



2020

ORTHOPAEDICS

ANNUAL
REPORT

 WVUMedicine

CONTENTS

01 WELCOME

02 FACULTY

- 06 Faculty Honors
- 08 Advanced Practice Providers
- 10 Staff

12 PATIENT CARE

- 13 Hand Repair
- 14 Sports Medicine
- 16 COVID-19 Update
- 17 WVU Health System

18 RESIDENCY PROGRAM

- 20 Graduates and Current Residents
- 22 Resident Research Year
- 23 Presentations and Publications

26 RESEARCH

- 28 Post-Operative Infection
- 29 Active Grants
- 30 2020 Publications: Orthopaedics

32 THANK YOU

THE CHAIRMAN'S

WELCOME

2020 — What a year!



A true pandemic, disrupting our social, business, and yes, medical lives. I will talk more about COVID later in this report, and although at time of this writing the virus is more under control, it is not over. Thankfully, our department's success has continued despite 2020. We have over 36 clinical faculty working our home base, J.W. Ruby Memorial Hospital, and five orthopaedists slated for regional system hospitals.

Developed for our Adult Reconstruction patients, we continue to expand our Orthopaedic Medical Optimization Program to our Spine Service. This program is powered by our internists Drs. Jami Pincavitch, Kate Kasicky, and Kylie Parrish and APPs Casey Mazingo and Valerie Matyus. Our longstanding Bone Health Program, led by our rheumatologist Dr. Colleen Watkins and Ashley Barber, PhD, RN,

FNP-BC, continues to earn national recognition as a Star Performer by the American Orthopaedic Association and US News & World Report.

The new WVU Children's Hospital is opening early 2022. With the arrival of Dr. Andrew Parsons this fall, we will have four pediatric orthopaedic surgeons to handle all orthopaedic services for anyone under 18. Not only are we anxious for the new hospital to open for its own sake, the entire practice plan (including Orthopaedics) will benefit by creating space in existing facilities. Ortho, like most services, is bursting at the seams for outpatient and operating room space. In a way, good problems to have, created by growth and expansion!

I hope you enjoy this edition of our Annual Report, as we highlight the people and services of our team!

Sanford E. Emery MD, MBA

Professor and Chairman
Department of Orthopaedics
Director of Surgical Services
West Virginia University

FACULTY

Clinical and Research



C R

Sanford E. Emery MD, MBA
Chairman; Professor
Orthopaedics, Surgery



C R

John C. France MD
Chief, Spine Service;
Professor and Vice Chairman,
Director, Spine Fellowship



C R

George Bal MD
Chief, Sports Medicine Service;
Associate Professor



C R

J. David Blaha MD
Professor, Orthopaedics



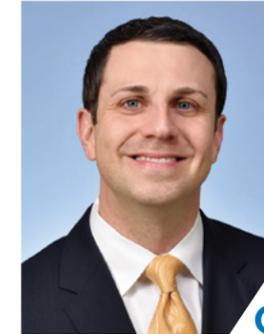
C R

Stephanie Ferimer MD
Assistant Professor, Physical
Medicine and Rehabilitation



C R

Benjamin Frye MD
Associate Professor, Orthopaedics,
Adult Reconstruction. Director,
Adult Reconstruction Fellowship



C R

Derik Geist MD
Assistant Professor,
Orthopaedics, Sports Medicine



C R

Daniel Grant MD
Assistant Professor,
Pediatric Orthopaedics



C R

Kathryn Bosia DPM
Assistant Professor,
Orthopaedics, Podiatry



C R

Jonathan Boyd PhD
Associate Professor,
Orthopaedics



C R

Michelle Bramer MD
Associate Professor,
Orthopaedic Trauma



C R

Rusty Cain DPM
Assistant Professor,
Orthopaedics, Podiatry



C R

Richard Harris DPM
Assistant Professor,
Orthopaedics, Podiatry



C R

Bethany Honce MD
Assistant Professor, Physical
Medicine and Rehabilitation



C R

David F. Hubbard MD
Chief, Orthopaedic
Trauma Service; Professor,
Orthopaedics



C R

**N.M. Nuala Crotty MB
BCh BAO**
Assistant Professor, Physical
Medicine and Rehabilitation



C R

Shari Cui MD
Assistant Professor,
Orthopaedics, Spine



C R

Scott Daffner MD
Professor, Orthopaedics,
Spine



C R

Matthew Dietz MD
Associate Professor,
Orthopaedics, Adult
Reconstruction



C R

Dina Jones PT, PhD
Professor Orthopaedics,
Human Performance - Physical
Therapy, WVU Injury Control
Research Center



C R

**Cherie L.
Kelly-Danhires DPM**
Assistant Professor,
Orthopaedics, Podiatry

The following faculty members earned promotions from Assistant Professor to Associate Professor on July 1, 2020.

DR. MICHELLE BRAMER

DR. BENJAMIN FRYE

DR. BROCK LINDSEY

CONGRATULATIONS!

FACULTY & STAFF

Clinical and Research



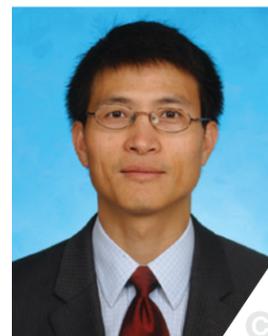
Kathryn Kasicky MD
Assistant Professor,
Orthopaedics, Internal
Medicine



Adam Klein MD
Assistant Professor,
Orthopaedics, Adult
Reconstruction



Andréa Lese MD
Assistant Professor,
Orthopaedics, Hand and
Upper Extremity



Bingyun Li PhD
Professor, Orthopaedics,
WVU Cancer Institute
Research Programs



Brock Lindsey MD
Chief, Adult Reconstruction;
Musculoskeletal Oncology, Associate
Professor, Orthopaedics; Director,
Orthopaedic Research Laboratory



Justin Lockrem MD
Assistant Professor,
Orthopaedics,
Sports Medicine



John P. Lubicky MD
Chief, Pediatric Orthopaedics;
Professor, Orthopaedics



David Lynch MD
Assistant Professor, Physical
Medicine and Rehabilitation



Ming Pei MD, PhD
Professor, Orthopaedics; Associate
Professor, Human Performance -
Exercise Physiology; WVU Cancer
Institute Research Programs



B. Joseph Prud'homme MD
Chief, Hand and Upper
Extremity; Associate
Professor, Orthopaedics



Mary Louise Russell MD
Assistant Professor, Physical
Medicine and Rehabilitation



Shafic Sraj MD
Assistant Professor, Orthopaedics,
Hand and Upper Extremity



E. Barry McDonough MD
Associate Professor,
Orthopaedics, Sports Medicine



Benjamin Moorehead MD
Assistant Professor,
Orthopaedics, Sports Medicine



T. Ryan Murphy MD
Assistant Professor, Orthopaedics,
Adult Reconstruction



Jami Pincavitch MD
Assistant Professor,
Orthopaedics, Internal Medicine



David Tager MD
Assistant Professor,
Pediatric Orthopaedics



John Taras MD
Professor, Orthopaedics,
Hand and Upper Extremity



Colleen Watkins MD
Associate Professor,
Orthopaedics, Rheumatology/
Metabolic Bone



David Waxman MD
Associate Professor, Orthopaedics,
Adult Reconstruction

WELCOME NEW FACULTY



Louis Bivona MD
Assistant Professor,
Orthopaedics, Spine



Andrew Parsons MD
Assistant Professor,
Pediatric Orthopaedics



Drew Wroblewski MD
Assistant Professor,
Orthopaedics, Hand
and Upper Extremity

FACULTY & STAFF

Awards and Honors



John P. Lubicky, MD, FAOA, is being honored as an AOA Pillar of the Orthopaedic Profession for his contributions to the subspecialty of pediatric orthopaedic surgery and pediatric spinal surgery. Dr. Lubicky's recognition is being championed by Sanford E. Emery, MD, MBA, FAOA.

