



C. WAYNE MCILWRAITH
TRANSLATIONAL
MEDICINE INSTITUTE
COLORADO STATE UNIVERSITY



ORTHOPAEDIC RESEARCH CENTER

ORTHOPAEDIC RESEARCH CENTER

2022 Annual Report



Highlight Story

Dr. Myra Barrett Leads Charge in Creation of American College of Veterinary Radiology- Equine Diagnostic Imaging. Read more on page 33.

Mission

To investigate the pathogenesis, diagnosis, treatment and prevention of neuro-musculoskeletal disease and injury for the advancement of both animal and human health.

Purpose

To find holistic solutions to neuro-musculoskeletal problems, addressing restoration of function, repair of injury, and reduction of pain.

Philosophy

To develop innovative research strategies that elevate the standard and quality of patient care, with continued critical assessment of our results, and to use these novel findings to guide management of neuro-musculoskeletal diseases.

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www.vetmedbiosci.colostate.edu/orc



Letter from the Director

The strength of a program is in its people. That statement has resonated with me throughout 2022 as the ORC program came out of COVID and in 2022 (continuing into 2023) has had one of the busiest periods in equine research to date. The year began with two Department of Defense grants investigating an osteoarthritis therapy, a subchondral bone imaging project and a large cartilage resurfacing project all at once. The resilience of the staff, graduate students and faculty has been impressive. While the work is challenging and hard, it is also incredibly rewarding when carried out with precision and passion leading to diagnostic advances and treatment therapies which can help our equine patients and also translate to musculoskeletal disease in people. It is an incredible privilege to be part of this program and help facilitate individuals delving into neuromusculoskeletal problems for which we still do not have answers. Our number of faculty members continues to expand. In this issue, you will read about two young faculty, Drs. Mindy Story and Yvette Nout-Lomas who were honored with a Chaired position and a chair endowment, respectively. Dr. Mindy Story was honored with the prestigious and inaugural Leslie A. Malone Presidential Chair in Equine Sports Medicine and Rehabilitation. This chair is only the second presidential chair within the College of Veterinary Medicine and was graciously given to the Orthopaedic Research Center by Dr. John and Mrs. Leslie Malone. Dr. Nout-Lomas was chosen to receive the inaugural New Bishop Professorship given by an anonymous donor. Interestingly, both Drs. Story and Nout-Lomas work closely together on neurologic causes of musculoskeletal disease that contribute to axial skeletal pain and performance issues in equine patients. They have a large effort to expand within this specialty to answer important questions regarding disease progression and optimal therapies.

We congratulate them for these deserving honors. Within this annual report, you will also read of several faculty accomplishments as well as a mentoring award to our founding director Dr. Wayne McIlwraith for decades of mentoring graduate students and trainees. Further in this annual report, we acknowledge the important role that imaging has played in the ORC program and the impact that starting a subspecialty in the American College of Veterinary Radiology had on equine diagnostic imaging in particular. This was a valiant effort led by Dr. Myra Barrett who completed her radiology residency within CSU's radiology program and who has been an important and valued member of the ORC team for her years of participation in equine research projects. We also highlight work by several of our faculty, graduate students, and staff that are making important contributions to imaging research in horses that are not only relevant to equine diseases, but also translating this work to musculoskeletal disease experienced by people.

Another important area that the ORC is building upon is the clinical trials program. We have three ongoing or "on the horizon" in regenerative therapies that are important and relevant to joint disease. These exciting trials will help us build on the work previously done in the ORC relating to orthobiologics and stem cell therapies. These trials allow us to evaluate these therapies in patients with naturally occurring diseases. These types of trials help us "close the loop" of idea to benchtop to patient impact. They also allow us to work with industry partners to bring these therapies to market and/or optimize them to maximally benefit our patients. Applying these therapies in our patients with naturally occurring diseases brings to light the "real-world" effects of therapies.

In every report we also acknowledge our philanthropic support that has allowed us to push the envelope in science and explore new concepts, and support our staff, graduate students and principal investigators. We remain incredibly grateful to our donor base that give in honor of the horse and the work we do to support these amazing animals.

Lastly, you will read our "in memorandum" section of two giants in the field that we lost, Dr. Alan Nixon and Dr. Richard Steadman. Dr. Alan Nixon was not only one of the first large animal surgery residents at CSU but also one of the most renowned for his many contributions to both veterinary orthopedics and to human medicine as a translational scientist. He was a pioneer in translational medicine before the term was even coined. He also happened to be my PhD mentor at Cornell, College of Veterinary Medicine which further highlights the contributions of carrying on the legacy of Dr. McIlwraith's strong influences on building people and programs. As you will read, he also became an important educator in our equine arthroscopy course taught at CSU annually. His talents, his intelligence and his infectious, fun personality will be deeply missed.

The second "giant" we lost was Dr. Richard Steadman. Also an incredible person, mentor, inventor, and innovator in the field of human orthopedics. He was the founder of the Steadman Clinic which began in 1990 in Vail, Colorado and remains one of the foremost orthopedic clinics in the country known for its highly skilled specialist orthopedic surgeons and also known for the Steadman Philippon Research Institute (SPRI). SPRI has been a pivotal collaborating partner program to the ORC. This collaboration began with Dr. Steadman recognizing the important work in equine orthopedics that so closely overlapped with two innovative techniques he was developing in people. While our collaborations with SPRI continue, we will never forget Dr. Steadman's contributions to our work and his character as a humble but driven clinician scientist.

Thank you for reading this report. I remain grateful and honored to be part of this legacy created decades ago and I am so appreciative of the hard work and dedication of this team, our supporters, collaborators and donors that allow us to carry on the important mission of the ORC.

Very respectfully,

Laurie Goodrich



ORC TEAM

Faculty/Principal Investigators

Laurie Goodrich - Director of ORC, Barbara Cox Anthony University Chair, Professor of Equine Surgery & Lameness

C. Wayne McIlwraith - University Distinguished Professor, Founding Director of ORC, Barbara Cox Anthony University Chair Emeritus

Myra Barrett - Associate Professor, Veterinary Diagnostic Imaging

Luke Bass - Associate Professor, Equine Field Service

Erin Contino - Associate Professor, Equine Sports Medicine & Rehabilitation

Felix Duerr - Professor, Small Animal Orthopedic Medicine

David Frisbie - Professor, Equine Sports Medicine & Rehabilitation

Kevin Haussler - Associate Professor, Equine Sports Medicine & Rehabilitation

Fiona Hollinshead - Associate Professor, Small Animal Reproduction

Christopher Kawcak - Iron Rose Ranch Chair, Professor of Equine Surgery & Lameness

Melissa King - Associate Professor, Equine Sports Medicine & Rehabilitation

Brad Nelson - Assistant Professor, Equine Surgery & Lameness

Yvette Nout-Lomas - Associate Professor, Equine Internal Medicine

Lynn Pezzanite - Assistant Professor, Equine Surgery & Emergency Critical Care, Equine Surgery & Lameness

Kelly Santangelo - Associate Professor, Microbiology, Immunology, and Pathology

Katie Seabaugh - Associate Professor, Equine Sports Medicine & Rehabilitation

Kurt Selberg - Associate Professor, Veterinary Diagnostic Imaging

Lauren Smanik - Assistant Professor, Equine Emergency & Critical Care

Melinda Story - Leslie A. Malone Presidential Chair, Assistant Professor, Equine Sports Medicine & Rehabilitation

Kelly Zersen - Imaging/ Anesthesia Coordinator

Postdoctoral and/or Graduate Students

Charlie Barton - Resident, Equine Surgery & Lameness

Taryn Boxleitner - DVM Candidate

Sandro Colla - Resident, Equine Sports Medicine & Rehabilitation

Angie Esselman - Resident, Equine Sports Medicine & Rehabilitation

Gabi Kawahisa Piquini - Resident, Equine Surgery & Lameness

Bethany Liebig - PhD and DVM Candidate

Tom O'Brien - Resident and MS Candidate, Equine Surgery & Lameness

Frances Peat - PhD Candidate, Equine Sports Medicine & Rehabilitation

Gabby Solum - Resident and MS Candidate, Equine Sports Medicine & Rehabilitation

Riley Thompson - Postdoctoral Candidate, Equine Reproduction

Mikala Vig - Resident and MS Candidate, Equine Sports Medicine & Rehabilitation

Zoe Williams - Resident, Equine Sports Medicine & Rehabilitation

Research Scientists and Staff

Michelle Alexander - Administrative Assistant, Equine Sports Medicine & Rehabilitation

Becca Cedar - Veterinary Technician, Equine Sports Medicine & Rehabilitation

Jennifer Daniels - Research Trials Coordinator

Skyla Hall - Program Coordinator, ORC

Natalie Lombard - Surgical Technician, ORC/TMI

Melinda Meyers - Research Assistant, Equine Reproduction

Meredith Park - Veterinary Technician, Equine Sports Medicine & Rehabilitation

Nikki Phillips - Laboratory Manager, ORC

Shelby Roberts - Veterinary Technician, Equine Sports Medicine & Rehabilitation

Ryan Shelton - Lead Technician

Parvathy Thampi - Research Scientist

Awards and Recognition

Dr. C. Wayne McIlwraith - International Cartilage Regeneration & Joint Preservation Society, James Richardson Award. See story below.

Dr. Brad Nelson - Journal of Orthopaedic Research Early-Career Award, Finalist.

Dr. Yvette Nout-Lomas - Colorado State University Inaugural Endowed Gordon and Joan Bishop Professorship Chair. See story on page 9.

Dr. Tom O'Brien - American College of Veterinary Surgeons Surgical Summit, One AO Award and Outstanding Surgery Residents Large Animal Residents' Forum Presentation, 2nd place.

Dr. Lynn Pezzanite - 1. AVMA/AVMFA Early State Investigator Award, 1st Place, in conjunction with Burroughs Welcome Finalist and Participant, "Use of immune activated cellular therapy in treatment of septic arthritis in horses." 2. BEVA Congress News Session Highlighted Research 2022 EVJ and EVE highlighted article "Comparison of equine synovial sepsis rate following intrasynovial injection in ambulatory versus hospital settings." 3. Wiley Top Cited Author 2022 (3 journal articles). 4. AAEP/Foundation of the Horse Kester News Hour Featured Articles (2 journal articles).

Dr. Lauren Smanik - Colorado State University Program of Research and Scholarly Excellence Graduate Student Stipend Award.

Dr. Melinda Story - Colorado State University Inaugural Leslie A. Malone Presidential Chair in Equine Sports Medicine. See story on page 16.

International Cartilage Regeneration & Joint Preservation Society awards Dr. Wayne McIlwraith the James Richardson Award

The International Cartilage Regeneration & Joint Preservation Society (ICRS) is the main forum for international collaboration in cartilaginous tissue research. Recognizing that there is a continuum from cartilage injury to degenerative joint disease, they bring together basic scientists, clinical researchers, physicians, and members of industry, engaged or interested in the field of articular biology, its genetic basis, and regenerative medicine. ICRS seeks to improve their patients' quality of life, decrease their disability, and reduce the impact of degenerative joint disease on healthcare systems worldwide. It's mission is to advance science and education of the prevention and treatment of cartilage diseases worldwide. The following excerpt from the ICRS newsletter was provided by Dr. Grande, President-elect of the International Cartilage Regeneration & Joint Preservation Society (ICRS):

Dr. McIlwraith is the one of the most forward thinking and influential leaders in the field of orthopedic surgery. He saw early the promise of arthroscopic surgery upon its initial introduction to human orthopedic surgery and enrolled in a course for other human surgeons but clearly envisioned the promise of this technique for his specialty of equine orthopedic surgery and was the first to adopt this technology for the equine veterinary field. He subsequently went on to collaborate with the late Richard Steadman, MD and performed seminal studies in the new surgical procedure of microfracture chondroplasty. He has developed several large animal models of osteoarthritis as well innovative strategies for addressing this unmet clinical need including novel gene therapy techniques. His work influenced how our field views relevant human models of disease for preclinical testing.



Over the course of his career, he has published over 550 peer review articles along with six textbooks. He has personally mentored 32 graduate students to successful defense of their theses as well as served on the committees of 35 other students. He has trained 20 equine surgical residents and eight sports medicine fellows. His legacy of both his many contributions to orthopedic surgery and fund-raising acumen are now ensconced in the newly dedicated Colorado State University C. Wayne McIlwraith Translational Medicine Institute, a testament to one of the original translational scientists in a generation.

Dr. Daniel Grande presenting Dr. Wayne McIlwraith with award in Berlin, 2022.

HISTORY

The Orthopaedic Research Center began as a multidisciplinary equine program dedicated to finding methods to treat and prevent equine neuromusculoskeletal disease and injury. Prior to 1984, the program's research was primarily clinical. During this time, many of the techniques for arthroscopic surgery were developed and optimized at CSU, and these techniques were used to treat joint problems more effectively and, further, enable continued athletic function of equine athletes.

We also identified and defined a number of new clinical conditions and documented some of the best methods for diagnosis and treatment for neuromusculoskeletal conditions. The goals of our program are summarized in our research focuses. As we developed arthroscopic surgical techniques to treat these clinical conditions, we identified limitations in terms of secondary osteoarthritis and articular cartilage loss, and this led into phase two of our program of finding solutions through scientific research. A major goal of the program has always been to find solutions to neuromusculoskeletal problems, especially joint injuries and arthritis. As clinicians, clinician scientists, and/or basic science researchers, we strive to offer the best possible treatment of clinical cases with continual and critical assessment of the results, which are then used to modify treatments and direct the research toward disease prevention. The program's goals are to use state-of-the-art research techniques to find new methods to rehabilitate neuromusculoskeletal injuries, specifically damaged joints, tendons, and bones, to prevent or decrease the occurrence of joint disease and neuromusculoskeletal injuries. We strive to improve methods of early detection, develop better treatments to prevent permanent damage to injured joints, and validate manual therapies and rehabilitation techniques.

