence-based feedback to patients and clinicians. Under the direction of Henrik Malchau, MD, PhD, the clinical research team conducts prospective national and international clinical studies on alternative bearing materials and new implant designs. This provides fast and valuable information on the performance of newly developed implants and helps compare them to historical standards. These studies also provide feedback on surgical techniques and skills to improve clinical outcomes. The clinical team is currently developing these capabilities into an Academic Coordinating Organization, ACRO, in order to perform comparative prospective multi-center studies as well as to augment these studies with performance data obtained from national and regional registries. In this way, they will be able to provide more timely data to industry and regulatory bodies and provide a sustainable, independent scientific and academic environment for research fellows, pre-medical and medical students.

Monoclonal Antibody & Immunotherapy Laboratory
Our basic science initiative focuses on understanding the means by which musculoskeletal neoplasms evade the immune system. Under normal circumstances the immune system surveys, identifies and removes cancerous and or pre-cancerous cells. One of the ways in which the immune system does this is via the interaction between T lymphocytes and cell surface proteins known as HLA class 1 antigens. HLA class 1 cell surface proteins are expressed by most of the normal nucleated cells of the body. These antigens present intracellular antigens to the host immune system via a T cell receptor. Most cells have normal proteins presented via HLA class 1 and thus are identified as normal and left alone. It is when cells present abnormal proteins, such as in the case of cancer cells, that lymphocytes are activated via their T cell receptor. The activated T cells then lyse the abnormal cells. This is one of the common means by which the immune system prevents cancers from growing.

There is increasing evidence that many cancer cells are able to circumvent the system using various mechanisms. One of the ways that cancer cells bypass this system is by down regulating their expression of HLA class 1, thereby making them invisible to the host immune response. If cells are not expressing HLA class 1, then the host T cells do not identify them and cannot select the abnormal proteins since the proteins are not visible to the T cells. Another way by which the cancer cells evade the immune system is by inhibiting T cell responses. A multitude of cell surface proteins inhibit T cell responses; this is a beneficial checkpoint under normal circumstances. These inhibitory proteins help prevent autoimmune destruction of cells by T cells. One such protein that can act as an
inhibitor of T cell function is B7H3. This is another area of focus in our laboratory.

Currently, our lab is focusing on three tumors including chondrosarcoma, chordoma, and giant cell tumors.

**Chondrosarcoma**

We have developed a tissue microarray of 80 chondrosarcoma tumors. We have used this tissue microarray to study the host immune response to chondrosarcoma. We have found, paradoxically, that many of the low-grade chondrosarcoma tumors do not express HLA class 1 antigens. Interestingly, there is data to suggest that normal cartilage cells also do not express HLA class 1 antigens. However, as chondrosarcomas become more aggressive, and their grade increases, we find a linear increase in HLA class 1 antigen expression. In fact, the most aggressive chondrosarcoma, so-called dedifferentiated chondrosarcoma, expresses the highest amount of HLA class 1 antigen. As one might expect, lymphocytic infiltrates should also increase as HLA class 1 antigen expression increases, and our data suggest a direct correlation between the HLA class 1 antigen expression and T cell infiltration. This is somewhat paradoxical since most aggressive tumors (in which patients usually die within one year of their diagnoses) express the highest level of HLA class 1 antigens and also have the most robust immune response. Clearly, there must be an inhibitory mechanism in place. We began to study whether the B7H3 was expressed in chondrosarcoma; interestingly, we found that B7H3 is expressed in chondrosarcoma and its expression increases as the grade of the tumor increases. In this way, it appears that the B7H3 is acting like an inhibitory protein preventing T cells from lysing the tumor cells. Pharmaceutical companies are currently developing therapeutic antibodies and small proteins targeting B7H3. These may serve as useful adjuvants in the treatment of patients with aggressive diseases.

**Giant Cell Tumors**

There is a lot of controversy about how to treat giant cell tumors. We have investigated the role of the HLA class 1 antigen system and the role of T-cell lymphocytes in treating giant cell tumors. Significant lymphocytic infiltrates in giant cell tumors exist that have never been described. Furthermore, little has been written about immune function in giant cell tumors. In many giant cell tumors there is a lack of HLA class 1 antigen expression. However, in some tumors HLA class 1 is intact and, in fact, there is a lymphocytic response. The most aggressive tumors seem to have the highest expression of B7H3. There seems to be a lymphocytic response to these giant cell tumors, but these tumors are circumventing the immune system, possibly by inhibiting T-cell function via B7H3.

**Pediatric Orthopaedic Laboratory for Tissue Engineering and Regenerative Medicine**

The Pediatric Orthopaedic Laboratory for Tissue Engineering and Regenerative Medicine is directed by Brian Grottkau, MD, and co-directed by Yonggang Pang, MD, PhD. The primary goals of our laboratory are: (1) 3D bioprinting for tissue regeneration and, (2) developing in vitro tissue models using bioprinting technology and tissue engineering. We are currently growing and preparing to move from our limited space on Simches 3 to a larger area in the Orthopaedic Department laboratories on Jackson 11. Over the past 18 months we have made great strides in a number of areas.