Dr. Lubicky graduated from Philadelphia-based Sidney Kimmel Medical College, then known as Jefferson Medical College of Thomas Jefferson University and completed his internship and residency from the Medical College of Virginia Hospitals, Richmond, VA. He continued his training in Chicago by completing two fellowships; one at Rush-Presbyterian-St. Luke's MC, University of Illinois MC in Spine Surgery and the other at Shriners Hospitals for Children in Pediatric Orthopaedic Surgery.

He was the first chair holder of Rush University's Ronald L. DeWald, MD, Endowed Chair in Spinal Deformities, established in 1996. As a Professor of Orthopaedics

at West Virginia University School of Medicine, Dr. Lubicky trains residents and fellows, and is involved with clinical research activities including the development of new treatments and procedures.

In 2018, Dr. Lubicky performed the first robotic-assisted pediatric spine surgery in West Virginia using the Mazor X robotic system to treat a patient's neurofibromatosis and severe scoliosis.

Throughout his influential career, he has provided patient care to children from around the world. Starting in 1992, in his work with Lithuanian Children's Hope at the Vilnius University Children's Hospital, he provided patient care as well as professional teaching in pediatric orthopaedics and spine surgery to the hospital's staff and residents for more than 15 years. During that time, he and his team also brought thousands of dollars' worth of donated instruments, implants, and OR materials to help the struggling staff.

As a member of the American Orthopaedic Association since 1993, Dr. Lubicky is a dedicated supporter of AOA programs and initiatives.

The AOA acknowledges and appreciates Dr. Lubicky's significant contributions to the orthopaedic specialty, and proudly recognizes him as an AOA Pillar of the Orthopaedic Profession.



AMERICAN
ORTHOPAEDIC
ASSOCIATION

"[This] honor for Dr. John Lubicky is to recognize his national and international contributions to the orthopaedic profession in pediatric orthopaedics and particularly scoliosis."

Sanford E. Emery, MD, MBA, FAOA, Chairman, Orthopaedics



Vice President's Award

Dr. Bingyun Li, Professor of Orthopaedics, was named 2020's recipient of the Outstanding Achievement in Research and Scholarly Activities by the selection committee for the Vice President's Awards for Outstanding Achievement.

West Virginia University Health Sciences recognized 11 individuals and one team with Vice President's Awards for their significant contributions to the mission of the Health Sciences Center.

Each year, the Vice President's Awards honor faculty and staff who have been recognized by their peers for their outstanding accomplishments. This award recognizes contributions that enhance the mission of the faculty's academic unit and the Health Sciences Center through outstanding achievements in research, scholarship, or creative activities. Winners were nominated by their peers and selected by their respective Achievement Award committees. Selection for this award among peers is a great professional distinction.

A virtual ceremony to honor the 2020 award winners was held in September 2020.

FACULTY & STAFF

Advanced Practice Providers

In addition to our many faculty and residents, the WVU Department of Orthopaedics employed the services of 24 Advanced Practice Providers (APPs) in 2020.

This group of APPs included 20 Physician Assistants and four Nurse Practitioners. We also have an additional three Physician Assistants who are expected to start throughout the summer in 2021.

As our department continues to expand, the role of our APPs has continued to evolve to help meet the changing needs of orthopaedic patient care. These APPs also play a vital role in our clinic and operating room efficiencies. Their responsibilities include, but are not limited to, evaluating and treating patients in clinic, assisting with surgeries and clinical procedures, pre-operative examinations, patient communication,

triage and follow-up, and data collection for ongoing research projects. Our APPs are involved in every subspecialty within our department as well as our Orthopaedic Medical Optimization Program (OMOP) and our inpatient service. In addition, several of our APPs participate in our satellite and outreach clinics across West Virginia and southwestern Pennsylvania. These providers travel with faculty to clinic locations in Fairmont, Parkersburg, Martinsburg, Wheeling, Summersville, and Waynesburg, PA. In collaboration with our faculty providers, our APPs continue to work diligently to provide high quality orthopaedic care to all of our patients at WVU Medicine.

UTC APPs – Left to Right: Jon Kline, Valerie Matyus, Casey Mozingo, Kelsey Laughery, Travis Randolph, Katie Seifried, Kris Smith, Amy Stubblefield, Niko Tasser



POC APPs –
Left to Right:
Laura Stavrakis,
Brittany Dzugan,
Holly Bonnell,
Stacy Skidmore

ADULT RECONSTRUCTION

Alicia Cooper, PA-C
Kelsey Laughery, PA-C
Kristianna Richio, PA-C
Katie Seifried, PA-C
Stacy Skidmore, PA-C

PEDIATRIC ORTHOPAEDICS

Holly Bonnell, PA-C
Brittney Dzugan, PA-C

PHYSICAL MEDICINE AND REHABILITATION

Gyl Cendana, PA-C
Meredith Liddle, PA-C

ATHLETICS

Travis Randolph, PA-C

HAND & UPPER EXTREMITY

Colleen Allison, APRN
Kyria Gaydosh, PA-C
Jon Kline, PA-C
Nikolas Tasser, PA-C

SPINE

Emily Courtwright, PA-C*
Morgan Neal, PA-C
Jackie Walker, PA-C*
Josee Zydonik, PA-C

INPATIENT

Laura Dent, PA-C
Thomas Gocke, PA-C
Claire Leinhauser, PA-C*

SPORTS MEDICINE

Kristopher Smith, PA-C
Amy Stubblefield, PA-C

TRAUMA

Laura Stavrakis, PA-C

METABOLIC BONE DISEASE

Ashley Wilson, APRN

WAYNESBURG CLINIC

Ron Bewick, PA-C

**Incoming 2021*

SPINE APPs - Left to Right:
Emily Courtwright, Morgan Neal,
Meredith Liddle



MUSCULOSKELETAL ONCOLOGY

Stacy Skidmore, PA-C

ORTHO MEDICAL OPTIMIZATION PROGRAM

Valerie Matyus, APRN
Casey Mozingo, APRN

FACULTY & STAFF

Staff Members



◀ **POC Staff** – Left to Right: Renee Dillow (Lead Ortho Tech), Todd Kinsley (ACA), Melissa McDonald (ACA), Amanda Davis (Ortho Tech), Ashley Luzader (ACA), Mickayla Blackburn (Ortho Tech), Victoria Gifford (ACA)

▼ **SPINE Staff** – Left to Right: Jordan Michaels (RN), Stacy Marolt (Registration Specialist), Christina Lattanzo (Lead Ortho Tech), Bri Mathess (Radiology Tech), Geoff Rozak (Radiology Tech)