The ORC collaborates closely with the Orthopaedic Bioengineering Research Laboratory, and we often function as a single unit. The ORC and OBRL, together with the Preclinical Surgical Research Laboratory and Orthopaedic Oncology, make up the Musculoskeletal Research Program, which is a Program of Research and Scholarly Excellence

at Colorado State University. This designation of PRSE to us was originally granted in 2004 and has been renewed in 2008, 2012, and 2016. The significant collaborations with the College of Engineering and School of Biomedical Engineering, as well as the Department of Health and Exercise Science, has added considerably to our research strengths. In recent years, considerable human-based funding – Orthopaedic Foundation, National Institutes of Health, Department of Defense, and corporate grants – has added to our support.

Another significant addition to the ORC has been the development of the equine ambulatory sports medicine service and an Equine Sports Medicine and Rehabilitation Residency Program. This followed the accreditation of the new American College of Veterinary Sports Medicine and Rehabilitation specialty and four of our faculty being made charter diplomates. We quickly developed an equine ACVSMR residency program and have added four diplomates (board-certified in American College of Veterinary Sports Medicine and Rehabilitation, equine specialty) to make us the largest Equine Sports Medicine and Rehabilitation Program in the U.S. This has led to considerable clinical and research advancements in the rapidly emerging field.

In 2016, we achieved funding of \$70 million to build the C. Wayne McIlwraith Translational Medicine Institute. This building came to fruition in 2018, and the Orthopaedic Research Center program moved into the TMI building at that time. The Gail Holmes building has now transitioned to be the Equine Sports Medicine and Rehabilitation Center led by Dr. Melissa King. The TMI is going to take us to a new level of orthopedic research in translational musculoskeletal research (as well as allied areas of biologic therapies and stem cell research), doing what we have always done for horses but greatly expanding our efforts in human musculoskeletal disease. This is made possible by a lead gift of \$40.5 million from John and Leslie Malone for the building (an additional \$10 million in operating funds), \$10 million from CSU, and a \$20 million matching gift from Princess Abigail K. Kawānanakoa of Hawaii.



Dr. Yvette Nout-Lomas Selected for New Bishop Professorship Endowed by Anonymous Donor

Adapted from an original story by Jeff Dodge



Thanks to a \$750,000 gift from an anonymous donor, two Colorado State University faculty members have been selected as inaugural holders of the Gordon and Joan Bishop Professorship, the first endowed professorship ever provided through the Office of the Provost.

Dr. Yvette Nout-Lomas, an associate professor in the Department of Clinical Sciences and an affiliate of the ORC, as well as Kelly Wrighton, an associate professor in the Department of Soil and Crop Sciences, will each hold the title for three years and will each receive an annual stipend to support their scholarly activities.

Donor's intent

According to the donor's wishes, the professorship is to be awarded to faculty in any discipline at CSU who demonstrate extraordinary contributions and excellence in all three areas of the university's mission – teaching, research and outreach/engagement. Interim Provost Janice Nerger said what impressed her is that "the donor is passionate about recognizing and honoring faculty for their dedication to learning and teaching, and feels that more needs to be done to acknowledge their contributions to higher education and to our society."

Nout-Lomas was selected through a university-wide process in which each academic dean was invited to nominate one faculty member from their college for the honor. A vote of the deans, including the dean of the Libraries and the dean of the Graduate School, was provided as a recommendation to Nerger, who made the final decision.

Areas of expertise

Nout-Lomas is an equine veterinarian and neuroscientist specializing in internal medicine and neurology of the horse. Her main clinical interests are neurologic disease and critical care, and her research focuses on enhancing diagnostic abilities in neurologic horses and developing treatments. She identifies objective methods to evaluate gait in horses with neurologic disease and evaluate outcomes of diagnostic imaging techniques.

"I want to relay my thanks to the donor," Nout-Lomas said. "It's a great way of acknowledging faculty and a huge honor for me to be one of the winners."

She said she plans to use the funding primarily as salary support for the graduate students and D.V.M. students she works with.

A motivating and impactful gift

Nerger noted that the competition for the award was extraordinary and said the other six nominees for the professorship were so impressive that she is providing each of them with a monetary award as well.

The donor hopes this award will motivate more alumni to establish other, similar endowments that recognize worthy faculty campus-wide. The inaugural professorship will be celebrated among other honors during the Provost Annual Awards Celebration this spring.

PROGRAM

Our Impact as a Preeminent Equine and Translational Orthopaedic Research Program

Both nationally and internationally, the ORC provides critical new findings of significant clinical impact and has been able to attract talented students who wish to pursue careers in orthopedic research. Students choose this program because of its excellent reputation and because of the opportunities they have to be involved in research during their undergraduate and pre-veterinary programs and veterinary or post-veterinary careers (either while in residencies or post residencies). Many pre-veterinary students have served as volunteers in equine orthopedic research over the past 10 years; this allows students to develop a high level of research expertise during this undergraduate experience. This involvement encourages students to pursue advanced degrees and ultimately research careers, rather than traditionally private veterinary practice. Our program also impacts undergraduate and pre-veterinary education by applying findings from research studies to clinical veterinary medicine.

The breadth of dissemination of information from the ORC is extensive, with information distributed to graduate and undergraduate students in eight departments within five colleges at Colorado State University. Many faculty members from these five colleges who are participants in the Orthopaedic Research Program are internationally recognized; they are therefore able to share research findings worldwide to the academic community, the equine industry, the scientific community, and private biomedical industry. The ORC's extensive collaboration with M.D.s doing research on similar areas of the musculoskeletal system, such as those at CU School of Medicine, Rush Medical Center, Stanford Medical Center, and Steadman Philippon Research Institute, as well as biotechnology companies, with collaboration in multiple NIH and Department of Defense research grants, has significantly impacted the treatment of humans with orthopedic injuries and osteoarthritis. Human medicine, as well as veterinary medicine, has been positively affected by the dissemination of the ORC's findings over the last several decades.

Impact of the Orthopaedic Research Center within the Translational Medicine Institute

Faculty and Staff: Over the last 25 years, funding for our orthopedic research and specialized personnel availability has increased dramatically. Until 1994, orthopedic research was being performed by faculty members within the Department of Clinical Sciences. The ORC research team now encompasses 23 full-time faculty members (including three bioengineering faculty) in our program. To support the work of faculty researchers, we now have 12 research associates/research trial coordinators/administrative assistants. We have 16 graduate students in the program as of 2022. To view the full list of ORC members, affiliates, graduate students, and postdoctoral candidates, please visit our website for their bios and publications (www.vetmedbiosci.colostate.edu/orc). Our current funding is approximately \$2 million to \$4 million annually.

Facilities: In 2002, thanks to generous private donors, most notably Gail Holmes and Herbert Allen, the construction of the Gail Holmes Equine Orthopaedic Research Center and the remodeling of the Orthopaedic Research Laboratories were completed with joint funding from the ORC, School of Biomedical Engineering, and vice president of research at the time, Dr Tony Frank. At the same time, we built a state-of-the-art equine MRI facility (the first equine-dedicated MRI in the U.S.), funded by Ken and Virginia Atkinson together with a College Chair to fund personnel (that also involved a significant contribution from Jon and Abby Winkelried). In 2018, with the completion of the C. Wayne McIlwraith Translational Medicine Institute, the Orthopaedic Research Center program moved into the TMI building along with the imaging efforts that were initiated in the Gail Holmes building. This allowed access to new surgical facilities, a new gait laboratory, high-speed treadmill, and equine barns for our preclinical investigations to be performed. The gait laboratory and equine barn are part of the ORC program and the building, which houses both the gait lab and the new barn, is called the Equine Performance Analysis Facility. The Gail Holmes building that once housed the ORC program is now dedicated to the Equine Sports Medicine and Rehabilitation Program, and the Orthopaedic Research Laboratories have received further renovation and are largely occupied by the OBRL. This space is shared, to some extent, with the ORC. These facility updates have greatly contributed to the larger vision of the ORC mission of impacting not only horses but also people through translational research.

Endowed Chairs: The ORC has three, \$3 million University Endowed Chairs; the Barbara Cox Anthony University Chair in Orthopaedics (held by Dr. Laurie Goodrich); Iron Rose Ranch Chair (held by Dr. Chris Kawcak); and the Abigail K. Kawānanakoa Chair in Alternative Medicine (supporting Dr. Kevin Haussler). We also have a \$1.5 million Chair in Musculoskeletal Imaging from the estate of Kenneth and Virginia Atkinson and, most recently, a \$6 million Presidential Endowed Chair from John and Leslie Malone named the Leslie Malone Presidential Chair in Equine Sports Medicine that Dr. Mindy Story now holds. Dr. Story, who completed her Ph.D. on cervical pain and dysfunction in 2021, is an assistant professor in equine sports medicine and rehabilitation. The funding also supports one of our equine sports medicine residencies. We continue to pursue endowed funding to make all our positions permanent.

Equine Ambulatory Sports Medicine and Rehabilitation Service: A new veterinary specialty, the American College of Veterinary Sports Medicine and Rehabilitation, was accredited by the American Veterinary Medical Association May 2009. There were 27 charter diplomates established by a nomination and Delphi election system. Four of our faculty, Drs. C. Wayne McIlwraith, Kevin Haussler, Chris Kawcak, and David Frisbie, were made charter diplomates of the new college. An equine

ambulatory sports medicine service was initiated in 2010 from within the ORC, and has now grown to the following members; Drs. Kawcak, Frisbie, Haussler, Melissa King, Mindy Story, Erin Contino, and Katie Seabaugh. There are now four clinical technicians/administrative assistants: Michelle Alexander, Becca Cedar, Meredith Park, and Shelby Roberts assisting in this service offering state-of-the-art expertise in equine ambulatory neuromusculoskeletal problems in athletic horses. The service has three sports medicine residents (one in each year) and has graduated 12 residents from the three-year program in equine sports medicine and rehabilitation.

Unrestricted Funding from Donors and Foundations: We have continued with good support and have been further able to increase faculty and staff positions, despite the COVID-19 pandemic that caused significant shutdowns, delays, and reorganization efforts. Donor support is critical to our continued operation and growth. In 2022, Ms. Gail Holmes donated 200,000 towards a residency program in equine sports medicine and rehabilitation, allowing the continued support of a resident for 3 years. Our team has come through this dark time with resolve and looks forward to carrying on our mission through much expanded and translational efforts of our team.



DONORS

With grateful acknowledgment to those who are so critical to the continued success of our program

\$35,000,000 and Above

Dr. John C. Malone and Mrs. Leslie A. Malone, Malone Family Foundation

\$20,000,000 to \$34,999,999

Abigail K. Kawānanakoa, Kawānanakoa Foundation

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Cherry Creek Equine

Robert N. Clay

Coalson Acres Ranch

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William Jr. and Michelle Cowan

Ron Crockett

A. Lindsay Croom, D.V.M.

David C. Davis, D.V.M. Family

Denali Stud

C. George Dewell, D.V.M. Family

Don Alberto Corporation

Dual H Horses

Joseph and Maureen Eddy

Kim Ellis

Billy Emerson

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Maryllynn A. Fischer Family

Fossil Creek Veterinary Hospital

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Gary West, D.V.M.

Gayle and Judith Trotter

GCH Land and Cattle Company, LLC

George S. Martin, D.V.M.

Nicole Gibson

Glenwood Veterinary Clinic, LLC

Laurie Goodrich, D.V.M., M.S., Ph.D.

Henry and Lorie Gordon

Graystone Ranch

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 Shannon Hall
 Paul L. Hansma
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 Dorothy Russel Havenmeyer
 Hidden Paint Ranch
 High Point Performance Horses
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 Mike Hollibaugh Family
 Jim Holmes Cutting Horses
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 Round & D'Angelo Partnership
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 Siena Farm
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 Stacy Smitherman Family
 Smokin Trona Syndicate, LLC
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 SR Instant Choice
 Alexis Stepas
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 Paula and Kent Trahan
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Dr. Melinda Story Steps into Inaugural Leslie A. Malone Presidential Chair in Equine Sports Medicine and Rehabilitation

*Adapted from an original story,
“There is no such thing as ‘bad’ horses”*

About the Malone Chair

The Leslie A. Malone Presidential Chair in Equine Sports Medicine and Rehabilitation was established in 2013 to support the research and study of equine sports medicine and rehabilitation at CSU.

“We are grateful to the Malones for their gift to support such an outstanding clinician and her groundbreaking work,” said Dr. Sue VandeWoude, dean of the College of Veterinary Medicine and Biomedical Sciences. “Dr. Story’s insights hold great promise for improving the health of humans and horses.”

Dr. Melinda Story came to CSU in 2013 as an assistant professor in equine sports medicine while working to complete her Ph.D. on cervical pain and dysfunction at the Translational Medicine Institute. She completed her Ph.D. in 2021, was reappointed as a tenure-track assistant professor of equine sports medicine and rehabilitation in 2022, and was then appointed to the Leslie A. Malone Presidential Chair in Equine Sports Medicine and Rehabilitation.

As the inaugural chair holder, Story is, above all else, grateful for the opportunity. “I want to make [the Malones] proud and make a difference enough to justify what they’ve done,” Story said. “I’ve seen how Leslie looks into a horse’s eye, and she just wants them to live a good life.”

Story feels honored to hold this position: “I respect John and Leslie so much for their desire to make things better in this world, for animals and humans. To be connected to them in any way is humbling.”

