



Musculoskeletal Research Center

2023-2024 ANNUAL REPORT



Children's Hospital Colorado



University of Colorado
Anschutz Medical Campus



A LETTER FROM OUR LEADERSHIP

Dear colleagues,

Our mission at the Musculoskeletal Research Center (MRC) is to conduct exemplary research within the University of Colorado's Department of Pediatric Orthopedics and Sports Medicine that achieves faculty academic advancement, staff professional development and improved patient outcomes. In the 2023-2024 academic year, we made significant organizational enhancements allowing us to coordinate our research, education and clinical care goals while strengthening existing local, national and international partnerships.

We have restructured our MRC research program to align with the University of Colorado's Orthopedic Research Department, which under the leadership of Mike Zuscik, PhD, has become a national leader in both clinical and basic science orthopedic research. Additionally, we expanded our MRC leadership and core resource group to include Deirdre Rafferty, MS, ATC, as our MRC administrative manager. Her exemplary communication and leadership skills provide an invaluable resource that will help improve our research culture as we continue to grow. To expand educational and research potential and reputation, we welcomed Kellen Krajewski, PhD, as the first postdoctoral research fellow in the MRC. Dr. Krajewski will be with us for the next two years, providing expertise in motor control and gait biomechanics. Catherine Donahue, PhD, ATC, also joined us as a post-doctoral fellow researcher. She brings a wealth of knowledge and expertise related to the interaction between concussion and sleep health.

This year, we advanced programmatic research across all our subspecialty areas. This success is evident in our many accomplishments across national and international communities, including 34 peer-reviewed manuscripts, 56 peer-reviewed abstracts presented at national/international meetings, 21 active and new grants, 34 study groups among the subspecialty areas and 19 active randomized control trials.

From an educational perspective, our department continues to offer the Robert E. Eilert Children's Orthopedics Day with two visiting professors each year joining us to share knowledge, as well as a competitive, ACGME accredited fellowship program (two per year). In 2023, we reinstated our summer internship program with eight participating interns. From a national perspective, we hosted two educational meetings in 2023: the annual Pediatric Research in Sports Medicine (PRISM) meeting and the Skeletal Dysplasia Management Consortium. This year, we are proud to host the International Consortium on Spine Genetics, Development and Disease, bringing together world's experts in spine genetics and development.

Finally, we've been awarded new funding from both public sources and private foundations within the last year. Funding has been distributed within clinical, translational and basic science areas to advance our overall mission.

We invite you to review our 2023-2024 annual report which highlights many of our exciting accomplishments from the past academic year.

Sincerely,



JAMES J. CAROLLO, PhD, PE

*Co-Director, Musculoskeletal
Research Center*



NANCY HADLEY-MILLER, MD

*Co-Director, Musculoskeletal
Research Center*



KLANE WHITE, MD, MSc

Chair, Pediatric Orthopedics

Meet the team

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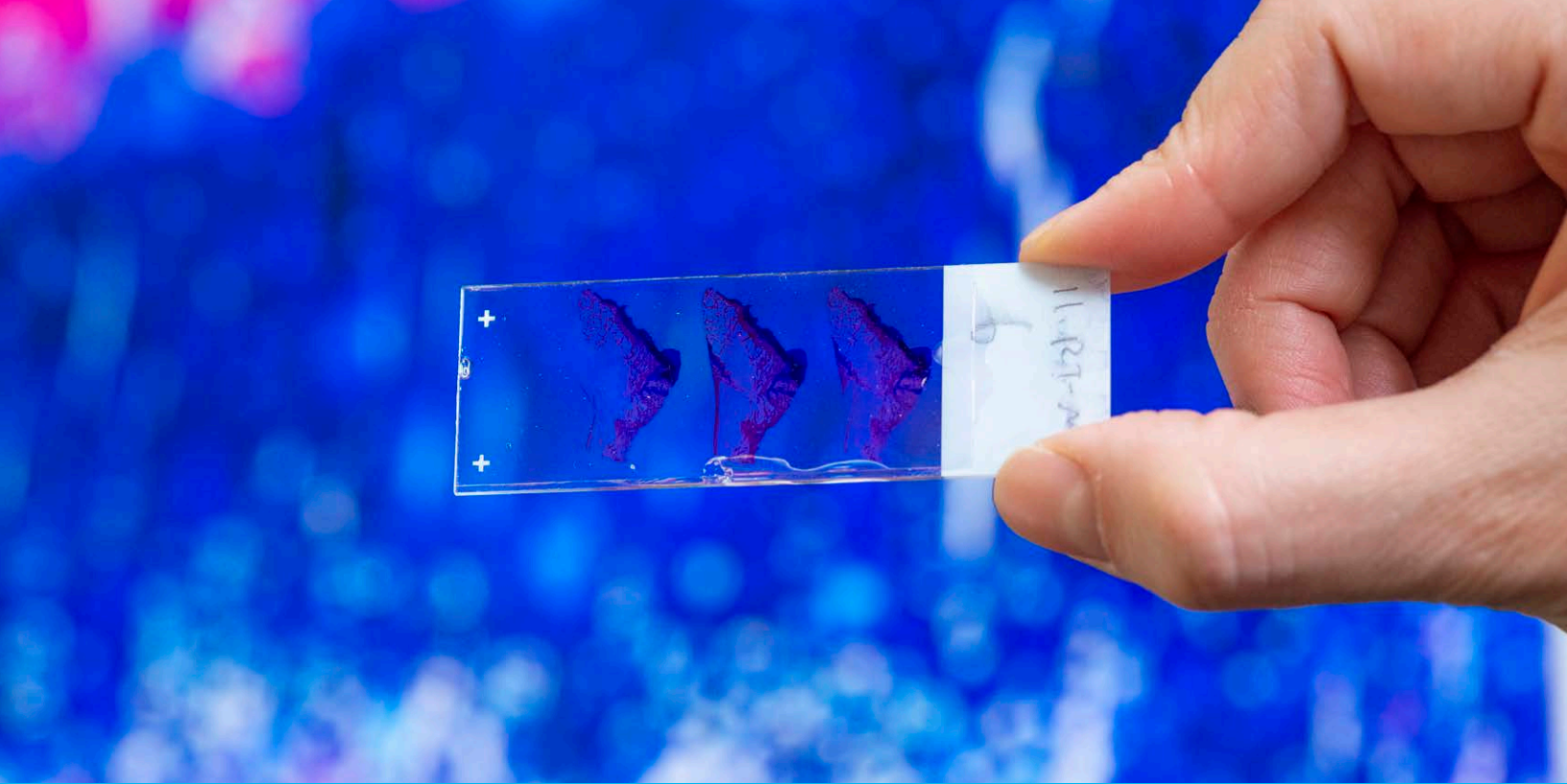