▲ **HSC Staff** – Left to Right: (front row) Logan Carpenter (Surgical Scheduler/Admin Assistant), Laasha Justice (Surgical Scheduler/Admin Assistant), Jenn Forquer (Surgical Scheduler/Admin Assistant), Melinda Quarrick (Surgical Scheduler/Admin Assistant), Heather Hudson (Surgical Scheduler/Admin Assistant), (back row) Antoinette Summers (Administrator), Brenda Sandy (Financial Analyst), Nancy McGalla (Surgical Scheduler/Admin Assistant), Elaine Cumberledge (Lead Surgical Scheduler/Admin Assistant), Lisa Myles (Surgical Scheduler/Admin Assistant), Kerry Fluharty (Executive Assistant)



▶ **UTC Staff** – Left to Right: Jackie Horton (Surgical Scheduler/Admin Assistant), Adrian Hagood (Surgical Scheduler/Admin Assistant)



▲ **UTC Staff** – Left to Right: Natalie Gilbert (RN), Felix Daniher (Care Manager), Paige Barker (RN), Cynthia Drummond (RN), Kerry Howard (RN)

CENTER: UTC Staff – Tera Fetty (Athletic Trainer)

◀ **UTC Staff** – Left to Right: (front row) Morgan Ford (Ortho Tech), Jamie Koval (Ortho Tech), Tiffany Whittaker (MA), Angela Lamp (MA), (back row) Holly Moore (Ortho Tech), Jess Kaczmarczyk (Ortho Tech)

PATIENT CARE



Life-Changing Hand Procedure

Shafic Sraj, M.D., WVU Medicine orthopaedic hand surgeon, offers a simple, life-changing procedure for patients who suffer from Dupuytren's contracture, a condition that pulls and holds fingers in a bent position.

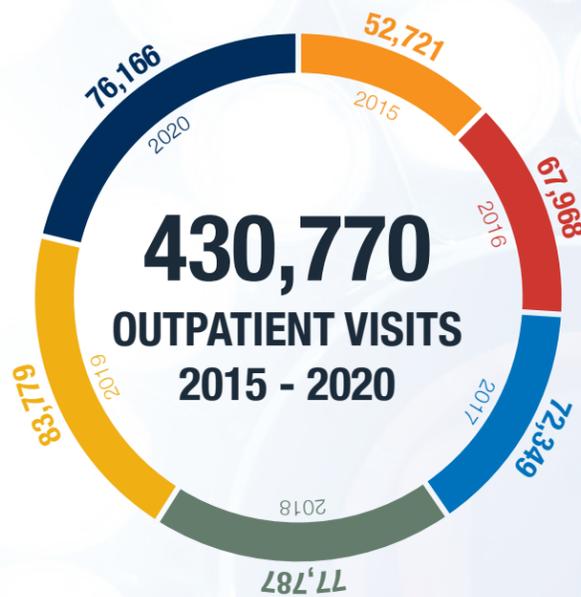
Dupuytren's contracture develops over time and is caused by diseased tissues of the palm and fingers. Over time, the contracture develops into thick cords and pulls the fingers toward the palm. The little and ring fingers are the most commonly affected.

"This condition can severely affect the patient's quality of life," Dr. Sraj said. "Patients have a hard time grabbing things and putting on gloves because they are unable to fully open their hand. The bent fingers can get caught in tight spaces like purses or pockets."

The cord can be released in less than a minute, usually during the very first visit, using the tip of a needle. The release allows the immediate improvement of motion, provides instant relief, and eliminates a trip to the operating room.

"Patients often neglect to treat this condition because they think it involves complicated surgery, which was the case historically," Sraj said. "Nowadays, however, we are able to greatly improve the patient's quality of life in a fast and minimally invasive way."

To see a video about the procedure, visit www.youtube.com/watch?v=GcQ0eGq0apA



ORTHOPAEDIC CLINICS

We have three conveniently located clinics in Morgantown, Fairmont, and now Waynesburg, PA. The Morgantown location is in the Physician Office Center, attached to J.W. Ruby Memorial Hospital. The Fairmont location is housed in our WVU Medicine Outpatient Center, directly across from the I-79 Downtown Fairmont exit. The Waynesburg clinic features multiple specialties and is located off the I-79 Waynesburg exit.

WVU MEDICINE SPORTS MEDICINE CENTER

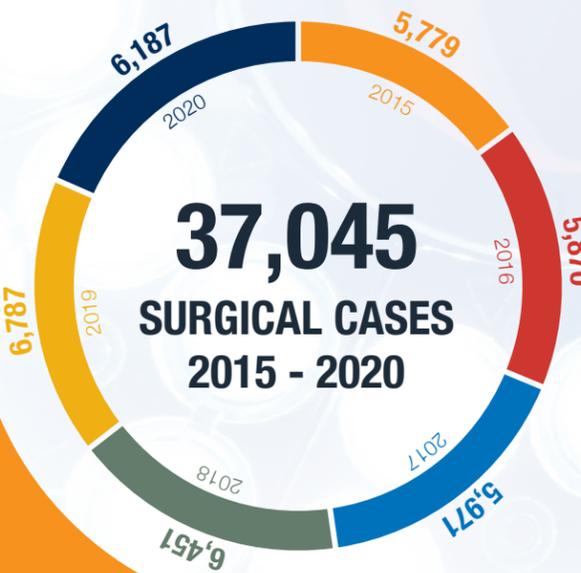
WVU's Sports Medicine Center cares for athletes of all levels. We work to get all patients back to their highest level of activity possible. Our physicians manage sports-related injuries and medical conditions that include muscle and joint pain, sprains, and concussions. The WVU Sports Medicine Center has access to specialists from multiple disciplines, including Orthopaedics and experts from the WVU Spine Center. Individuals with sports injuries have same-day access to our services, which are available around the clock, seven days a week.

UNIVERSITY TOWN CENTRE

University Town Centre is the home for several of our Orthopaedic centers, including the Center for Joint Replacement, the WVU Sports Medicine Center, and the Orthopaedic Hand Clinic. WVU Medicine University Town Centre is conveniently located in the University Town Centre development just off I-79 in Granville. This spacious center offers patients access to their favorite primary care providers.

WVU SPINE CENTER

The WVU Spine Center brings specialists together with a multidisciplinary team approach to provide our patients with comprehensive spinal care. We use a full range of treatment options to ensure that patients with spine problems get the treatment they need quickly, efficiently, and easily. The Spine Center combines the expertise of WVU neurologists, orthopaedic specialists, neurosurgeons, pain management physicians, and rehabilitation services to target every patient's particular problem and provide optimal treatment.



CENTER FOR JOINT REPLACEMENT AT WVU MEDICINE

The Center for Joint Replacement at WVU Medicine offers patients a comprehensive planned course of treatment. We believe our patients play a key role in ensuring a successful recovery. Our goal is to involve our patients in their treatment through each step of the program.

PATIENT CARE

Sports Medicine

On November 22, 2019, Jennings Newcome, an employee of WVU Medicine, was installing a parking lot light at Jefferson Medical Center and was electrocuted. A jolt of energy coursed through his body, contracted his muscles forcefully, and knocked him backwards to the ground.

As he lay there in shock, his thoughts focused on what had just occurred, unaware of the excruciating searing pain that would set in approximately 45 minutes later in both shoulders.

Shortly thereafter, the staff at the Jefferson Medical Center Emergency Room evaluated Mr. Newcome's injuries. Review of the x-rays showed that he sustained

left and right proximal humerus fractures, resulting from the intense force of all his muscles contracting. These contractions crushed the ball portion of the ball and socket joints of his shoulders. Mr. Newcome was in disbelief – he never had any prior shoulder pain or any inability to function at home or work until now.