Story is equally honored to get to work on the horses at one of the Malones’ horse farms. She loves helping horses reach their greatest potential.

“Horses are such amazing animals; to watch them in motion, to feel their breath on my face, feeling their muscles softly under my fingertips – those are the things that make my heart happy. To be given the gift to spend my days around horses, and people like the Malones, is an incredible blessing.”

More about Dr. Story

Dr. Melinda Story doesn’t believe in bad horses. Even when they are behaving poorly, she doesn’t chalk it up to a bad attitude, but rather her research into the equine axial skeleton supports the idea that horses act out when they are experiencing pain; they’re trying to tell us something.

Often, when a horse exhibits behavioral issues, it’s because they’re experiencing lameness, or an inability to stand or move normally. When a horse’s attitude changes without an underlying diagnosis of lameness, the go-to industry explanation is often that they’re just behaving badly. Story is actively working to alter this perception.

“I passionately believe that horses are rarely born with mean personalities, and they don’t just become bad horses later in life. There’s a reason.” Story said. “Horses are trying to tell us something they can’t use words for. There is almost always something else going on.”

Since Dr. Story came to CSU in 2013 she been investigating the equine axial skeleton – which includes the neck, back and pelvis – and nerve pain ever since. She has been around and working with horses her whole life, and years spent as a veterinarian in private practice is what clued her into the idea of neuropathic pain as a potential explanation of behavioral changes in the first place.

“I would have horses come for evaluation for poor performance or behavioral concerns, and it was difficult to understand why the horse might be presenting that way if they weren’t lame, which is the obvious sign of musculoskeletal pain in a horse,” Story said. “We have now evaluated some horses at a deeper level and found evidence of chronic, neuropathic pain.”

A literal pain in the neck

Part of a burgeoning – but still small – group of researchers internationally, Story is actively working to collaborate with peers and get the word out to the greater equine community about neuropathic pain as an alternative explanation to behavioral issues. When described as “back pain” (sometimes known clinically as “kissing spines”), there is general acceptance of the condition among owners, riders, and veterinarians, but “neck pain” has not yet been embraced on the same level.

“The neck is my greatest interest because it is the least understood region of the axial skeleton,” Story said. “We’re really trying to help the greater good by seeing these horses in a different way.”

Story was involved in starting a working group made up of clinicians and researchers from around the world focused on improving the understanding of cervical pain. She is also part of a team of researchers at CSU, with expertise in neurology, surgery, sports medicine, imaging, and pathology, working towards developing a center for excellence focused on the equine axial skeleton. Many of these researchers – including Story – also see equine patients at the Johnson Family Equine Hospital of the CSU Veterinary Health System, and are able to not only increase awareness of cervical pain to peers and clients, but also offer services informed by their research.

“Story’s work on pain stemming from the neck and back in the horse comes at a pivotal point where there is both an increased awareness of this problem globally, and where we will start offering streamlined services for horses with neck and back disorders at CSU,” said Dr. Yvette Nout-Lomas, an associate professor of equine internal medicine at CSU and one of Story’s colleagues.

Better for horses and humans

Not only does Story’s work mean potential future benefits for horses, but because neck and back pain in horses closely mirrors similar conditions in humans, there is great potential for translational impacts, as well.

“If you talk to someone who has really bad back or neck pain, it’s difficult to diagnose and treat,” Story said. “It’s a debilitating problem in human medicine and is similar in horses.”

Story and her peers have high hopes that this work is just the beginning of increased awareness and positive outcomes for horses and potentially people.

“We hope that future work will uncover critical inflammatory and immune-mediated mechanisms that contribute to the development of chronic pain syndromes that is translatable to humans and other animals,” said Dr. Kevin Haussler, an associate professor in the equine sports medicine service at the Johnson Family Equine Hospital at CSU and another of Story’s colleagues.

Carving out a neck pain niche at CSU is just one part of Story’s efforts toward helping equine enthusiasts and veterinarians understand an alternative, underlying reason for behavioral issues in horses. At the end of the day, she just wants horses to be able to live a good life.

“I love to be able to help horses be better,” Story said. “I want them to be comfortable and happy so they live a better life and enjoy their job.”



CLINICAL TRIALS

About Clinical Trials

Clinical trials are research studies that help medical professionals improve the detection and treatment of illnesses. Our clinical trials program enrolls client-owned horses to evaluate the effectiveness of new drugs such as blood-derived biologics, mesenchymal stem cells therapies, and gene therapy techniques to treat orthopedic diseases. Many of the musculoskeletal treatments used in horses today are the result of pre-clinical trials within the Orthopaedic Research Center, specifically the use of corticosteroids and novel biologic therapies. We learn valuable information from every patient, and we use this information to improve their care as well as the care of future patients, both horses and people.

Each clinical trial has specific eligibility criteria that need to be fulfilled for a horse to participate, and these vary among studies. Some clinical trials are designed for horses with a particular diagnosis of orthopedic disease (i.e. osteoarthritis), while others are open to horses with a variety of orthopedic abnormalities. In general, to qualify for Colorado State University's trials, horses need to have a specific musculoskeletal problem that is diagnosed by their veterinarian or one of veterinarians, and are otherwise healthy. Owners also must be willing to comply with study protocols and commit to coming into the clinic for the visits that are required by the trial.

Why are Clinical Trials Important

With help from equine participants, clinical trials help doctors in the medical and veterinary fields discover disease prevention methods and find new ways to improve detection, diagnosis, and treatment of animal illnesses, all while enhancing the quality of care each patient receives. The clinical trials within the ORC contribute to research that discovers better treatments for horses and people with orthopedic disease, and provide an alternative when standard treatment options are no longer effective. Our clinical trials also explore new therapies to treat disease that is unlikely to have a significant response to standard treatment. Finally, clinical trials offer financial assistance for potentially life-saving treatments that clients otherwise may not be able to afford.

Prostride Clinical Trial

Dr. Erin Contino and Dr. Laurie Goodrich

Sponsored by: Zoetis

"Evaluation of autologous protein solution (Prostride) as an intra-articular anti-inflammatory therapy for adult horses."

This double blinded clinical trial is currently enrolling horses with naturally occurring lameness of the stifle (specifically the medial femorotibial joint). Horses will be randomly divided into two groups and treated with either Prostride or corticosteroid/hyaluronan and followed over 6 months to assess response to treatment.

For more information on study protocols, eligibility, and owner responsibilities please visit:

 <https://col.st/v2oii>



eQcell, Inc Clinical Trial

Dr. Katie Seabaugh and Dr. Laurie Goodrich (cases are also being recruited and treated at VetweRx North and Front Range Equine Performance and Rehabilitation)

Sponsored by: eQcell, Inc.

"Evaluation of allogeneic umbilical cord blood-derived mesenchymal stromal cells for treatment of synovitis in horses."

The purpose of this study is to evaluate the efficacy and dosing of a single administration of frozen allogeneic mesenchymal cells at a dose of either 10 million activated (stimulated) umbilical derived mesenchymal stromal cells or 10 million nonactivated (unstimulated) umbilical derived mesenchymal stromal cells for the treatment of synovitis. Horses are randomly assigned to one of two groups. This ongoing clinical trial is assessing naturally occurring lameness isolated to one carpal joint, or front or hind fetlock.

For more information on study protocols, eligibility, and owner responsibilities please visit:

 <https://col.st/39Afi>



Freeze-Dried Conditioned Serum Clinical Trial

Dr. Erin Contino and Dr. David Frisbie

"Evaluation of the safety and efficacy of intra-articular allogeneic freeze-dried conditioned serum (FDCCS) in horses with lameness regionalized to the distal interphalangeal joints."

This clinical trial will be starting soon and aims to compare freeze dried allogenic conditioned serum (conditioned serum is also referred to as IRAP) to a placebo treatment. Horses with naturally occurring lameness isolated to the front feet will be eligible for enrollment.

For more information on study protocols, eligibility, and owner responsibilities please visit:

 <https://col.st/ac7tJ>





Promote the Repair and Optimal Health of Neuro-Musculoskeletal Tissues

- a. Orthobiologic Therapies
- b. Pharmacologics
- c. Surgical Techniques
- d. Physio-therapy, Rehabilitation, and Conditioning

Publications and Presentations

Textbook Chapters

Dow S, Pezzanite L, Chow L. Immunotherapy options for managing chronic infectious diseases. *Small Animal CVT*. In press.

Rawlinson JE, Pezzanite L, Griffenhagen G. Local anesthesia of the equine head and neck. *Large Animal Local Anesthesia*. Wiley Publishing. In press.

Pezzanite L, Chow L, Dow S, Goodrich L, Schnabel L, Gilbertie J. Antimicrobial properties of equine platelets and stem cells and future horizons. *Veterinary Clinics: Equine Practice on Regenerative Medicine*. Elsevier. In press.

King MR. Rehabilitation: Proprioception, Incoordination and Paresis. *Veterinary Clinics of North America, Equine Practice*, Philadelphia: W.B. Saunders Company. pp.557-568.

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Pezzanite LM, Chow L, Phillips J, Griffenhagen G, Moore AR, Schaer TP, Engiles JB, Werypy N, Gilbertie J, Schnabel L, Antczak D, Miller D, Dow S, Goodrich LR. Use of immune activated cellular therapy in treatment of septic arthritis in horses. Minneapolis, MN.

Kawcak CE. AO-Arthrex Train the Trainer Meeting Chair. Translational Medicine Institute, Colorado State University, Fort Collins, CO June 8-9.

Kawcak CE. a. Arthroscopic Surgery of the Tarsocrural Joint Laboratory; b. Arthroscopic Surgery of the Fetlock Laboratory; c. Arthroscopic Surgery of the Carpus Laboratory; d. Arthroscopic Surgery of the Fetlock Joint; e. Approaches to the Plantar Pouch of the Tarsocrural Joint. CSU Basic Equine Arthroscopy Course. Translational Medicine Institute, CSU, August 17-18. Course Chair.

Kawcak CE. a. Carpal Slab Fracture, Internal Fixation and Carpal Sheath Laboratory; b. Fetlock Internal Fixation and Distal Interphalangeal Joints Laboratory; c. Distal Limb Wet Laboratory; d. Proximal Hindlimb Laboratory; e. Arthroscopic Surgery of Shoulder and Elbow. CSU Advanced Equine Arthroscopy Course. Translational Medicine Institute, CSU, August 19-21.

Kawcak CE. a. Arthroscopic-guided Repair of Equine Articular Fractures; b. MC Condylar Fracture Repair Laboratory; c. PSB Fracture Repair Laboratory; d. Third Carpal Bone Fracture Repair Laboratory; e. SBC Screw Placement Laboratory; f. Technique Variations; g. Review of Post-operative CT Images. AO VET NA Advanced Course, Translational Medicine Institute, Colorado State University, Fort Collins, CO. September 12-14. Course Chair.

Story M. A whole horse approach to achieve longevity in the equine athlete. At: Platinum Performance: Proactive strategies: improving patient outcomes from lameness to the gut. Las Vegas, NV, December 9.

Story M. Equine sports medicine and rehabilitation. History and physical examination of treatments and outcomes. Full day discussion/case consultation/demonstration at: Adobe Veterinary Center. Tucson, AZ, December 19.

Thampi P, Seabaugh KA, Pezzanite LM, Chu CR, Phillips JN, Grieger JC, Mcllwraith CW, Samulski RJ, Goodrich LR. Optimization of scAAVIL-1ra dose in a large animal model of post-traumatic osteoarthritis. 4th Annual Orthopedic Research Symposium & D'Ambrosia Diversity Lectureship, Aurora, CO. October. Oral presentation.

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Johnson SA, Gustafson C, King MR, Frisbie DD. Safety Validation of blood flow restriction training: A pilot investigation. Proceedings American Association of Equine Practitioners. San Antonio, TX. Oral Presentation.

Johnson SA, Chicco AJ, Selberg KT, King MR, Dunkle ZP, Owens JG, Frisbie DD. Short-term effects of blood flow restriction training on equine skeletal muscle oxidative capacity. Havemeyer Equine Poor Performance. Big Sky, MT. Oral presentation.

Liebig B, Goodrich LR, Kisiday J. Suppression of stimulated lymphocyte proliferation by adult equine chondrocytes increases with extensive expansion. Orthopaedic Research Society Annual Meeting, Tampa, FL. Poster presentation.

Larson B, Griffenhagen G, Hendrickson D, Bass L, Okudaira M, Pezzanite L. Safety and analgesia of liposomal bupivacaine administered intra-abdominally and peri-incisionally for laparoscopic ovariectomy in mares. CVMB Research Day. Fort Collins, CO.

Pezzanite LM. a. Insights in One Health in Veterinary Surgery; b. Insights into antimicrobial use in joints; c. Translational orthopedic perspectives in large animal surgery. ACVS Conference. Portland, OR.

Contino E. Managing neck and back pain in horses. Northeast Association of Equine Practitioners Vet & Farrier Conference, Saratoga Springs, NY. September.

Rosenzweig ES, Sinopoulou E, Brock JH, Lu P, Kumamaru H, Weber JL, Hawbecker S, Mannion C, Hyde J, Wurr R, Macon R, Huie JR, Torres-Espin A, Kyritsis N, Sparrey CJ, Nout-Lomas YS, Havton LA, Ferguson AR, Beattie MS, Bresnahan JC, and Tuszynski MH. Grafts of Human Spinal Cord Neural Stem Cells into Primate Hemisection and Contusion Spinal Cord Injury Improve Functional Outcomes After 3 Months. Society for Neuroscience, San Diego, CA

Goodrich LR. a. Management of Orthopedic Infection; b. Surgical Approach and Plate Application of Simple Olecranon Fractures. AO North America Principles in Equine Fracture Course, Columbus, OH.