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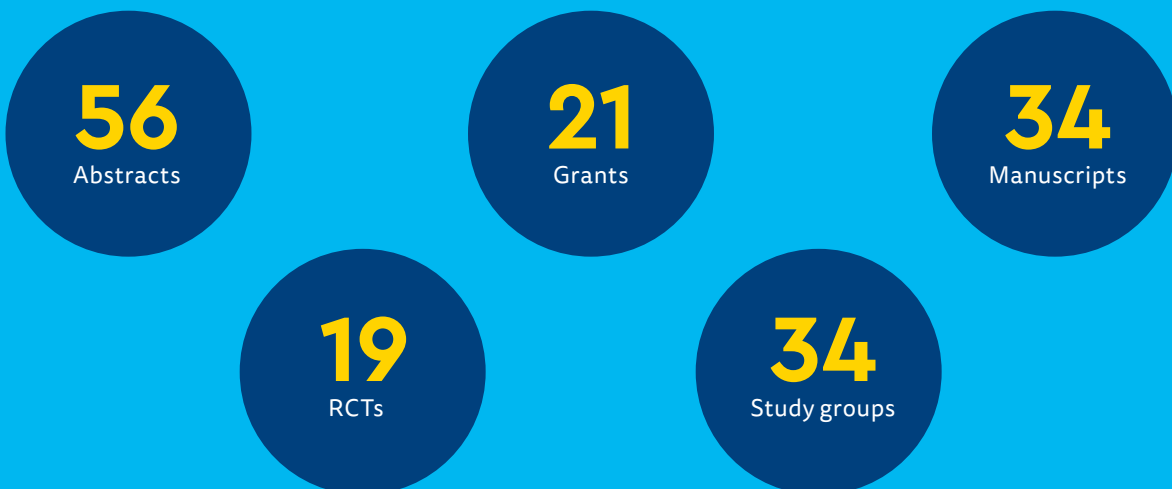


Research overview

Key consortiums

There are currently 242 active IRB-approved projects within the MRC. Orthopedic clinical investigators were involved in over 30 multi-site research collaborations related to the study of many orthopedic conditions including complex spinal deformity, skeletal dysplasia, Legg-Calve-Perthes Disease, sports medicine, cerebral palsy and fracture management.

Peer-reviewed research summary



Impactful research

MRC used the Altmetric Attention Score to highlight the papers that have received the most attention online. The score reflects online engagement with a scholarly article, incorporating mentions in news articles, social media, blogs, policy documents and more. All three of the articles below scored in the top 25th percentile of research outputs calculated by Altmetric.

"Postconcussion Moderate to Vigorous Physical Activity Predicts Anxiety Severity among Adolescent Athletes"

Physical activity can be an important part of overall health, including mental health. Following a concussion, athletes used to be told to avoid strenuous activity. Over recent years, however, evidence has shifted toward encouraging activity following concussion to facilitate optimal healing. This study found that engaging in higher intensity physical activity (moderate-to-vigorous physical activity) after a concussion may play a vital role in helping teenagers feel less anxious while recovering. Addressing anxiety in the concussion recovery process can have an impact on schoolwork, relationships and general well-being. Thus, physical activity-based interventions may help to manage anxiety and promote improved mental health after concussion.