Discussions between Jefferson Medical Center and J.W. Ruby Memorial Hospital in Morgantown directed Mr. Newcome to Derik Geist, MD, a surgeon in the WVU Department of Orthopaedics who specialized in sports medicine and shoulder reconstruction.

With both arms in slings and experiencing significant pain, Mr. Newcome arrived at Dr. Geist's clinic for evaluation. Based on the severity of his injuries and the destruction of his bone, it was recommended that he undergo staged reverse total shoulder arthroplasties for his condition. At J.W. Ruby Memorial Hospital, Mr. Newcome underwent surgery for the right shoulder on December 20, 2019. This was followed by surgery for the left shoulder on January 9, 2020. Post-operatively, he stayed overnight in the Bone and Joint Hospital within J.W. Ruby Memorial Hospital, which is dedicated to treatment of orthopaedic patients. Regarding his hospital stays, Mr. Newcome stated, "The care I was given, I was very pleased with."

After his surgeries, Josh Miller, PT, DPT, COMT and Head of the Department of Physical Therapy at Jefferson Medical Center, nurtured Mr. Newcome to recovery. Mr. Newcome acknowledged that "he needed someone to push him" towards his goals, and Josh was a vital partner towards that success.

Currently, Mr. Newcome feels that he is "90%-95% back" to what he perceives as his "normal" function with his shoulders. He stated, "I have very little pain." Although he did note that he might sense

"[Dr. Geist is] very professional, very good at his job, and I'm just very pleased with what he's done for me."

Jennings Newcome, patient

BEFORE:
LEFT SHOULDER



RIGHT SHOULDER



AFTER:
LEFT SHOULDER



RIGHT SHOULDER



AFTER:
SHOULDER MOBILITY



a difference with changes in the weather, he is now able to do day-to-day activities and reach fully overhead without hindrance or pain. He is now able to do all of his electrical and maintenance duties at his job that he was previously doing, and is back to keeping Jefferson Medical Center up and running without any concerns regarding his shoulders.

When asked about his experiences regarding Dr. Geist's treatment and care of him, Mr. Newcome stated, "He's very professional, very good at his job, and I'm just very pleased with what he's done for me."

PATIENT CARE

COVID-19 Update

As Chair of the Department of Orthopaedics at WVU, I am extremely proud of our faculty, staff, and residents in response to the COVID-19 crisis of 2020.

In anticipation of a full hospital, our elective surgical services were shut down in March, April, and part of May. Clinics remained open, but were smaller as patients avoided going out. Trauma, infection, tumor, and some neurological cases kept us surgically busy at a basal rate. Medicine and ICU physicians plus staff were getting the brunt of the virus attack.

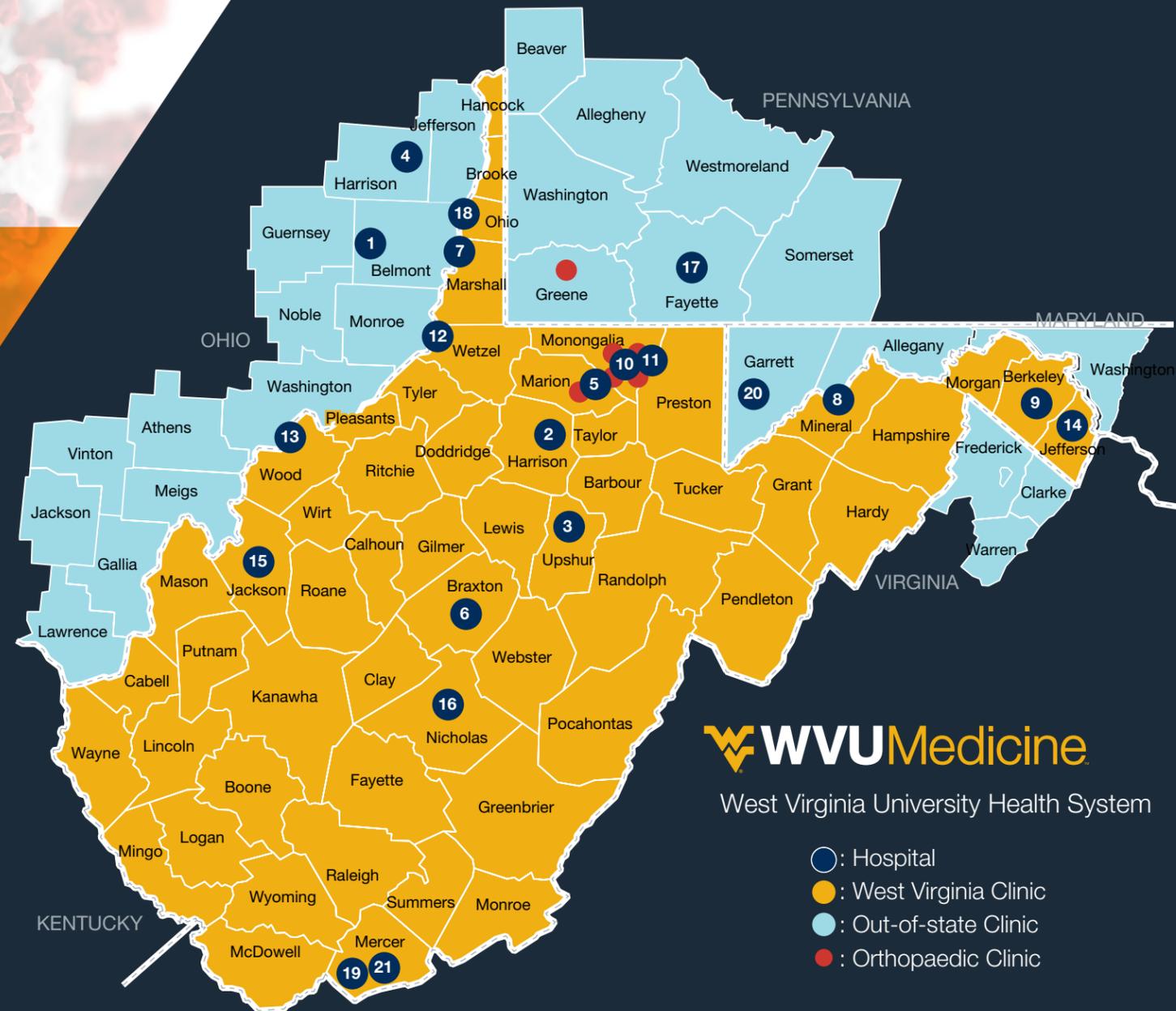
Catch up plans for Orthopaedics were created by our faculty and instituted June through September. During these months, our total joint teams performed elective operations on Saturdays and Sundays to address the backlog of patient needs. Kudos to our faculty, APPs, nursing, and surgical tech staff for working above and beyond the call of duty! It was a major effort and greatly appreciated by patients and the department.

In response to the second COVID surge in November 2020 - January 2021, we again suspended elective surgeries like the rest of the country. As of this writing, we have been busier than ever since March, hoping the severity of COVID-19 will be controlled by vaccines as we move toward 2022.