Goodrich LR. a. Postoperative Management of Osteochondral Repair; b. Subchondral Bone Cyst Management; c. SBC Screw Placement Laboratory; Third Carpal Bone Laboratory; d. PSB Fracture Repair Laboratory; e. MC Condylar Fracture Repair Laboratory Colorado State University. CSU Advanced Equine Arthroscopy Course. Translational Medicine Institute, CSU, August 19-21.

Goodrich LR. a. Arthroscopic Surgery of the Carpus Laboratory; b. Arthroscopic Surgery of the Tarsocrural Joint Laboratory; c. Arthroscopic Surgery of the Fetlock Joint Laboratory; d. Basic Arthroscopic Techniques and Diagnostic Arthroscopy; e. Advanced Fetlock Internal Fixation and Distal Interphalangeal Joints Laboratory; f. Advanced Proximal Hind Limb- Stifle and Hock Wet Laboratory; g. Advanced Distal Limb Wet Laboratory; h. Advanced Carpal Slab Fracture, Internal Fixation, and Carpal Sheath Wet Laboratory; i. Advanced Navicular Bursoscopy. CSU Continuing Education Short Course, Fort Collins, CO.

Kawcak CE. Fracture, Osteochondral Defect, Bone Marrow Edema, Subchondral Cyst; Mechanical Principles of Osteochondral Repair. Arthroscopic-guided Repair of Equine Articular Fractures. AO Webinar. August.

Gadomski B, Labus K, Stewart H, Nelson B, Bisazza K, Puttlitz C, McGilvray K, Regan D, Easley J. Distal Carpal Stabilization in an Ovine Preclinical Model of Foot and Ankle Surgery. Orthopaedic Research Society Annual Meeting. Tampa, FL, February.

Contino E. Update on non-biologic treatments and rehabilitation for tendon & ligament injuries, Virtual panel discussion, VetPD. November.

Larson B, Griffenhagen G, Bass L, Okudaira M, Hendrickson D, Pezzanite L. Intra-abdominal liposomal bupivacaine in mares. American College Veterinary Surgeons. Portland, OR.

Jones K, Peraza J, Wotman K, Frisbie D, Henriksen MdL. Investigation of the anti-inflammatory effect of interleukin-1 receptor antagonist protein (irap) on canine keratoconjunctivitis sicca (kcs): a pilot study. American College of Veterinary Ophthalmology, Palm Springs, CA.

Sikes KJ, Wist S, Fernandez K, Easley J, Santangelo K, Frisbie D. Deleterious Effects of Systemic Myo-Inositol Supplementation on Tendon Healing in a Murine Model. Orthop Res Soc. Tendon Conference, University of Pennsylvania, Philadelphia, Pennsylvania. May 5-7.

King MR. a. Equine aquatic therapy: Uncharted waters; b. Measurements of success: Monitoring response to rehabilitation; c. The relationship between postural stability and paraspinal muscle adaptation in lame horses. ACVSMR annual meeting. Oral Presentation.

Alexander K, Simon E BS, Mama K, Rao S, Bass L. Comparison of Intrathecal Mepivacaine and Intravenous Pentobarbital for Humane Equine Euthanasia. International Veterinary Emergency and Critical Care Symposium. September.

Alexander K, Simon E BS, Mama K, Rao S, Bass L. Comparison of Intrathecal Mepivacaine and Intravenous Pentobarbital for Humane Equine Euthanasia. American Association of Equine Practitioners Convention. December.

Johnson SA, Sikes KJ, Johnson JW, Van Zeeland, King MR, Frisbie DD. Blood flow restriction training alters equine tendon stiffness. Orthopaedic Research Society. Accepted Poster Presentation.

King MR. a. Therapeutic Modalities: Hot Topics that Come in Waves; b. Measurements of Success: Monitoring Response to Rehabilitation; c. Equine Rehabilitation: Can We Make a Difference?; d. From PT to Grand Prix. AVEQ Congrès. Quebec City, Canada. Invited Speaker.

King MR. How to Incorporate Rehabilitation in Your Daily Practice/ At Home Care. Alamo Pintado Symposium. Los Olivos, CA. Invited Speaker.

King MR. Rehabilitation of Equine Cervical Pain and Dysfunction Cervical Workshop. Denver, CO. Invited Speaker.

King MR. Equine Underwater Treadmill Exercise: Current Practices. Veterinary Rehabilitation Services of Virginia. Gordonsville, VA. Invited Speaker.

Webster M, Ammons D, Chow L, Kurihara J, Goodrich L, Phillips N, Dow S, Pezzanite L. Defining the phenotype and function of equine synovial macrophages with relevance to osteoarthritis progression. CVMB Research Day. Fort Collins, CO.

O'Brien TJ, Johnson JW, Kawcak CE, McGilvray KC, Gadomski BC, Nelson BB. Novel Implant for Repair of Midbody Proximal Sesamoid Bone Fractures in Horses. Portland, OR. Podium.

Labus K, Johnson J, Goodrich LR, McGilvray K, Puttlitz C, Gadomski B. Comparison of Fresh and Cryopreserved ProChondrix Thin Osteochondral Allograft Mechanics in Explant Conditions. International Cartilage Repair Society World Congress, Berlin, Germany. Oral presentation.

Rockow M, Dow S, Chow L, Impastato R, Webster M, Timkovich A, Santangelo K, Hendrickson D, Pezzanite L. Toll-like receptor activation of mesenchymal stromal cells for improved cellular treatment of osteoarthritis. American Association of Veterinary Medical Colleges National Veterinary Scholars Symposium. Minneapolis, MN.

Pezzanite LM, Timkovich AE, Sikes KJ, Chow L, Hendrickson DA, Becker JR, Webster M, Santangelo KS, Dow S. Erythrocyte removal from bone marrow aspirate concentrate improves efficacy as intra-articular cellular therapy in a rodent osteoarthritis model. UC Denver Orthopedic Research Symposium & D'Ambrosia Diversity Lectureship. Denver, CO.

Larson B, Ammons D, Chow L, Dow S, Pezzanite L. Transcriptomic response to osteoarthritis determined by single cell sequencing techniques. American Association of Veterinary Medical Colleges National Veterinary Scholars Symposium. Minneapolis, MN.

Liebig B, Goodrich LR, Kisiday J. Suppression of stimulated lymphocyte proliferation by adult equine chondrocytes increases with extensive expansion. Orthopaedic Research Society Annual Meeting, Tampa, FL. Poster presentation.



Dr. Melissa King and "Odie" on the water treadmill. STATE magazine, Mary Neiberg Photography



Investigations of the Origins of Neuro-Musculoskeletal Disease

- a. Neuro-musculoskeletal pain and dysfunction
- b. Biomechanics and sensory input
- c. Repetitive stress response
- d. Cell markers

Publications and Presentations

Textbook Chapters

Nout-Lomas YS. Traumatic Nervous System Injury. In: Reed, S.M. ed. Equine Neurology. Veterinary Clinics Equine: Equine Practice. Philadelphia, PA, USA: Elsevier. pp. 363-377.

Refereed Publications

Kim AY, Elam L, Lambrechts NE, Salman MD, Duerr FM. Appendicular skeletal muscle mass assessment in dogs: A scoping literature review. BMC Veterinary Research 2022; 18(1):280. PMID: 35842654.

Tasma Z, Hou W, Damani T, Seddon K, Kang M, Ge Y, Hanlon D, Hollinshead FK, Hisey CL. Production of extracellular vesicles from equine embryo-derived mesenchymal stromal cells. Reproduction 2022; 164(4):143-154. PMID: 35938796.

Daniels A, Pezzanite LM, Griffenhagen GM, Hendrickson DA. Evaluation of factors associated with surgical site infection in equine proximal interphalangeal joint arthrodesis: 54 cases (2010-2019). Veterinary Medicine Science 2022; 4:1478-1488. PMID: PMC9297777.

McDermott JE, Pezzanite LM, Goodrich LR, Dow S, Santangelo K, Chow L, Wheat W. Equine innate immunity and osteoarthritis. Animals (Basel) 2022; 11(11):3247. PMID: PMC8614551.

Acutt, EV, Contino, EK, Frisbie, DD, Barrett, MF. Deep digital flexor tendon lesions in the pastern are associated with the presence of distal tendinopathy. Equine Veterinary Journal 2022; 54(3):502-512. PMID: 34050982.

Story MR. Integrative approach to neck pain and dysfunction. Veterinary Clinics of North America: Equine Practice 2022; 38(3):485-492. PMID: 36244941.

Louie EW, Streeter R, Story M, Scrivani PV, Barrett M, Mullen KR. Complex central nervous system malformations in a Dutch Warmblood foal. Journal of Veterinary Internal Medicine 2022; 36(3):1173-1178. PMID: PMC9151493.

Sullivan HM, Acutt EV, Barrett MF, Salman MD, Ellis KL, King MR. Influence of chronic lameness on thoracolumbar musculus multifidus structure in the horse. Journal of Equine Veterinary Science 2022; 117:104053. PMID: 35753637.

Johnson JW, von Stade D, Gadomski B, Easley JT, Nelson BB, Bisazza KT, Regan D, Troyer K, Zhou T, McGilvray KC. Modified alendronate mitigates mechanical degradation of the rotator cuff in an osteoporotic ovine model. American Journal of Sports Medicine 2022; 50(13):3649-3659. PMID: 36259712.

Sikes KJ, McConnell A, Serkova N, Cole B, Frisbie D. Untargeted metabolomics analysis identifies creatine, myo-inositol, and lipid pathway modulation in a murine model of teninopathy. Journal of Orthopedic Research 2022; 40(4):965-976. PMID: 34081345.

Johnson SA, Biscoe EW, Eilertson KE, Lutter JD, Schneider RK, Roberts GD, Cary JA, Frisbie DD. Tissue predictability of elastography is low in collagenase induced deep digital flexor tendinopathy. Veterinary Radiology Ultrasound 2022; 63(1):111-123. PMID: 34585463.

Ford MG, Nelson BB, Ford TS, Souza CRS, Easley JT, Hackett ES. Complications in foals undergoing surgical repair for uroperitoneum. Journal of Equine Veterinary Science 2022; 110:103852. PMID: 34958882.

McCready E, Easley JT, Risch M, Troyer KL, Johnson JW, Gadomski BC, McGilvray KC, Kisiday JD, Nelson BB. Biomechanical, morphologic, and biochemical characteristics of articular cartilage of the ovine humeral head. Cartilage 2022; 13(1):19476035221081465. PMID: 35225009.

Research Abstracts, Presentations, Proceedings

Kawcak CE, Carpenter R, Ramzan P. Fetlock Bone Fractures – Practical Solutions for Minimising Risk Webinar. BEVA-AAEP transatlantic equine clinics. March 16.

Larson B, Ammons D, Chow L, Dow S, Pezzanite L. Transcriptomic response to osteoarthritis determined by single cell sequencing techniques. UCDenver Orthopedic Research Symposium & D'Ambrosia Diversity Lectureship. Denver, CO.

Sullivan H, Acutt E, Barrett M, Ellis K, King M. Influence of chronic lameness on thoracolumbar musculus multifidus structure in the horse. Proceedings American Association of Equine Practitioners. San Antonio, TX. Oral Presentation.

Story M. Neck pathology and dysfunction in sports horses: diagnosis, treatment and rehabilitation. Centaur Biomechanics. Virtual, November 5.

Story M. Lameness Originating from the neck, Facilitator. American Association of Equine Practitioners Annual Convention. San Antonio, TX, November 20.

Story M. Lameness Originating from the neck, Facilitator. American Association of Equine Practitioners Annual Convention. Virtual, November 30.

Johnson JW, von Stade D, Gadomski B, Easley JT, Nelson BB, Bisazza K, Regan D, McGilvray K. Bisphosphonate Mitigates Tendon Mechanical Degradation in An Ovine Model of Osteoporosis. 9th World Congress of Biomechanics, Taipei, Taiwan; Podium. July.

Middlebrooks B, McCue P, Nelson BB, May E, Divine C, Barton C, Conley A. Monorchidism in a phenotypic mare with a 64,XY, SRY-positive karyotype. International Symposium on Stallion Reproduction. Fort Collins, CO; Podium. March.

Michalko B, Brekhus, Johnson JW, Easley JT, Nelson BB, Sikes KJ. Biomechanical contributions of the LDE and ACL in stability of ovine stifle: Implications for a novel model of posttraumatic osteoarthritis. National Veterinary Summer Scholars. St. Paul, MN; Poster. August.

Michalko B, Brekhus, Johnson JW, Easley JT, Sikes KJ, Nelson BB. Biomechanical contributions of the LDE and ACL in stability of ovine stifle: Implications for a novel model of posttraumatic osteoarthritis. Summer Slam, CVMBS Veterinary Summer Scholars Program. St. Paul, MN; Podium. July.

McIlwraith CW, Peat FJ, Kawcak CE, Berk JT, Keenan DP, Mork DS. Subchondral Lucencies of the Medial Femoral Condyle in Yearling and Two-Year-Old Thoroughbred Sales Horses. Am Assoc Equine Pract. San Antonio, TX, November.

Labus K, Johnson J, Goodrich LR, McGilvray K, Puttlitz C, Gadomski B. Comparison of Fresh and Cryopreserved ProChondrix Thin Osteochondral Allograft Mechanics in Explant Conditions. International Cartilage Repair Society World Congress, Berlin, Germany; Oral presentation.