This year we made significant progress in developing injectable micro bone and cartilage
tissues for tissue regeneration via a minimally invasive approach. Dr. Dongyang Ma, a post-doctoral fellow from China, joined us and worked on developing and preparing 3D bioprinted injectable cartilage tissues. Dr. Ma and other colleagues prepared proof-of-concept studies in piglet ex vivo cartilage specimens.

Zhixin (Cindy) Hui, MS, joined us from Georgetown University as a technologist and lab manager. She has been working on tumor and liver model bio-printing. The focus of her research is on cancer cell bioprinting and liver model cell printing for drug development and high-throughput screening. We made significant advances in this translation medicine arena and hope to develop commercially relevant tissues for industrial and academic collaboration.

Regarding industry collaboration, we have been in talks with Eli Lilly to potentially utilize our patent pending technology to produce tumor and liver micro tissues for high-throughput screening and drug development.

Dr. Yao, using our well-developed 3D printing and water soluble mold technique, made tissue engineering long bones patterned from the 3D CT of the mirror image of the contralateral long bone (e.g., femur). We envision that this technique can be used to provide anatomically precise intercalary engineered autografts for limb salvage or fracture loss. Additionally, engineered joints could be used to replace arthritic ones.

In order to fully develop both our injectable bone and cartilage microtissues and micro cancer and liver models, we tasked a summer student, Andrew Grottkau, to develop a 3-D bioreactor. With the assistance of Drs. Pang and Grottkau, Andrew designed and built a novel 3D rotating bioreactor, which is used to culture our live printed cells in three dimensions.

**Technology Implementation Research Center**

The Technology Implementation Research Center (TIRC) is under the direction of Orhun Muratoglu, PhD, and Kartik Mangudi Varadarajan, PhD. The goal of the TIRC is to conduct translational research addressing critical challenges in adult reconstructive surgery, principally in relation to implants, surgical instrumentation and biomaterials. TIRC projects and expertise are structured to expedite the translation of basic science research to active clinical use. The TIRC works with several physicians in the department including Drs. Andrew Freiberg, Henrik Malchau, and Harry Rubash. The clinical insights brought by the physician team members are instrumental to the success of the TIRC’s overall mission. The TIRC also has an outstanding team of Research & Development engineers who bring incredible energy and engineering skill to the laboratory.

This year marked the successful completion and publication of important studies related to TIRC technologies. A series of studies on the kinematic performance of ACL-preserving and ACL-sacrificing “biomimetic” knee implants were accepted in leading peer-reviewed journals. These studies showed how biomimetic articular surfaces that mimic normal knee anatomy and meniscus function, and could aid in more closely reproducing normal knee motion following knee replacement surgery. Another TIRC technology involves an anatomic dual mobility liner designed to mitigate soft-tissue impingement by reducing distal profile of the implant. A biomechanical study showing the efficacy of this design in reducing soft-tissue impingement and liner entrapment in cadaver specimens was recently published. To further analyze the interaction of the new design with native soft tissues, a number of finite element analysis studies are being conducted. Initial results from these studies show that the anatomic liner design may reduce both the mechanical stresses experienced by the soft tissue, as well as the load transfer to the liner rim during engagement with the femoral stem. The TIRC also presented over 25 abstracts at major national and international conferences, related to these and other studies.

The TIRC continues to build upon the hard work of past years to bring about clinical adoption of technologies that can benefit patients. The center has several other exciting projects in the pipeline, which we hope to share in the future.
Holiday Party
We celebrated our 11th annual holiday party this past December. This enormously popular event, held at the beautiful Seaport Hotel, was another resounding success. Over 500 guests were treated to a delicious dinner and a fantastic evening of dancing and entertainment. Everyone had a wonderful time and enjoyed the collegiality of the extraordinary Orthopaedic Department. This is one of our favorite events!

Some of our staff enjoying the holiday party!

Greg Pauly, MGPO Chief Operating Officer, and wife Pauline Pauly; Ruby Kang, wife of James Kang, MD, Chief of Orthopaedic Surgery at Brigham and Women's Hospital; Arun Shanbhag, PhD, MBA, daughter Meera, and wife Manashi

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**Sports Medicine Service**


**Orthopaedic Trauma Service**


Sarcoma Molecular Biology Laboratory


3. G. Laboratory for Musculoskeletal Tissue Engineering


Bioengineering Laboratory


8. G. Laboratory for Musculoskeletal Tissue Engineering


Musculoskeletal Genetics and Regenerative Biology Laboratory

Harris Orthopaedic Laboratory

Monoclonal Antibody & Immunotherapy Laboratory
Pediatric Orthopaedic Laboratory for Tissue Engineering and Regenerative Medicine


Technology Implementation Research Center