Sanford E. Emery MD, MBA

Chairman, Department of Orthopaedics



WVUMedicine

West Virginia University Health System

WVU ORTHOPAEDIC CLINIC LOCATIONS

- MORGANTOWN**
Physician Office Center
- MORGANTOWN**
WVU Spine Center
- MORGANTOWN**
WVU Medicine Sports Medicine Center
- MORGANTOWN**
Center for Joint Replacement at WVU Medicine
- FAIRMONT**
WVU Medicine Outpatient Center: Fairmont
- WAYNESBURG**
WVU Medicine Outpatient Center: Waynesburg

MEMBER SYSTEM HOSPITALS

- 1. BARNESVILLE, OHIO**
Barnesville Hospital
- 2. BRIDGEPORT**
United Hospital Center
- 3. BUCKHANNON**
St. Joseph's Hospital
- 4. CADIZ, OHIO**
Harrison Community Hospital
- 5. FAIRMONT**
Fairmont Medical Center
A CAMPUS OF J.W. RUBY MEMORIAL HOSPITAL
- 6. GASSAWAY**
Braxton County Memorial Hospital
- 7. GLEN DALE**
Reynolds Memorial Hospital
- 8. KEYSER**
Potomac Valley Hospital
- 9. MARTINSBURG**
Berkeley Medical Center
- 10. MORGANTOWN**
Children's Hospital
A CAMPUS OF J.W. RUBY MEMORIAL HOSPITAL
- 11. MORGANTOWN**
J.W. Ruby Memorial Hospital
- 12. NEW MARTINSVILLE**
Wetzel County Hospital

MANAGED HOSPITALS

- 13. PARKERSBURG**
Camden Clark Medical Center
- 14. RANSON**
Jefferson Medical Center
- 15. RIPLEY**
Jackson General Hospital
- 16. SUMMERSVILLE**
Summersville Regional Medical Center
- 17. UNIONTOWN, PENNSYLVANIA**
Uniontown Hospital
- 18. WHEELING**
Wheeling Hospital
- 19. BLUEFIELD**
The Behavioral Health Pavilion
A CAMPUS OF PRINCETON COMMUNITY HOSPITAL
- 20. OAKLAND, MARYLAND**
Garrett Regional Medical Center
- 21. PRINCETON**
Princeton Community Hospital

The WVU Department of Orthopaedics Residency Program had another successful academic year in 2020-2021. Despite the COVID-19 pandemic, the residents continue to receive excellent training in each of the orthopaedic specialties at J.W. Ruby Memorial Hospital.

RESIDENCY PROGRAM

CONTINUED EXCELLENCE IN EDUCATION AND FACILITIES

WVU orthopaedic residents are immersed in multifaceted educational opportunities at top-notch facilities including the cadaver dissection and arthroscopy labs. Orthopaedics welcomed four new interns this year, and WVU has been provisionally approved for adding a fifth resident in the coming years.

Resident research efforts continue to be an important aspect of the program, with residents presenting their work at multiple national and regional conferences. The department took a big step back to normalcy hosting the Annual Resident Research Symposium in person May 2021, which was a great success.

FELLOWSHIP NEWS

The Chief Resident Class all attained competitive fellowships this year:

Lunden Ryan - University of Kentucky (Lexington, KY), Trauma

Brian Grisez - Holy Cross Orthopedic Institute (Fort Lauderdale, FL), Adult Reconstruction

Alexander Conti - OrthoOne Trauma at Swedish Medical Center (Denver, CO), Trauma

Daniel Liechti - Fairview/Twin Cities Orthopaedics (Minneapolis, MN), Sports

ARRIVALS AND DEPARTURES

As we say goodbye to the outgoing chiefs, we welcome a new intern class. The class of 2026-2027 includes Tyler Quinet (Medical College of Georgia), Edwin Chaharbakhshi (Loyola University), Nathaniel Williams (Penn State), and Ken Sabacinksi (Florida Atlantic).

The 2020-2021 academic year has faced unique challenges but has been a very successful one for the WVU Department of Orthopaedics. As WVU continues to train competent and conscientious orthopaedic surgeons, we look forward to what the 2021-2022 academic year has in store.



RESIDENCY PROGRAM

Graduates and Current Residents



Alex Conti MD
SOM: West Virginia University
Fellowship: Swedish Medical Center Trauma Fellowship



Brian Grisez MD
SOM: West Virginia University
Fellowship: Holy Cross Orthopaedic Institute Adult Reconstruction Fellowship



Danny Liechti MD
SOM: University of Illinois, Peoria
Fellowship: Fairview/Minneapolis Orthopaedic Sports Medicine Institute



Lunden Ryan MD
SOM: West Virginia University
Fellowship: University of Kentucky Orthopaedic Trauma Fellowship



Daniel Shubert MD
SOM: Tufts University
Fellowship: University of Missouri Orthopaedic Sports Medicine Fellowship



Taylor Shackelford MD
SOM: University of Kentucky



Keenan Atwood MD
SOM: Medical College of Wisconsin



Michael Booth MD
SOM: SUNY Upstate Medical University



Michael Niemann MD
SOM: West Virginia University



Will Brooks MD
SOM: East Tennessee State University
Fellowship: UT Houston Orthopedic Sports Medicine and Shoulder Fellowship



Julie Glener MD
SOM: University of Central Florida
Fellowship: Holy Cross Orthopaedic Institute – Shoulder and Elbow



Jason Kinney MD
SOM: Augusta University
Fellowship: Johns Hopkins Adult Hip and Knee Replacement Fellowship



Justin Ray MD
SOM: East Carolina University
Fellowship: OrthoCarolina Foot and Ankle Fellowship



Benjamin Giertych MD
SOM: University of Wisconsin



Michael Quinet MD
SOM: Medical College of Georgia at Augusta University



Kenneth Sabacinski MD
SOM: Charles E. Schmidt College of Medicine at Florida Atlantic University



Nathaniel Williams MD
SOM: Pennsylvania State University College of Medicine



Justin Vaida MD
SOM: University of Massachusetts



Patrick Luchini MD
SOM: West Virginia University



Eric Neumann MD
SOM: West Virginia University



Joshua Reside MD
SOM: University of Florida



Edwin Chaharbakhshi MD
SOM: Loyola University Chicago Stritch School of Medicine



Brendan Farley MD
SOM: Central Michigan University College of Medicine



Grant Slack MD
SOM: Wright State University Boonshoft School of Medicine



Christopher Wilson MD
SOM: Penn State College of Medicine



John Pisquiy MD
SOM: Texas Tech University Health Science Center El Paso Foster School of Medicine

RESIDENCY PROGRAM

Resident Research Year

At West Virginia University, the Accreditation Council for Graduate Medical Education offers an accredited orthopaedic surgery research position each year.

At West Virginia University, the Accreditation Council for Graduate Medical Education offers an accredited orthopaedic surgery research position each year. This position is a six-year track, compared to the traditional five-year categorical track. It is completed between the residents' first and second years.

During this time, residents have no hospital-based duties or call responsibilities, which provides them with the autonomy to establish and conduct their own research projects. They also have the opportunity to participate in ongoing studies alongside several faculty research members. The residents are expected to prepare grant submissions, oversee and manage studies, present poster and podium presentations, and submit peer-reviewed manuscripts.

Brock Lindsey, MD, (Chief, Adult Reconstruction and Musculoskeletal Oncology), is the Director of the WVU Department of Orthopaedics Research Laboratory and advises lab residents during their research year. He, along

with Matthew Dietz, MD, (Adult Reconstruction), Ming Pei, MD, PhD, Bingyun Li, PhD, and Jonathan Boyd, PhD, conduct the majority of the Department's basic science research with main focuses on:

NANOTECHNOLOGY

IMMUNOTHERAPY

TISSUE REGENERATION

ONCOLOGY

INFECTION (BIOFILM)

TOXICOLOGY

The Department also has an active clinical research focus with ongoing projects in every orthopaedic subspecialty.