Bartmeyer PM, Biscola NP, Raimundo MM, Rosenzweig ES, Hyde J, Mannion C, Hawbecker S, Wurr R, Macon R, Nout-Lomas YS, Sparrey CJ, Beattie MS, Bresnahan JC, Tuszynski MH, Havton LA. Monitoring of Autonomic Dysreflexia in Rhesus Macaques after Cervical Spinal Cord Injury and Delayed Intramedullary Grafting of Human Neural Stem Cells. Society for Neuroscience, San Diego, CA.

Faramarzi B, Greene H, Nout-Lomas YS. Incidence of distal phalanx palmar process fractures in Arabian foals. ICEEP, Uppsala, Sweden.





Improve the Detection of Neuro-Musculoskeletal Disease

- a. Advanced analytics
- b. Imaging modalities
- c. Interpretation of clinical examination
- d. Novel diagnostic techniques
- e. Behavior

Publications and Presentations

Refereed Publications

Rosen S, Duerr FM, Elam L. Prospective evaluation of complications associated with orthosis and prosthesis use in canine patients. *Frontier Veterinary Science* 2022; 9:892662. PMID: PMC9372342.

Navas De Solis C, Gabbett T, King M, Keene R, McKenzie E. The Dorothy Havemeyer International Workshop on Poor Performance in Horses: Recent advances in technology to improve monitoring and quantification. *Equine Veterinary Journal* 2022; 54(5):844-846. PMID: 35905088.

Smanik L, Stefanovski D, Reilly PT, Richardson DW. Computed tomographic guidance for internal fixation of type II distal phalangeal fractures in 51 horses. *Equine Veterinary Journal* 2022; 54:679-692. PMID: 34107077.

Ellis K, Contino E, Nout-Lomas YS. Poor performance in the horse: Diagnosing the non-orthopedic causes. *Equine Veterinary Education* 2022; 35:208-224.

Stewart HL, Easley JT, Selberg KT, Puttlitz CM, Nakamura LK, Johnson JW, Kawcak CE. Experimental models of bone marrow lesions in ovine femoral condyles. *Veterinary Surgery Epub* 2022; 52(2):284-298. PMID: PMC10108275.

Hinkle FE, Selberg KT, Frisbie DD, Barrett MF. Radiographic changes of the proximal third metatarsal bone do not predict presence or severity of proximal suspensory desmopathy in a predominately Quarter Horse population. *Equine Veterinary Journal Epub* 2022; 55(1):24-32. PMID: 35092318.

Madsen LM, Gutierrez-Nibeyro SD, Barrett MF, Gray SM, Reising AC. What is your diagnosis? *Journal of American Veterinary Medical Association* 2022; 260(2):166-168. PMID: 34793326.

Posukonis MN, Daglish J, Wright IM, Kawcak CE. Novel computed tomographic analysis demonstrates differences in patterns of bone mineral density between fracture configurations in distal condylar fractures of the third metacarpal/metatarsal bones in 97 Thoroughbred racehorses. *American Journal of Veterinary Research* 2022; 7:1-9.

Sullivan HM, Barrett MF, Zhou T, Kawcak CE. Ultrasonographic evaluation of the suspensory ligament in quarter horses used for cutting. *Journal of Equine Veterinary Science* 2022; 119:104139. PMID: 36252794.

Research Abstracts, Presentations, Proceedings

Contino E. a. All things suspensory; b. Nontraditional causes of poor performance. *Northeast Association of Equine Practitioners Vet & Farrier Conference*. Saratoga Springs, NY. September.

Contino E. a. Diagnostic analgesia: Considerations when it's not adding up; b. Going the extra mile: Working up cases of poor performance. *Hagyard Bluegrass Equine Symposium*, Lexington, KY. October.

Contino E. Managing proximal suspensory desmopathy in horses. *68th Annual Convention American Association of Equine Practitioners*, San Antonio, TX. November.

Bisazza K, Nelson BB, Stewart HL, Sikes KJ, Easley JT. Comparison of Advanced Imaging Modalities to Assess Bone Mineral Density in the Sheep Model. *Colorado State University, College of Veterinary Medicine and Biomedical Sciences Annual Research Day*. Fort Collins, CO.

Seabaugh KA. Diagnostic Analgesia of the Distal Limb. *CSU Lameness Course*, Fort Collins, CO. July.

Bisazza K, Nelson BB, Sikes KJ, Anthony R, Goodrich LR, McGilvray K, Burton L, Stewart HL, Easley JT. Using the Ovariectomized Ewe to Model Postmenopausal Osteoporosis Disease Progression. Colorado State University, College of Veterinary Medicine and Biomedical Sciences Annual Research Day. Fort Collins, CO.

Bisazza K, Nelson BB, Stewart HL, Sikes KJ, Easley JT. Comparison of Quantitative Computed Tomography and Dual-Energy X-Ray Absorptiometry to Determine Bone Mineral Density in the Sheep Lumbar Spine. Orthopaedic Research Society. Tampa, FL.

Bouse-Eaton C, Anderson W, Simske S, Contino E, et al. Verifying correlation between equine clinical examination parameters and inertial measurement unit data to optimize wearable inertial sensor development poster. 23rd Annual CSU College of Veterinary Medicine and Biomedical Sciences Research Day. Fort Collins, CO. January.

Contino EK, Kawcak CE, Seabaugh KS. Benefits and Pitfalls of Blocking Panel. Equine Lameness – How to get a sound diagnosis. Colorado State University, Fort Collins, CO. July.

Contino E. Going the extra mile. Equine Lameness – How to get a sound diagnosis. Colorado State University, Fort Collins, CO. July.

Kawcak CE, Contino EK. Direct Measurement of Athletic Load in the Event Horse. Dorothy Havemeyer International Workshop on poor performance in horses: Recent advances in technology to improve monitoring and quantification. Big Sky, MT. May 23-26.

Kawcak CE, Peat FJ, McIlwraith CW, Berk JT, Keenan DP, Mork DS. Radiological Findings in the Proximal Sesamoid Bones of Yearling and Two-Year-Old Thoroughbred Sales Horses, Am Assoc Equine Pract. San Antonio, TX, November.

Kawcak CE. Development of the Athletic Health Cycle. TMI Scientific Advisory Board Meeting, Translational Medicine Institute, Colorado State University, Fort Collins, CO. July 28.

Kawcak CE. a. Diagnostic Analgesia of the Upper Limb; b. Lameness Examination - Musculoskeletal palpation and routine lameness examinations Laboratory; c. Clinical Case Work Up - Work-up lameness cases including diagnostic blocking. Equine Lameness – How to get a sound diagnosis. Colorado State University, Fort Collins, CO. July 29-30.

Nout-Lomas YS, Aanstoos M, Weaver D, Tjerkstra B, Luining B. Triaxial accelerometers and inertial measurement units detect differences between sound and ataxic horses. Havemeyer “Equine Poor Performance Workshop: How do we use emerging technology to identify and quantify poor performance in horses?”. Big Sky, Montana.

Contino E, Smith P. Poor performance in horses Table Talk. 68th Annual Convention American Association of Equine Practitioners, San Antonio, TX. November.

Colla S, Zanotto GM, Seabaugh KA, Selberg KT. Blinded versus ultrasound-guided low volume injection of tibial and fibular nerves in equine cadaver limbs. Abstracted presented at AAEP Annual Conference November.

Sidky EY, Stewart HL, Kawcak CE, McIlwraith CW, Duff MC, Pan X. Exploiting voxel-sparsity for bone imaging with sparse-view cone-beam computed tomography, Proc. SPIE 12304. 7th International Conference on Image Formation in X-Ray Computed. Tomography, 123041Y. October 17.

Kawcak CE. Update on Equine Wearable Sensor. TMI TAP Symposium. Translational Medicine Institute, Colorado State University, Fort Collins, CO. December 2.

Kawcak CE. Practical Application of Equine Research Findings to Your Horse’s Health. United States Eventing Association Annual Meeting, Savannah, GA. December 7-10.

Scott L, Selberg KT, Seabaugh KA. The ability to quantify effusion of equine cervical articular process joints using ultrasound. Abstracted presented at AAEP Annual Conference November.

Moorman VJ, King MR. Use of a portable media device to assess postural stability in horses. Havemeyer Equine Poor Performance. Big Sky, MT. Oral presentation.

King MR. Functional Assessment of the Axial and Appendicular Skeleton. Animal Rehab Institute. Loxahatchee, FL. Invited Instructor.

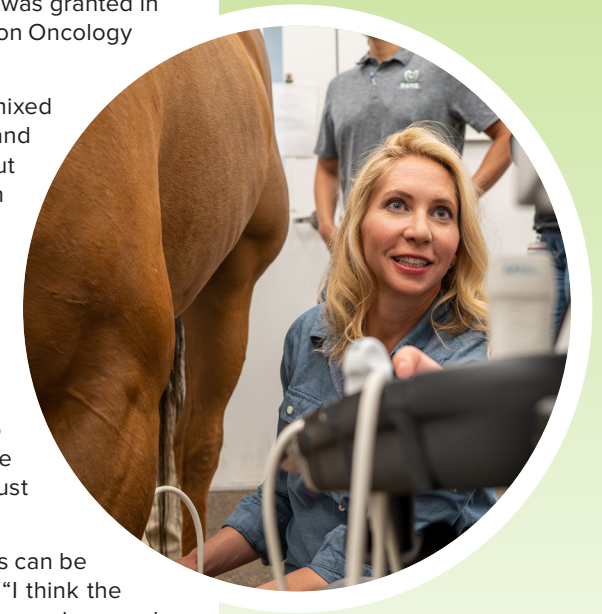
Dr. Myra Barrett Leads Charge in Creation of American College of Veterinary Radiology-Equine Diagnostic Imaging

With the expansion of equine diagnostic medicine, large animal veterinarians and researchers sensed an obvious gap when it came to diagnostic imaging. Until recently, veterinary radiology developed a heavy focus on small, companion animals. This led to not only a misunderstanding of the ailments large animals faced, but also a mistrust from the veterinarians who consulted with veterinary radiologists who felt that they were not receiving optimal information. This need for change on the equine side of radiology is what drove Dr. Myra Barrett, Associate Professor of Veterinary Diagnostic Imaging, and a team of her veterinary radiologist colleagues who also specialize in equine diagnostic imaging to create the Equine Diagnostic Imaging (EDI) subspecialty within the American College of Veterinary Radiology.

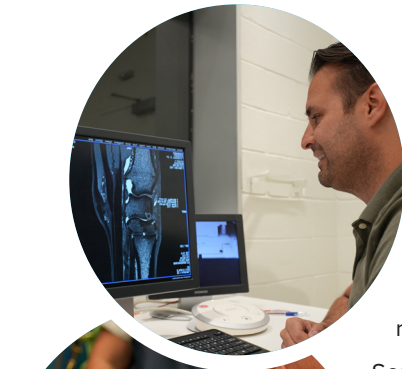
The American College of Veterinary Radiology (ACVR) was founded in 1961 and is one of 22 veterinary specialties recognized by the American Board of Veterinary Specialties (ABVS) of the American Veterinary Medical Association (AVMA). The ACVR is an all-species college, but as time went on and companion animal medicine expanded, large animals became less emphasized. Those with a passion for equine care and research were left behind with little specialized training compared to their small animal- focused colleagues. “We were not gaining the knowledge we needed to be leaders and advance the field” said Dr. Barrett. Approval from ABVS as a Recognized Veterinary Specialty was granted in February 2019. The last subspecialty to be recognized by ACVR was Radiation Oncology in 1994.

While the development of the equine radiology subspecialty was met with mixed reactions, there was a sigh of relief from those working in equine medicine and surgery. Residents are still trained to have a cross-species understanding, but now there is an opportunity for further specialization in equine radiology with this 3-year specialty residency. The EDI residency explores all diagnostic imaging modalities, as well as orthopedic, soft tissue, abdominal, airway, and cardiac imaging. Until a recent policy change made by ABVS, newly formed specialties could grant specialty board certification without members taking a board exam, but this is not the case with ACVR-EDI. “We did not grandfather anyone in” Dr. Barrett said, “everyone who is EDI certified took the certifying exam.” The first person to complete the EDI residency was a CSU radiology resident Dr. Elizabeth Acutt, who went on to pass both the qualifying and certifying exams, subsequently becoming the first ACVR Diplomate to complete an ACVR-EDI residency program, in August 2022.

With the development of ACVR-EDI, the standard of care for equine patients can be raised exponentially, and Dr. Barrett has high hopes for the future of EDI. “I think the College and subspecialty will grow and nurture the next generation of researchers and clinicians” she said. The researchers and clinician scientists of the Orthopaedic Research Center (ORC) have established that the equine pre-clinical model provides incredible insight into understanding joint and cartilage diseases, osteoarthritis, along with many other musculoskeletal diseases, and how the care and treatments translate to human medicine. As EDI continues to grow, Dr. Barrett is optimistic for the future of the field, “we can grow with the times, for example expanding how we use artificial intelligence, and stay ahead of the curve.”



IMAGING



Diagnostic imaging has been a key component of the Orthopaedic Research Center for over three decades. X-ray, diagnostic ultrasound, computed tomography (CT) and magnetic resonance imaging (MRI) have all been studied and applied as essential tools for both research and clinical practice. The pathogenesis and characterization of musculoskeletal diseases in the horse is largely informed by the advances in this field, giving us methods to both identify the diseased tissues and monitor their healing over time. Diagnostic imaging has also allowed us to identify normal changes in tissues that come with age and exercise, preventing over-interpretation and reporting of false positive findings.

Some of the first work in this field started with reporting of xray findings in Thoroughbred yearlings. Led by Dr. McIlwraith in the 1990's, the industry was informed of radiographic changes that can cause problems, but also, most importantly, those changes that have no impact on performance. Drs. McIlwraith and Kawcak, along with Dr. Frances Peat, a PhD student in the ORC, have performed the largest study to date, showing progression of radiographic changes over time in the Thoroughbred racehorse, and incorporating ultrasound changes as well. This was also applied to the yearling cutting horse industry by Drs. McIlwraith and Kawcak, similarly, informing the industry on radiographic changes of significance. Also, Drs. Kawcak and Barrett showed ultrasound changes in suspensory ligaments of young cutting horses over time. All of this work has been of practical importance to the industries, helping owners to make informed decisions on purchases.

Advances in volumetric (3-dimensional) imaging also evolved in the ORC. Dr. Kawcak initially used CT to characterize exercise-related changes in subchondral bone of young horses, comparing those findings to the ultrastructural changes in bone due to exercise. This has become important today, as the subchondral bone is known to be the origin of joint injury in racehorses. With this modality, damage could be seen, but also patterns of joint shape, bone thickening and bone loss were correlated to prediction of injury. The clinical use of CT has grown significantly, leading to improved identification of horses at risk of injury. In addition, Drs. Kawcak and Selberg, along with Drs. Nelson and Stewart (as graduate students in the ORC), have developed advanced methods to characterize articular cartilage metabolism, subchondral bone edema (fluid accumulation indicative of bruising) and soft tissue inflammation using CT. Dr. Kawcak is also collaborating with industry partners to develop a portable, low-cost CT device for clinical use.

MRI has significantly improved our ability to manage the equine athlete. Much of the work to develop MRI in horses started in the ORC, with Dr. McIlwraith investing in both equipment and personnel to improve this essential modality. The first dedicated equine MRI facility in the world was built in the ORC at CSU. Along with Drs. Kawcak, Frisbie, Richard Park and Natasha Werpy, they not only established a clinical imaging center, but also performed much of the initial work demonstrating the meaning and significance of MRI findings and correlating those findings to the clinical signs. Again, there are some MRI findings that are normal, or not of significance, and the work to demonstrate that was critical.

With our move into the C. Wayne McIlwraith Translational Medicine Institute, we now have a 3 Tesla MRI (Siemens), a CT (Siemens) and development of a standing, mobile CT which is ongoing and led by Dr. Kawcak. These imaging modalities are now run and operated by the Veterinary Health System on the South Campus at CSU, which is an important collaborating unit to the ORC.

Drs. Myra Barrett and Kurt Selberg are founding members of the ACVR-EDI and specialists that are not only training the next generation of equine focused clinicians but also guiding them in research techniques that will be important to musculoskeletal research efforts within our program. This annual report highlights some of the important work that is on-going as part of the ORC within the TMI.

Computed tomography and fluoroscopy versus radiographic guidance for internal fixation of simulated dorsomedial-plantarolateral CTB fractures in non-racehorses

L. Smanik, K. Selberg, C. Kawcak, H. Stewart, L. Goodrich

Funding: American College of Veterinary Surgeons Foundation Diplomate Research Grant

Central tarsal bone (CTB) fractures are uncommon but well described in horses. In non-racehorses, they commonly extend from dorsal/dorsomedial to plantarolateral, involving the articulation between the central and fourth tarsal bones. Internal fixation is challenging due to the small width and curvature of the bone, and frequency of comminution. Observations from clinical cases in our hospital revealed that computed tomography (CT) provided additional information not detected on preoperative radiographs including an altered diagnosis and identification of comminution. As CT-imaging may not be available to every surgeon, information on how to optimize internal fixation using alternative imaging modalities, such as fluoroscopy and digital radiography, is critical. There are no published studies that directly compare CT and/or fluoroscopic guidance to radiography alone for internal fixation of CTB fractures in horses. The objective of this study was to assess screw placement in simulated

dorsomedial-plantarolateral CTB fractures in 10 pairs of cadaver tarsi from non-racehorses using CT and fluoroscopy compared to radiographic guidance. We hypothesized that, compared to radiography alone, preoperative CT with intraoperative fluoroscopy would result in a faster repair and more precise screw placement, as judged by an ideal screw trajectory perpendicular to the fracture and midway between the proximal and distal articular surfaces. One tarsus per pair was randomly assigned to have a 4.5mm cortical screw placed across the CTB using CT and fluoroscopy (CT/F group) or radiography alone (DR group), with the CT and radiographic images of a clinical case used as a reference for simulating fractures in cadavers (Figure 1). Postoperative CT was performed on all limbs. Variables related to marker placement, procedure time, and screw positioning were recorded and compared.

This study concluded that internal fixation of CTB fractures can be successfully performed using either technique for imaging guidance. CT and fluoroscopic guidance did not result in a faster total procedure time or more precise screw placement versus radiographs alone; however, the ability to judge screw length was more accurate using CT and intraoperative fluoroscopy. While CT is recommended for improved understanding of fracture configuration and surgical planning, especially given the frequency of comminution often undetectable on preoperative radiographs, radiographic guidance may be a suitable alternative for internal fixation of dorsomedial-plantarolateral fractures. It is important to recognize that mild adjustments to the fluoroscopic or radiographic angle can dramatically alter the perception of screw placement within the bone, including proximity to adjacent articular surfaces, the angle of the screw within the CTB, and selection of appropriate screw length.

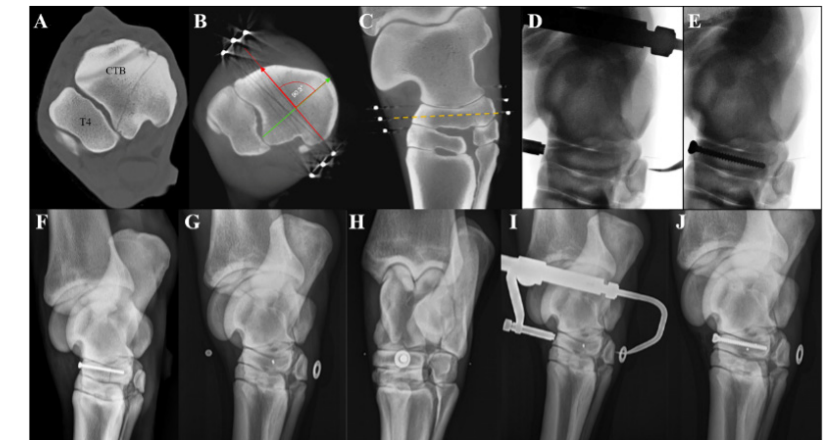


Figure 1: Images depicting the procedure for screw placement in the CT/F (A-E) and DR (F-J) groups. Transverse CT image (A) and dorsomedial-plantarolateral oblique radiograph (F) of the clinical case, depicting the dorsomedial-plantarolateral CTB fracture used as a reference for screw placement in the cadavers. When placing a screw in the CT/F group (B-E), fiducial markers were placed in a grid pattern dorsolaterally and plantaromedially on the tarsus. The markers that best aligned with the desired drill path on preoperative CT were selected to guide screw placement. For the DR group (G-J), the simulated fracture line was delineated with fiducial markers. A metallic BB and washer were used to identify the ideal screw trajectory perpendicular to the simulated fracture plane.

Contrast administration via ultrasound-guided injection of the cranial tibial artery results in contrast enhancement of the soft tissues of the metatarsus in horses undergoing CT

E. Acutt, T. Zhou, K. Mama, B. Nelson, K. Selberg, M. Barrett

Funding: American College of Veterinary Radiology

The use of mesenchymal stem cells (MSC) in the treatment of musculoskeletal injuries has become common in equine practice and achieved favorable results in several tendinous and ligamentous structures. Often, MSC are injected intralesionally; however, such injections present limitations for treatment of diffuse injuries, or where lesion accessibility is difficult. Additionally, there is potential for iatrogenic disruption to normal or healing soft tissue surrounding a lesion as a result of direct injection, and care must be taken when selecting when and where to perform intralesional injections. Due to these factors, it is useful to have another option for MSC delivery to regions of injury.

The objective of this study was to utilize computed tomography (CT) to document the nature of the distribution of nonionic iodinated contrast media throughout the vasculature and metatarsal soft tissues following ultrasound-guided injection of the cranial tibial artery. Of particular interest was the proximal suspensory ligament (PSL), which presents a challenging injection target. It was hypothesized that CT-contrast studies would demonstrate that ultrasound-guided cranial tibial artery injection would result in contrast perfusion throughout the metatarsus including the PSL, supporting the use of this technique as an effective method of MSC delivery. Six adult horses without lameness underwent CT of the distal hindlimbs.

Scans were obtained prior to ultrasound-guided catheterization of the cranial tibial artery, in addition to early and delayed scans acquired following intra-arterial contrast administration. Region of interest analysis of the superficial and deep digital flexor tendons and suspensory ligament was used to assess contrast enhancement within these structures. Linear mixed models were used to determine statistical significance. Significant ($P < 0.05$) mean contrast enhancement was seen in all post-injection time points in all soft tissue structures of interest. This indicates that ultrasound-guided injection of the cranial tibial artery results in perfusion of injectate throughout the distal hind limb, including the major soft tissue structures of the metatarsus. This provides further support for this technique as a method of MSC delivery to multifocal or inaccessible injury of these structures, including the proximal suspensory ligament. Three-dimensional reconstructions of the contrast-filled metatarsal vasculature demonstrated the distribution of contrast throughout the vascular supply to the soft tissue structures of interest, including the caudal branches of the saphenous artery, medial and lateral plantar arteries (and perforating tarsal branch), medial and lateral plantar metatarsal arteries, and dorsal metatarsal artery (Figure 1) in 11 of 12 limbs (extravasation of contrast occurred in one horse). Figure 2 demonstrates the increases in attenuation values—that is contrast enhancement—within each soft tissue structure of interest in the early and delayed postcontrast phases. Significant mean contrast enhancement occurred in all soft tissue structures at all postcontrast time points. The largest postcontrast change in mean attenuation values was seen in the early postcontrast phase in all soft tissue structures.

This study builds upon previous work to further validate the use of ultrasound-guided injection of the cranial tibial artery for delivery of injectate to metatarsal soft tissues. Overall, soft tissue structures were seen well on pre-contrast CT scans, supporting previous literature suggesting that this is an appropriate technique for assessment of contrast delivery to these tissues.



Figure 1: Three-dimensional reconstruction of the distal limb during the arterial phase of contrast administration demonstrating contrast medium within the vasculature.

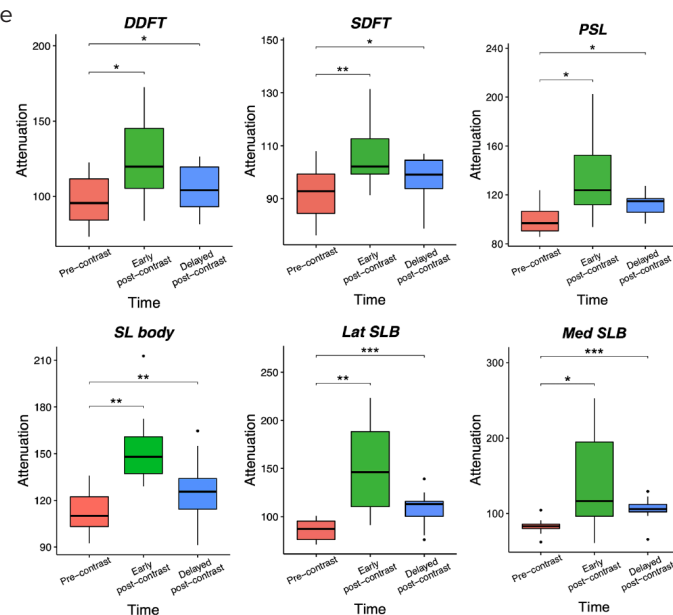


Figure 2: Average attenuation values for the metatarsal soft tissue structures of interest at all time points. Box and whisker plots represent the median, interquartile range, and full range excluding outliers; outliers are marked by the dots. Asterisks indicate the level of significance.

*P-value 0.01–0.05, **P-value 0.001–0.01, ***P-value < 0.001. DDFT, deep digital flexor tendon; SDFT, superficial digital flexor tendon; PSL, proximal suspensory ligament; SL body, suspensory ligament body; Lat SLB, lateral suspensory ligament branch; Med SLB, medial suspensory ligament branch.

Development of an Experimental Model of Palmar Osteochondral Disease in Horses

L. Smanik, H. Stewart, K. Selberg, L. Pezzanite, M. Harris, R. Moore, S. Dow, C. Kawcak

Funding: Grayson-Jockey Club Research Foundation, AAEP Graduate Student Research Grant

Palmar osteochondral disease (POD) is a traumatic fatigue injury of the subchondral bone (SCB) of the palmar distal third metacarpal condyles of Thoroughbred racehorses. A prominent feature of early POD is microcrack formation and osteocyte necrosis within the SCB, often visible on advanced diagnostic imaging as a bone marrow lesion (BML). A successful model for inducing POD does not yet exist and most research involves the use of impact devices that diffusely injure the articular cartilage. An experimental model of POD that would allow researchers to study the progression in a controlled, prospective manner would open the doors for future studies on variables that may affect lesion severity and facilitate development of an optimized treatment plan. The objective of this pilot study is to evaluate the potential of a previously validated pin penetration model to create BMLs in the medial and lateral distal third metacarpal condyles of horses, and to evaluate lesion progression and host response. By combining this model with a high-speed treadmill exercise protocol previously shown to induce SCB remodeling, we hypothesized that this would be a simple, minimally-invasive, and reproducible experimental technique for the induction of BMLs in the third metacarpal condyles in horses, and that the host response and progression of disease would be similar to that published for horses with POD. Lesion progression and host response were monitored via serial lameness examinations, synovial fluid and cytokine analysis, digital radiography, magnetic resonance imaging, computed tomography, and positive contrast arthrography. Horses were euthanized after 6 months and lesions analyzed via gross examination, microcomputed tomography, and histopathology.