The WVU Department of Orthopaedics Research Laboratory is located on the fifth floor of the WVU Health Sciences Center adjacent to the main hospital campus. The 4,000-square-foot lab space contains state-of-the-art amenities capable of conducting basic science research with emphasis on tissue engineering, nanotechnology, and cadaver and pre-clinical model studies.

The Research Resident also participates in daily resident education conferences, performs monthly cadaver dissection for anatomy conference, and provides lectures to students in the School of Medicine. The opportunities and experiences generated from this year are meant to serve as a foundation for a career as a clinician-scientist.

2019-2020 Presentations and Publications

PODIUM AND POSTER PRESENTATIONS

Vaida J, Bravin D, Bramer M. Evaluating the Efficacy of Topical Vancomycin Powder in the Treatment of Lower Extremity Fractures. Virtual Poster. AAOS Annual Meeting. Mar 2020.

Vaida J, Liechti DJ, Shackelford TL, Lubicky JP. Complications Associated with Implant Removal after Femoral Shaft Fractures in Pediatric Populations. Virtual Podium. SOA Annual Meeting. Jul 2020.

Luchini PM, Glener JE, Vaida J, McCabe LA, Tara JS. Percutaneous Threaded Pin Fixation of Distal Radius Fracture in the Athlete.
• Virtual Poster. ASSH Annual Meeting. Oct 2020.
• Virtual Podium. NYU 2020 Scientific Program and Sir Robert Jones Lecture. Nov 2020.

Glener JE, Vaida J, Luchini PM, Kessler MW, McCabe LA, Taras, JS. Threaded Pin and Volar Plate Fixation of Distal Radius Fractures: Early Functional Recovery. Virtual Poster. ASSH Annual Meeting. Oct 2020.

Lu Z, Zhou S, **Vaida J**, Gao G, Stewart A, Parenti J, Yan L, Pei M. Matrix Mediated Cartilage Regeneration in a Rabbit Articular Defect Model. ORS Annual Meeting. Feb 2020.

Shackelford TL, Niemann M, Vaida J, Davis S, Braga S, Coyne K, Bronikowski D, Sraj S. Second Interosseous Pinch Strength: Normative Values and Potential Use as an Indicator of Isolated Ulnar Nerve Intrinsic Motor Function. ASSH Annual Meeting. Oct 2020.

Vaida J, Ray JJ, Shackelford TL, Santrock RD. Reduction of Foot Width with Triplanar Tarsometatarsal Arthrodesis for Hallux Valgus Deformity. Virtual Poster.
• ACFAS Annual Scientific Conference. Feb 2020.
• AOFAS Annual Meeting. Sept 2020.
• SOA Annual Meeting. Jul 2020.

Reside JM, Ray JJ, Shackelford TL, Koay J, Dayton P, Hatch DJ, Smith WB, Santrock RD. Impact of Preoperative Metatarsus Adductus on Surgical Correction after Triplanar Tarsometatarsal Arthrodesis. Virtual Poster. AOFAS Annual Meeting. Sept 2020.



From Left to Right: Residents Michael Booth, Michael Niemann, Taylor Shackelford, Ben Giertych, and Eric Neumann enjoy a meal in their free time.

Shackelford TL, Ray JJ, Lancaster J, Grant DR. The Effects of State Legislation on Narcotic Prescribing Practices after Surgery at a Pediatric Hospital. Virtual Poster. Pediatric Hospital Medicine Conference. Jul 2020.

Shackelford T, Nasr L, Niemann M, Davis S, Koay J, Sraj S. Impact of Pregnancy on Development of Thumb Carpometacarpal Osteoarthritis.
• ASSH Residents and Fellows Conference. 2020.
• ASSH Annual Meeting. 2020.

Shackelford T, Prince N, Boyd J, Penatzer J, Dietz M. Spatial Distributions of Cytokines in Chronic Localized Infections. MSIS Annual Meeting. Aug 2020.

Shackelford T, Glener J, Reside J, Dietz M. Fluorescent Angiography in Primary and Revision Knee Arthroplasty.
• SOA Annual Meeting. Jul 2020.
• MSIS Annual Meeting. Aug 2020.

Interested in learning more?
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RESIDENCY PROGRAM

2019-2020 Presentations and Publications (cont.)



From Left to Right: Residents Eric Neumann, Michael Booth, Julie Glener, Joshua Reside, and Taylor Shackelford enjoy a day out on the water.

Shackelford T, Atwood K, Lemons W, Eicher J, Dietz M, Frye B, Murphy T, Klein A. Post-Discharge Opioid Use Following Total Hip and Total Knee Arthroplasty. SOA Annual Meeting. Jul 2020.

Shackelford T, Niemann M, Vaida J, Davis S, Braga S, Coyne K, Bronikowski D, Sraj S. Second Interosseous Pinch Strength: Normative Values and Potential Use as an Indicator of Isolated Ulnar Nerve Intrinsic Motor Function. ASSH Residents and Fellows Conference. 2020.

Lokant M, Lastinger A, Dietz M, **Giertych B, Niemann M, Makani A, Williams S, Eicher J.** Utilization of a Distress Thermometer in Prosthetic Joint Infection Combined Clinics. Virtual Podium. ACS West Virginia Chapter Meeting. 2020.

PUBLICATIONS

Bostian PA, **Ray JJ, Karolcik BA, Bramer MA, Wilson A, Dietz MJ.** Thromboelastography is Predictive of Mortality, Blood Transfusions, and Blood Loss in Patients with Traumatic Pelvic Fractures: A Retrospective Cohort Study. European Journal of Trauma & Emergency Surgery. 2020. Epub ahead of print. DOI: 10.1007/s00068-020-01533-8

Hatch DJ, Dayton P, DeCarbo WT, McAleer JP, **Ray JJ, Santrock RD, Smith WB.** Analysis of Shortening and Elevation of the First Ray with Instrumented Triplane First Tarsometatarsal Arthrodesis. Foot & Ankle Orthopaedics, 5(4), 1-8. 2020. DOI: 10.1177/2473011420960678

Vaida J, Ray JJ, Shackelford TL, DeCarbo WT, Hatch DJ, Dayton P, McAleer JP, Smith WB, Santrock RD. Effect on Foot Width with Triplanar Tarsometatarsal Arthrodesis for Hallux

Valgus. Foot & Ankle Orthopaedics, 5(2), 1-5. 2020. DOI: 10.1177/2473011420934804

Dietz MJ, **Ray JJ, Witten BG, Frye BM, Klein AE, Lindsey BA.** Portable Compression Devices in Total Joint Arthroplasty: Poor Outpatient Compliance. Arthroplasty Today, 6(1), 118-122. Mar 2020. DOI: 10.1016/j.artd.2019.12.004

Shackelford TL, Andrews R, Cui S. Neurologic Deterioration, Instrumentation Failure, and Cervical Autofusion Secondary to Noncompliance Following Reconstruction for Discitis. Case Reports in Orthopedic Research. 2020.

Prince N, Penatzer JA, **Shackelford TL, Stewart EK, Dietz MJ, Boyd JW.** Tissue-Level Cytokines in a Rodent Model of Chronic Implant-Associated Infection. Journal of Orthopedic Research. 2020.