Significant BMLs were successfully induced in the third metacarpal condyles bilaterally in 3 skeletally-mature (2-3yr) research horses using the pin penetration model previously developed by a subset of the investigators (Figure 1). There was no contrast seen permeating through the articular cartilage at the level of the pin tract at any time point, suggesting that the articular cartilage was completely sealed within 4 weeks. All horses exhibited an intermittent, inconsistent, bilateral forelimb lameness. Gross examination was consistent with early POD-type lesions including articular cartilage thinning, SCB bruising visible through the articular surface, and mild articular cartilage fibrillation. Microcomputed tomography showed progressive, radial sclerosis surrounding the pin tracts with focal areas of SCB resorption. Results from dual-energy computed tomography, trabecular morphometry analysis, synovial fluid and cytokine analysis, and histopathology are pending. The results of this pilot study have provided in vivo proof-of-concept that the pin penetration technique combined with high-speed treadmill exercise will produce significant BMLs in the palmar third metacarpal condyles, similar to those seen in the early stages of POD on advanced diagnostic imaging. This pilot study will provide a foundation for future studies bridging the gap between descriptive, associative, and predictive factors for the progression of POD-type lesions, as well as studies on how to better optimize treatment.

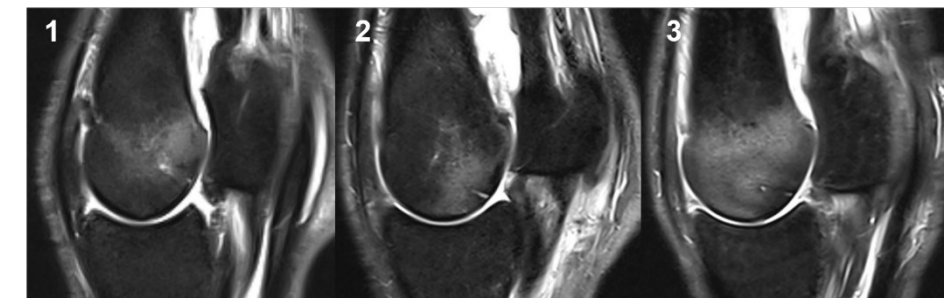


Figure 1: Representative 3-Tesla magnetic resonance images of horses #1-3 acquired 4 weeks post-operatively. Sagittal PD Dixon (water phase) images showing increased fluid signal within the palmar third metacarpal condyles surrounding each pin tract.

Quantitative Evaluation of Equine Articular Cartilage Using Cationic Contrast-Enhanced Computed Tomography

B. Nelson, R. Stewart, C. Kawcak, J. Freedman, A. Patwa, B. Snyder, L. Goodrich, and M. Grinstaff

Funding: Cooperative Veterinary Scientist Research Training Fellowship at Colorado State University (Nelson) the Grayson-Jockey Club Research Foundation

Detection of early articular cartilage injury is a substantial problem in humans and horses. Early cartilage degeneration begins with changes in the extracellular matrix, particularly the loss of glycosaminoglycans (GAGs). In normal (healthy) articular cartilage, the negative charges on GAGs attract water, maintaining tissue hydration and affording compressive stiffness. Contrast-enhanced computed tomography (CECT) is a promising imaging technique that is widely available and offers shorter acquisition times and higher spatial resolution compared with MRI. However, commercially available iodinated contrast media are either negatively charged or uncharged and have limited penetration into articular cartilage. Exploiting the high negative charges in the extracellular matrix, a cationic contrast agent (CA4+) was developed by our collaborators at Boston University for its electrostatic attraction to GAGs with a similar chemical structure to ioxaglate (a contrast agent used clinically). The CECT attenuation obtained with CA4+ (cationic CECT) is 2.9 times higher than with anionic contrast media. Cationic CECT attenuation correlates with GAG ($R^2 = 0.63-0.87$) greater than anionic contrast media ($R^2 = 0.2-0.62$). The objectives of this study are to characterize the diffusion profile of CA4+ into equine articular cartilage, to determine the capability of cationic CECT to highlight differences in degenerative and normal cartilage and to establish the quantitative relationship between CECT attenuation and GAG content and mechanical stiffness (equilibrium modulus, Eeq).

The mean diffusion time constant was longer for medial condyle cartilage (3.05 ± 0.1 hours) than lateral condyle cartilage (1.54 ± 0.3 hours, $P = 0.04$). In a second experiment, cationic CECT attenuation was lower in joints with cartilage defects than the control joint ($P = 0.005$). Mean cationic CECT attenuation from the lateral trochlear ridge was lower in the defect joint than in the control joint (2223 ± 329 HU and 2667 ± 540 HU, respectively; $P = 0.02$). A loss of cationic CECT attenuation was observed at locations adjacent to articular cartilage defects, highlighting the progressive deterioration that occurs of normal cartilage (Figure 1). Cationic CECT attenuation was strongly correlated with both GAG ($\rho = 0.79$, $P < 0.0001$) and Eeq ($\rho = 0.61$, $P < 0.0001$). MicroCT evaluation highlights how lower uptake in degenerative articular cartilage corresponds to degeneration seen on histology (Figure 2).

This study concluded that equine articular cartilage volume and anatomic location affect the diffusion profile and time to reach equilibrium for CA4+. Also, cationic CECT imaging reflects the biochemical, biomechanical, and histological state of normal and degenerative articular cartilage. The next steps in the translation of this technology to the clinic include additional studies examining variability between animal species, efficacy and pharmacokinetic/biodistribution studies in vivo and comparisons of this cationic CECT imaging method to other currently available quantitative MRI techniques. The potential research, preclinical, and clinical benefits of rapid articular cartilage imaging with a quantitative assessment of tissue volume, GAGs and Eeq warrants continued development of new contrast agents and imaging modalities, and their performance evaluation in ex vivo and in vivo models.

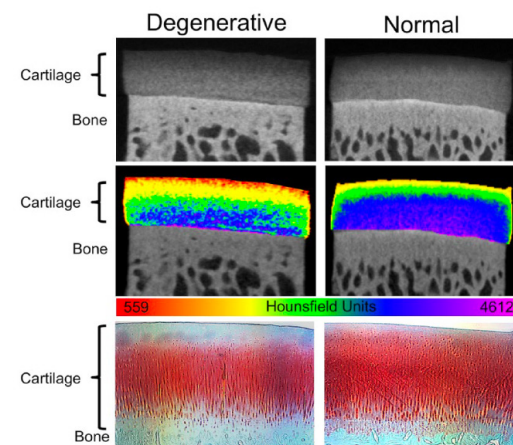


Figure 1: Cationic contrast-enhanced computed tomography (CECT) imaging of degenerative and normal (healthy) equine cartilage with comparative histology images. The top row of images shows cationic CECT of osteochondral plugs. The degenerative plug was collected from a location adjacent to a full-thickness articular cartilage defect. The normal cartilage sample was collected from a joint with no macroscopic cartilage damage. The middle row images show the same microCT scans with an applied color map to highlight the ranges of cationic CECT attenuation throughout each tissue. Note the lower cationic CECT attenuation in all zones in the degenerative versus normal samples despite similar tissue thickness. The bottom row shows comparative histology (safranin-O fast green stain) of the plugs after microCT imaging. High amounts of safranin-O (red) uptake indicate high levels of proteoglycans / glycosaminoglycans in the tissue.

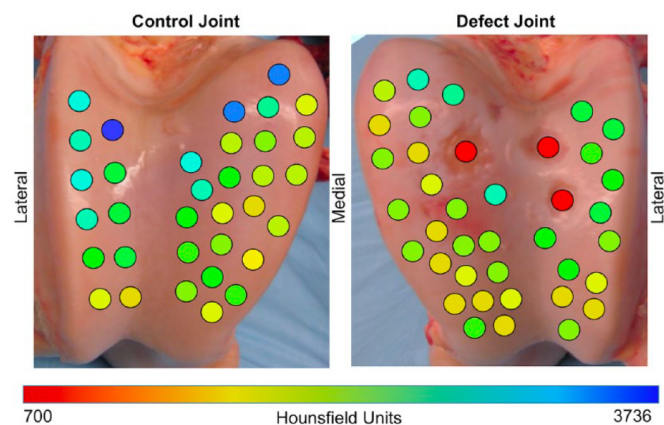


Figure 2: Topographical relationship between the mean cationic contrast-enhanced computed tomography (CECT; microCT) attenuation of each osteochondral plug at equilibrium and the locations of their harvest on the femoral trochlear surfaces in a 4-year-old horse 7 weeks after surgical defects were created. Three critically sized chondral defects were created in the left femoropatellar (defect) joint, while the right (control) joint was sham-operated. The samples shown in red reflect the locations of the chondral defects. Note the lower cationic CECT value surrounding the cartilage defects in the defect joint relative to the control joint.

BUDGETS

Revenue and Expense

REVENUE	FY2022
Total Interest	\$731,552
Service Activity Total	\$4,871
Medical Center Clinical Service Total	\$231,801
Research Project Accounts Total	\$175,775
Stallion Auction	\$19,000
State Funds Total	\$102,591
Total Donations	\$892,320
TOTAL REVENUE	\$2,157,910
EXPENSE	FY2022
Total Salaries	\$1,195,631
Faculty Travel	\$1,970
Materials and Supplies	\$384,195
Other Direct	\$217,549
Building	\$5,589
Equipment	\$0
EXPENSE SUBTOTAL	\$609,303
FACILITY AND ADMINISTRATIVE OVERHEAD COSTS	\$90,868
TOTAL EXPENSE AND OVERHEAD	\$1,895,801
ACCOUNT BALANCE	\$262,109

REVENUE BREAKDOWN	FY2022
INTEREST ON ENDOWMENTS	
Mcllwraith Scholarship	\$7,075
Cox Anthony Chair	\$158,317
Iron Rose Ranch Chair	\$139,500
Atkinson Chair	\$55,288
Kawanakoa Chair	\$109,483
Malone Chair	\$261,889
TOTAL INTEREST	\$731,552



REVENUE BREAKDOWNS	FY2022
STATE FUNDS	
Story CRC Grant	\$20,669
Nelson CRC Grant	\$24,995
Pezzanite CRC Grant	\$24,996
Frisbie CRC Grant	\$6,931
Kawcak CRC Grant	\$25,000
STATE FUNDS TOTAL	\$102,591

EXPENSE	FY2022
SALARIES	
Faculty Salaries	\$468,965
Research Associate Salaries	\$378,362
Administrative Salaries	\$34,747
Residents	\$230,651
Graduate Student Salaries	\$6,960
Hourly Students	\$75,946
TOTAL SALARIES	\$1,195,631

FUNDING

Grants

INVESTIGATORS	SPONSOR	PROJECT TITLE	PERIOD	AMOUNT
Erin Contino, Laurie Goodrich (Co-PIs)	Zoetis	Prospective clinical trial: Evaluation of autologous protein solution (APS) as an anti-inflammatory therapeutic for adult horses with naturally-occurring lameness isolated to the medial femorotibial joint	1/1/22-12/1/25	\$315,844
Felix Duerr (PI), Laurie Goodrich (Co-PI)	Morris Animal Foundation	Intra-articular gene transfer of interleukin-10: development of a new strategy for the treatment of canine osteoarthritis	10/1/20-9/30/22	\$49,490
David Frisbie (PI)	College Research Council (CRC)	The effect of blood flow restriction therapy on interleukin-1 receptor antagonist protein and stem cell harvest in horses: A proof of concept study	7/1/22-6/30/23	\$6,931
David Frisbie (PI), Myra Barrett, Katie Seabaugh (Co-PIs)	Smith and Nephew, Inc.	Evaluation of minced cartilage as a method for healing cartilage defects	11/1/18-6/30/22	\$359,756
Laurie Goodrich (PI), Steven Dow, Lynn Pezzanite (Co-PIs)	The Foundation for The Horse	The temporal course of the cytokine, immune and transcriptomic response in osteoarthritis progression	11/1/20-10/31/22	\$19,660
Laurie Goodrich (PI), Jeremiah Easley (Co-PI)	Cayman Biomedical Research Institute	Evaluation of the use of small novel compounds KMN 159 and KMN 224, as osteogenic inducers in horse and sheep cultures	11/16/20-11/15/22	\$74,757
Laurie Goodrich (PI), Lauren Smanik, Kurt Selberg, Chris Kawcak (Co-PIs)	American College of Veterinary Surgeons	Computed Tomography versus Radiographs Guidance for Internal Fixation of Central Tarsal Bone Fractures in Non-Racing Horses	6/1/21-5/30/22	\$10,000
Laurie Goodrich (PI), Brad Nelson, Kirk McKilvrey, Ben Gadomski (Co-PIs)	AlloSource	Comparison of Fresh to Cryopreserved Human Osteochondral Allografts (COCA): Characterization of Cellular, Biomechanical and Structural Markers Over Fresh and Extended Storage Conditions	8/1/21-12/31/23	\$151,852
Laurie Goodrich (PI), Brian Johnstone, Parvathy Thampi (Co-PIs)	American Quarter Horse Association	Effect of donor age on the functionality of equine articular chondroprogenitor cells	10/1/21-9/30/22	\$20,000
Laurie Goodrich (Mentor), Bethany Liebig (PI), John Kisiday (Co-PI)	The Foundation for The Horse	Evaluation of persistence of chondrocytes or mesenchymal stromal cells after intra-articular injection	1/1/22-12/31/22	\$19,704
Laurie Goodrich (PI), Parvathy Thampi, Brian Johnstone, Steven Dow, Linda Chow (Co-PIs)	Hong Kong Jockey Club Research Foundation	Immunomodulatory effects of equine chondroprogenitor cells in an animal model of osteoarthritis	4/1/22-3/30/23	\$37,935
Laurie Goodrich (PI), David Frisbie, Myra Barrett, Christopher Kawcak, C. Wayne Mcllwraith, Constance Chu (Co-PIs)	DOD-US Department of Defense	Development of Diagnostic and Treatment Strategies for Post Traumatic Osteoarthritis (PTOA)	9/1/18-8/31/22	\$711,101
Laurie Goodrich (PI), Steven Dow (Co-PI)	Grayson-Jockey Club Research Foundation	Antimicrobial properties of equine mesenchymal stem cells: an approach to cure septic arthritis	5/1/19-3/30/22	\$198,056
Laurie Goodrich (PI), David Frisbie, Myra Barrett, Christopher Kawcak, C. Wayne Mcllwraith (Co-PIs)/Constance Chu (PI)	Stanford University (DOD-US Department of Defense)	Localized Gene therapy for Prolonged Anti-inflammatory Treatment to Prevent or Delay PTOA in an Equine Model	1/15/20-8/31/22	\$952,862
Christopher Kawcak (PI), Brad Nelson (Co-PI), Holly Stewart (Co-PI), Kelly Zersen (Co-PI), Kurt Selberg (Co-PI)	The Foundation for The Horse	Validation of an innovative contrast subtraction technique to detect equine bone marrow lesions using CT	10/1/20-12/31/22	\$19,981
Christopher Kawcak (PI), Lauren Smanik (Co-PI), Kurt Selberg (Co-PI), Holly Stewart (Co-PI)	Grayson-Jockey Club Research Foundation	Development of an experimental model of palmar osteochondral disease in the horse: a pilot study	4/1/22-3/31/23	\$15,002

INVESTIGATORS	SPONSOR	PROJECT TITLE	PERIOD	AMOUNT
Christopher Kawcak (PI), MC Duff (Co-PI), Xiaochuan Pan (Co-PI), Emil Sidky (Co-PI), Kurt Selberg (Co-PI), Holly Stewart (Co-PI), C. Wayne Mcllwraith (Co-PI)	Grayson-Jockey Club Research Foundation	Development of Limited View 3D imaging for the equine distal limb	4/1/18-3/31/23	\$198,836
Christopher Kawcak (PI), C. Wayne Mcllwraith (Co-PI), Frances Peat (Co-PI), Kurt Selberg (Co-PI), David Frisbie (Co-PI)	Grayson-Jockey Club Research Foundation	Thoroughbred Sales Radiology-Ultrasonography Study	4/1/18-7/1/22	\$144,577
Christopher Kawcak (PI), Steve Simske, Luke Bass, Erin Contino (Co-PIs)	College Research Council (CRC)	Development of a visual AI technique to characterize musculoskeletal pain in horses	7/1/22-6/30/23	\$25,000
John Kisiday (PI)	American Kennel Club Canine Health Foundation, Inc.	Characterizations of mesenchymal stromal cell properties of canine culture-expanded articular chondrocytes	3/1/21-2/28/22	\$14,973
John Kisiday (PI), Laurie Goodrich (Co-PI), Berthany Liebig (Co-PI)	American Quarter Horse Association	Comparing the immunomodulatory potency of equine culture-expanded articular chondrocytes	10/1/21-9/30/22	\$20,000
Brad Nelson (PI), Katie Sikes (Co-PI)	College Research Council (CRC)	Development of an equine chronic tendinopathy model: A more clinically applicable approach for testing emerging therapies	7/1/22-6/30/23	\$24,995
Brad Nelson (PI), Ben Gadomski (Co-PI), Christopher Kawcak (Co-PI), Kirk McGilvray (Co-PI), Tom O'Brien (Co-PI)	American College of Veterinary Surgeons	Comparison of the Osteocentric bone screw fastener to the AO buttress screw in an ex vivo model of equine midbody proximal sesamoid bone fracture repair	5/1/21-5/1/22	\$14,811
Lynn Pezzanite (PI), Dean Hendrickson, Steve Dow (Co-PIs)	College Research Council (CRC)	Exploring the link between gut dysbiosis and inflammation in progressive osteoarthritis in horses	10/1/22-9/30/23	\$24,996
Melinda Story (PI)	College Research Council (CRC)	A cross sectional survey of dorsal root ganglionitis in horses	7/1/22-6/30/23	\$20,669



IN MEMORIAM

Alan Nixon, B.V.Sc., M.S.

Dr. Alan Nixon, one of our first large animal surgery residents at Colorado State University, (CSU) and certainly one of our most renowned, passed away March 1st, 2023 at the age of 67 after a long battle with cancer. Dr. Nixon's contributions to orthopedics, in both the veterinary and human fields are both significant and far reaching.

Dr. Nixon was born in Australia and graduated from the University of Sydney Veterinary School in 1980. Following an internship at the University of Sydney and a brief period in private practice, he joined us at CSU in July, 1980 as a large animal surgery resident, which he completed in 1983. He also completed a Master of Science degree during that time. In August 1970, two of our 3 internships were changed to residency positions and Drs. Alan Nixon and George Martin were selected for those positions. They were extremely memorable and exciting years. His talent for both surgery and scientific research were immediately obvious. He went on to be one of the most foremost equine orthopedic clinician- scientists of his generation, had an outstanding career in equine surgery, and is internationally recognized for the development of new arthroscopic surgery techniques, as well as innovative advances in orthopedic research.

Following his time at CSU, he became an Assistant Professor of Large Animal Surgery at the University of Florida, College of Veterinary Medicine 1983 to 1988, and then moved on to a long and fruitful career at the Cornell College of Veterinary Medicine from 1988 through 2021. During this time, Alan trained 15 interns, 40 surgical residents, 15 postdoctoral trainees, 15 Ph.D. candidates, and 10 M.S. candidates, as well as countless D.V.M. students. He was a talented orthopedic surgeon with a calm air of confidence that inspired all whom he trained.

His profound contributions to equine orthopedic surgery are exemplified by his being the Editor of Equine Fracture Repair (both first and second editions) and coauthor of the 3rd and 4th editions of Diagnostic and Surgical Arthroscopy of the Horse. As well as numerous publications of original techniques, usually with one of his residents as his first author. He is also extremely accomplished in basic science research, being a pioneer in equine chondrocyte and mesenchymal stem cell culturing, as well as manipulation of cartilage repair including gene therapy and, most recently, small interference RNA. He received an NIH RO1 grant which is evidence of the level his science reached.

He received multiple awards for his contributions to orthopedic research including the Neer Award from the American College of Shoulder and Elbow Surgeons, the Founders award from the American College of Veterinary Surgeons, and was also inducted into the Equine Research Hall of fame in 2009.

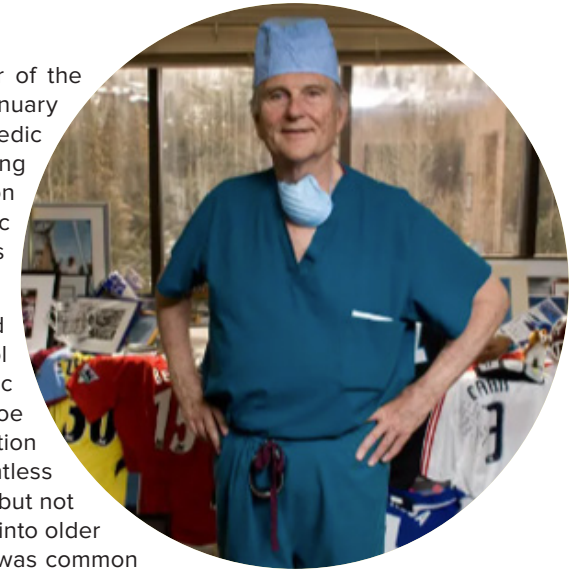
He was the mentor of Dr. Laurie Goodrich for her Ph.D. at Cornell before she joined us here at CSU and is a coauthor on multiple collaborative projects between Drs. Dave Frisbie, Laurie Goodrich, and myself with multiple graduate students at CSU. His relationship with CSU came full circle in the last 15 years when he has participated as faculty of our Advanced Equine Arthroscopic Surgical courses each year, together with Drs. Chris Kawcak, Dave Frisbie, Laurie Goodrich, Ian Wright (UK), and more recently Drs. Brad Nelson, Wes Sutter, and Ryan Carpenter (the latter one is one of our star residents at CSU). He was also long-term faculty member in the AO Fracture Fixation courses. Allen was a prolific mentor to a generation of aspiring veterinary clinicians- scientists including ICRS past- President Lisa Fortier and Laurie Goodrich amongst them. Although Dr. Nixon did not have a Ph.D., he took a sabbatical to work with Linda Sandell, Ph.D. to learn how to do more advanced molecular techniques that accelerate his gene therapy program. He became one of the world's experts in clinical applications of gene therapy for the musculoskeletal system and was frequently called upon to consult to FDA on issues related to clinical translation.



J. Richard Steadman, M.D.

Renowned human orthopedic surgeon, and close friend and collaborator of the Orthopaedic Research Center (ORC) Dr Richard Steadman passed away on January 20th, 2023. Dr. Steadman was widely considered one of the best orthopedic surgeons of his generation, though he tended to shrink from praise, insisting that he was no better than anyone else and that his secret was the organization he had built around himself. Renowned both for revolutionizing orthopedic surgery by inventing ground-breaking procedures and for helping countless athletes return to competition.

After attending Texas A & M on a football scholarship. Dr. Steadman earned his medical degree from the University of Texas Southwestern Medical School in Dallas, served the US army in Germany then completed his orthopedic residency in New Orleans. In 1970, he moved his family to South Lake Tahoe where he joined a local orthopedic practice and that is where his long association with the US Ski Team began, and his worldwide reputation for saving countless knees and careers of skiers, as well as other professional athletes, and last but not at least, non-professional athletes who wanted to continue athletic pursuits into older age. He also began innovative treatments for knee injuries. At the time, it was common practice to immobilize a reconstructed knee in a cast for 8 weeks; Dr. Steadman knew this was the wrong thing to do and was an innovator of early motion and further rehabilitation procedures after surgery and that, arguably, was key to his excellent success rate.



He developed the technique of subchondral microfracture for enhancing repair of articular cartilage defects in the knee, and his innovation extended into his "healing response" technique of performing microfracture at ligamentous insertions to promote repair. The ORC association with Dr. Steadman started after he moved to Vail, CO and started the Steadman Clinic in 1990. Dr. Bill Rodkey, a veterinary surgeon who joined Dr. Steadman in Vail as his Research Advisor, introduced him to Wayne McIlwraith. After a visit to Vail, Dr. Steadman came to the ORC, scrubbing in on some equine surgeries with Drs. Dave Frisbie and Wayne McIlwraith. They started what was a pivotal research collaboration that represented their initiation of translational research into human orthopedics. Their initial project was validating in a controlled manner in horses that microfracture did enhance articular cartilage repair compared to debridement of the defect alone. They then went on to do further studies including evaluation of the early tissue and molecular changes that occurred with microfracture and showed significant upregulation of critical components of the articular cartilage (published in Clinical Orthopedics and Related Research), followed by a controlled study demonstrating that it was critical for ultimate efficacy to remove all calcified cartilage from the defect before performing microfracture. This was a pivotal paper that changed the method of debridement of defects in human orthopedics and was published in the American Journal of Sports Medicine. They then went on to show that they could further augment the microfracture repair with mesenchymal stem cells, and this is published in the Journal of Arthroscopic Surgery. All of these research projects were funded by the non-profit started by Dr. Steadman, initially the Steadman Hawkins Sports Medicine Research Foundation and later the Steadman Philippon Research Institute) for a total of over \$1,000,00. Everything he did, including funding this research, was to keep making things better for his patients. This collaboration, and the publications from it led to corporations and researchers recognizing the value and equivalence of the horse in articular cartilage in humans and coming to us to collaborate resulting in further advances.

In addition to his orthopedic surgery and innovation renown, Dr. Steadman was equally notable as a special person in that was both humble and caring about his patients. The first time I saw him doing clinical examinations with patients it was clear that the patient was the only person in the room; he was totally focused but also patient in answering every question. He actually was quite renowned for the fact that his clinical appointment schedule got behind later and later in the day because of his priority of communication with the patient.

He was a great friend of veterinarians and veterinary surgeons, and had the greatest respect for what we did. Drs. Rodkey, Steven Arnoczsky, and Wayne McIlwraith were on his scientific advisory committee of the Steadman Hawkins Sports Medicine Research Foundation, as well as the Steadman Phillippon Research Institute. At each meeting when the new intake of fellows were introduced, they were given a lesson in what veterinary surgeons could do and how critical they were to acquiring knowledge in orthopedic sports medicine. In all our dealing with Dr. Steadman, it is easy to note his integrity, humbleness, and incredible drive to make things better for both his and our patients. Our friendship and collaboration continued into the evolution of the Translational Medicine Institute.



The Orthopaedic Research Center at Colorado State University is known worldwide for joint problem prevention and healing research in horses, with complementary work in human athletes. We are at the forefront of developing novel therapies, including stem cells that offer exciting treatment options for neuromusculoskeletal disease and injury.

Your gift to the ORC will advance our research program, support innovation in clinical treatments and regenerative therapies, and advance translational research. If you have more questions about giving opportunities at the ORC, please contact Sarah Schmidt, Executive Director of Development, at s.schmidt@colostate.edu.

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