Vaida J, Conti ADB, Ray JJ, Bravin DA, Bramer MA. Evaluating the Efficacy of Topical Vancomycin Powder in the Treatment of Open Lower Extremity Fractures. Trauma. Dec 2020.

Luchini PM, Glener JE, Vaida J, McCabe LA, Taras JS. Percutaneous Threaded Pin Fixation of Distal Radius Fracture in the Athlete. Hand. Dec 2020.

Quinet MT, Raghavan M, Morris E, Smith T, Cook H, Walter N, Shuler M. Effectiveness of Amniotic Fluid Injection in the Treatment of Trigger Finger: A Pilot Study. Journal of Hand Surgery Global Online. 2(5), 301-305. 2020.

Niemann M, Brooks W, Cavanaugh P, Lese A, Taras J. Excision of a Rare Triquetral Body Fracture Nonunion. Journal of Hand Surgery Global Online. Jan 2021. DOI:10.1016/j.jhsg.2020.12.002

Booth M, Sraj S. Clinical Photography is a 'Snap' to Implement. American Academy of Orthopaedic Surgeons Now. Oct 2020.

BOOK CHAPTERS

Vaida J, Dietz MJ. When the Race is Lost: The Clinical Impact of Prosthetic Joint Infections. Racing for the Surface: Pathogenesis of Implant Infection and Advanced Antimicrobial Strategies. Springer, 3-31. 2020.



From Left to Right: Residents Jason Kinney, Julie Glener, Will Brooks, and Justin Ray.

RESEARCH

Welcome to the West Virginia University Orthopaedic Research Laboratory. In the lab, you will find research and education opportunities in the areas of tissue/cartilage engineering, stem cell research, immunophenotyping, nanotechnology/nanomedicine, and toxicology. There are also opportunities in the clinical areas of adult reconstruction, spine, sports medicine, trauma, and hand and upper extremity.



The laboratory conducts *in vivo* and *in vitro* research in a modern environment. The laboratory faculty and staff are multidisciplinary and include faculty from Orthopaedics, Microbiology and Immunology, Pathology, Chemistry, and Statistics.

Graduate students from the university's Health Sciences Center collaborate with orthopaedic surgeons and bioengineers on MS and PhD research topics. The lab is situated within the Department of Orthopaedics at WVU and provides support to orthopaedic residents in research projects, both basic science and clinical. The lab is well equipped and encourages multidisciplinary musculoskeletal research between various departments in the Health Sciences Center.

RESEARCH

Post-Operative Infection

Thanks to a grant from the National Science Foundation, Matthew Dietz, MD, an Associate Professor in the WVU Department of Orthopaedics, and his colleagues can begin to understand how to successfully adapt and develop technology to combat rare infections in joint replacement surgeries.

Total hip and knee replacements have become popular for patients in recent years, and for good reason. With increasingly efficient surgeries and high success rates, it's a viable treatment for those with chronic joint problems.

But in some cases, a post-operative infection can occur with orthopaedic procedures that's particularly troublesome to combat due to limited ways to administer antimicrobials in the concentrations needed to the surgery site in an effective way, and according to Dietz, the five-year mortality rate of this complication approaches that of colon cancer, approximately 30 percent.

“[T]he ability to provide better care for patients is limited by current technology. A device that can deliver antibiotics in a better and more complete way would really decrease the burden on the patients.”

Matthew Dietz MD

“We really started down this path because we noticed the ability to provide better care for patients is limited by current technology. A device that can deliver antibiotics in a better and more complete way would really decrease the burden on the patients who get these kinds of infections,” said Dietz. “Really the only way to treat them currently is through additional procedures that limit recovery and rehabilitation.”

Along with his colleagues, Graig Marx, Dominic Lombardo, and Hamid Bhatti, Dietz will start down the path of exploring the viability of adapting or developing technology to combat these complications and what it would take to get an efficient modality of treatment in these complicated infections to market.

Dietz added that doctors are skilled in certain areas, such as performing surgeries, but may need assistance in others, like product development. This grant aims to help fill those inherent gaps.

“Like any idea, especially in medicine, it's challenging to bring it to be fully translational. Getting it from bench to bedside requires a slightly different set of skills and knowledge base of the current market and how to develop new technologies for use,” he said.

The solution wouldn't be limited to knee and hip replacements, but also orthopaedic trauma, spinal infections, and other joint replacements. According to Dietz, a solution to the problem could save the United States healthcare system more than \$1.6 billion annually.

2020 Active Grants: Faculty

JONATHAN W. BOYD PHD

- Title: Spatiotemporal Inflammation Associated with Agent Exposure
Source: US DoD – Defense Threat Reduction Agency
- Title: Neuroinflammation-related Phosphoprotein Signaling Pathways as Potential Therapeutic Targets for GWI using an Established Model.
Source: US DoD – Defense Health Agency
- Title: Future Fieldable Mass Spectrometry for Stress Biomarkers
Source: Zeteo Tech, LLC

SCOTT D. DAFFNER MD

- Title: A Phase 2b, Randomized, Double-Blind, Placebo-Controlled Study to Evaluate the Safety and Efficacy of Staphylococcus Aureus 4-Antigen Vaccine (SA4Ag) in Adults Undergoing Elective Posterior Instrumented Spinal Fusion Procedures
Source: Pfizer Pharmaceutical
- Title: M6-C Artificial Cervical Disc IDE Pivotal Study
Source: Spinal Kinetics
- Title: M6-C Artificial Cervical Disc IDE Post-Approval Study
Source: Spinal Kinetics

MATTHEW J. DIETZ MD

- Title: Relationship of Biomarkers and Fluorescence in Prosthetic Knee Infections
Source: US DHHS-NIH-National Institute of Arthritis, Musculoskeletal & Skin Diseases
- Title: Prescrib3d Technologies Active Antibiotic Spacer
Source: US NSF-Biological Sciences
- Title: WVCTSI Research Scholar Program
Source: West Virginia Clinical and Translational Science Institute

SANFORD E. EMERY MD, MBA

- Title: Prospective, Randomized, Controlled, Blinded Pivotal Study – Transforaminal Lumbar Interbody Fusion (TLIF) At 1 Or 2 Levels Using Infuse™ Bone Graft and The Capstone™ Spinal System with Posterior Supplemental Fixation For Treatment of Symptomatic Deneration.
Source: Medtronic Incorporated

JOHN C. FRANCE MD

- Title: Thoracolumbar Burst Fractures (AOSpine A3, A4) in Neurologically Intact Patients: An Observational, Multicenter Cohort Study Comparing Surgical Versus Non-Surgical Treatment
Source: AO Research Foundation

BENJAMIN M. FRYE MD

- Title: Fellowship in Adult Reconstruction
Source: OMeGA Medical Grants Association

DAVID F. HUBBARD MD

- Title: Fixation Using Alternative Implants for the Treatment of Hip Fractures
Source: McMaster University
- Title: A Prospective, Randomized, Multicenter Controlled Trial of CERAMENT™|G as Part of Surgical Repair of Open Diaphyseal Tibial Fractures
Source: BONE SUPPORT AB

DINA JONES PT, PHD

- Title: Adaptation of an Evidence-Based Fall Prevention Program for Adults with Traumatic Brain Injury in West Virginia
Source: CDC

BINGYUN LI PHD

- Title: Unique Nanotechnology Converts Carbon Dioxide to Valuable Products
Source: US DoE – Department of Energy
- Title: Innovative Nano-Hybrids with Controlled Drug Release for Bone Regeneration
Source: US DoD – Defense Health Agency
- Title: Innovative Implant Nanocoatings with Controlled Dual Drug Release for Bone Regeneration
Source: US DoD – Secretary of Defense
- Title: 3D Printed Nanoclay Enhanced Calcium Phosphate Ceramic Composite
Source: University of California at San Francisco

BROCK A. LINDSEY MD

- Title: A Prospective, Post-Market, Multi-Center Study of Tritanium Acetabular Shell
Source: Stryker
- Title: A Longitudinal Multi-Center Study of Robotic-Arm Assisted THA: Acetabular Cup Placement Accuracy and Clinical Outcomes
Source: Stryker
- Title: Delineating Mechanisms of Checkpoint Blockade Failure While Manipulating MDSCs as a Treatment to this Conundrum
Source: Musculoskeletal Tumor Society / Sarcoma Strong Foundation
- Title: Comparative Effectiveness of Pulmonary Embolism Prevention after Hip and Knee Replacement (PEPPER): Balancing Safety and Effectiveness
Source: Dartmouth College/Medical University of South Carolina

MING PEI MD, PHD

- Title: Decellularized Matrix and Cartilage Regeneration
Source: US DHHS – NIH – National Institute of Arthritis, Musculoskeletal, and Skin Disease
- Title: Allogeneic Matrix Mediated Cartilage Reconstruction
Source: Musculoskeletal Transplant Foundation

SHAFIC SRAJ MD

- Title: Mechanical Characterization of Soft and Hard Tissues for Finite Element Analysis of Impacts on Hands
Source: WVU Research and Scholarship Advancement

RESEARCH

2020 Publications: Orthopaedics

Araoye I, He JK, Gilchrist S, Stubbs T, McGwin G Jr, Ponce BA; **Collaborative Orthopaedic Educational Research Group**. A National Survey of Orthopaedic Residents Identifies Deficiencies in the Understanding of Medical Statistics. *J Bone Joint Surg Am*. 2020 Mar 4;102(5):e19. doi: 10.2106/JBJS.19.01095. PMID: 31895239.

Parvizi J, Gehrke T, Krueger CA, Chisari E, Citak M, Van Onsem S, Walter WL; **International Consensus Group (ICM) and Research Committee of the American Association of Hip and Knee Surgeons (AAHKS)**. Resuming Elective Orthopaedic Surgery During the COVID-19 Pandemic: Guidelines Developed by the International Consensus Group (ICM). *J Bone Joint Surg Am*. 2020 Jul 15;102(14):1205-1212. doi: 10.2106/JBJS.20.00844. Erratum in: *J Bone Joint Surg Am*. 2020 Oct 7;102(19):e113. PMID: 32675662; PMCID: PMC7431146.

Boukhemis K, Perez M, Olness E, Hensley JL, Lindstrom J, **McDonough EB, Bal GK**. Prospective Evaluation of Cognitive Outcomes After Anesthesia for Patients in the Beach Chair Position. *Orthopedics*. 2020 Jan 1;43(1):e27-e30. doi:10.3928/01477447-20191031-09 Epub 2019 Nov 8. PMID: 31693746

Penatzer JA, Miller J, Han A, Prince N, **Boyd JW**. Salivary Cytokines as a Biomarker of Social Stress in a Mock Rescue Mission. *Brain, Behavior, & Immunity – Health*. 2020; (4). doi: 10.1016/j.bbih.2020.100068.

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Prince N, Penatzer JA, **Dietz MJ, Boyd JW**. Impact of Cytokines and Phosphoproteins in Response to Chronic Joint Infection. *Biology (Basel)*. 2020 Jul 16;9(7):167. doi: 10.3390/biology9070167. PMID: 32708756; PMCID: PMC7407198.

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Sangani R, Rojas E, Forte M, Zulfikar R, Prince N, Tasoglou A, Goldsmith T, Casuccio G, **Boyd J**, Olfert IM, Flanagan M, Sharma S. Electronic Cigarettes and Vaping Associated Lung Injury (EVALI): Rural Appalachian Experience. *Hosp Pract (1995)*. 2020 Nov 2. doi: 10.1080/21548331.2020.1843282. Epub ahead of print. PMID: 33136442.

Prince N, Penatzer JA, **Dietz MJ, Boyd JW**. Localized cytokine responses to total knee arthroplasty and total knee revision complications. *J Transl Med*. 2020 Aug 31;18(1):330. doi: 10.1186/s12967-020-02510-w. PMID: 32867801; PMCID: PMC7461261

Shackelford T, Andrews R, **Cui S**. Neurologic Deterioration, Instrumentation Failure, and Cervical Autofusion Secondary to Noncompliance following Reconstruction for Discitis. *Case Rep Orthop Res*. 2020 May 14;(3):68-73. doi: 10.1159/000506359

Robinson WA, Carlson BC, Poppendeck H, Wanderman NR, Bunta AD, Murphy S, Sietsema DL, **Daffner SD**, Edwards BJ, Watts NB, Tosi LL, Anderson PA, Freedman BA. Osteoporosis-related Vertebral Fragility Fractures: A Review and Analysis of the American Orthopaedic Association's Own the Bone Database. *Spine (Phila Pa 1976)*. 2020 Apr 15;45(8):E430-E438. doi: 10.1097/BRS.0000000000003324. PMID: 31770343

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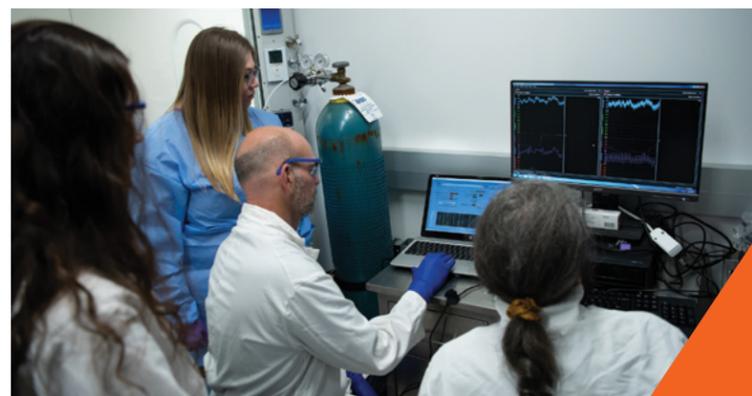
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Dr. Jonathan Boyd reviews study data with his lab students.



L-R: (1st Row) Amanda Stewart (Research Associate), Elizabeth Stewart (Research Assistant II), (2nd Row) Josh Parenti (Research Assistant III), (3rd Row) Suzanne Danley (Research & Grants Analyst), Jenn Eicher (Manager of Clinical Research & Patient Outcomes)

Turtle J, Kantor A, Spina NT, **France JC**, Lawrence BD. Hangman's Fracture. *Clin Spine Surg*. 2020 Nov;33(9):345-354. doi: 10.1097/BSD.0000000000001093. PMID: 33044269.

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Li J, Narayanan K, Zhang Y, Hill RC, He F, Hansen KC, **Pei M**. Role of lineage-specific matrix in stem cell chondrogenesis. *Biomaterials*. 2020 Feb;231:119681. doi: 10.1016/j.biomaterials.2019.119681. Epub 2019 Dec 16. PMID: 31864016; PMCID: PMC6958706.

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