Smulligan KL, Wingerson MJ, Magliato SN, Rademacher JG, Wilson JC, Howell DR. Postconcussion Moderate to Vigorous Physical Activity Predicts Anxiety Severity among Adolescent Athletes. *Med Sci Sports Exerc.* 2024;56(5):790-795. doi:10.1249/MSS.0000000000003368

"Once-weekly TransCon CNP (navepegritide) in children with achondroplasia (ACcomplisH): a phase 2, multicentre, randomised, double-blind, placebo-controlled, dose-escalation trial"

This phase 2 clinical trial evaluated the benefit of a once weekly CNP analog aimed at increasing growth velocity in children with achondroplasia, a genetic condition that causes short stature. In this trial, a new therapy was shown to be safe, well-tolerated and effective in increasing annualized growth velocity. This work represents one of several clinical trials that the Skeletal Dysplasia Program is participating in at Children's Hospital Colorado.



Savarirayan R, Hoernschemeyer DG, Ljungberg M, Zarate YA, Bacino CA, Bober MB, Legare JM, Hagler W, Quattrin T, Abuzzahab MJ, Hofman PL, White KK, Ma NS, Schnabel D, Sousa SB, Mao M, Smith A, Chakraborty M, Giwa A, Winding B, Volck B, Shu AD, McDonnell C. Once-weekly TransCon CNP (navepegritide) in children with achondroplasia (ACcomplisH): a phase 2, multicentre, randomised, double-blind, placebo-controlled, dose-escalation trial. *EClinicalMedicine.* 2023 Nov; 65:102258. PMID: 37823031

"Exercising More Than 150 min/wk After Concussion Is Associated With Sleep Quality Improvements."

Concussions can significantly disrupt multiple facets of life, including sleep health. This study identified that increasing exercise to 150 minutes per week during concussion recovery can improve sleep quality. This strategy has also been shown to benefit other aspects of recovery and underscores the critical role of physical activity in supporting overall concussion rehabilitation.



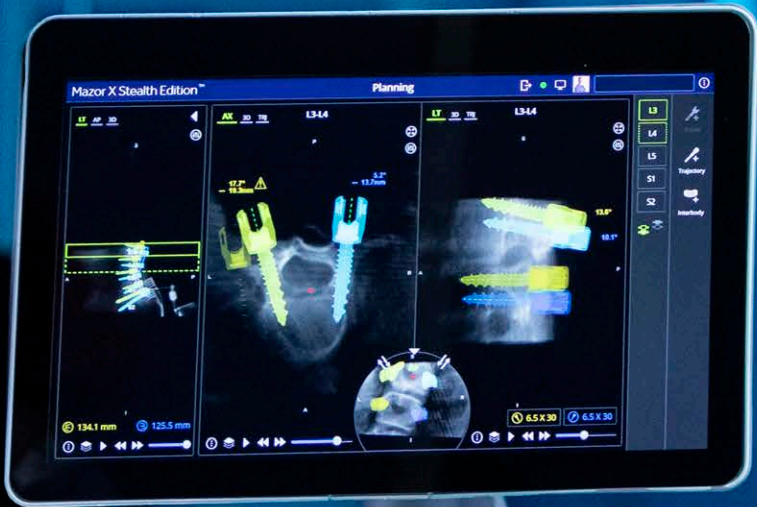
Howell DR, Wingerson MJ, Smulligan KL, Magliato S, Simon S, Wilson JC. Exercising More Than 150 min/wk After Concussion Is Associated With Sleep Quality Improvements. *J Head Trauma Rehabil.* 2024;39(4):E216-E224. doi:10.1097/HTR.0000000000000918



Click the icon to read more

Discover more by clicking on the icons throughout this report to read the full study or learn more about our research.







Research programs in the MRC

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Postdoctoral Research Fellow Program



Cerebral Palsy/Neuromuscular Program

PROGRAM OVERVIEW

The neuromuscular team at Children's Hospital Colorado treats orthopedic conditions that arise from neuromuscular conditions and provide care from infancy through adulthood. Their research aims to improve and innovate surgical treatment to enhance functional capabilities while simultaneously reducing patient rehabilitative burden. Projects include case reports, retrospective chart reviews, cross-sectional studies and prospective non-randomized treatment studies. In collaboration with the Center for Gait and Movement Analysis (CGMA), treatment outcomes and their impact on maintaining gait performance in individuals with cerebral palsy are clinically evaluated and objectively measured over the lifespan.

RESEARCH HIGHLIGHTS

"Effect of split posterior tibialis tendon transfer on foot progression angle in children with cerebral palsy"

A common issue for children with cerebral palsy is hindfoot varus deformity that results from spasticity. A split posterior tibialis tendon transfer (SPOTT) is one surgical option. A retrospective cohort of 44 limbs were analyzed in the Center for Gait and Movement Analysis revealing that SPOTT changes foot progression angle by 10.9 degrees.



Sayan D, Skinner A, Tagawa A, et al. Effect of split posterior tibialis tendon transfer on foot progression angle in children with cerebral palsy. *Foot (Edinb)*. 2024;59:102087. doi:10.1016/j.foot.2024.102087

"Retrograde Insertion Approach for Anterior Distal Femoral Hemiepiphysiodesis Procedure: A Case Report"

Knee flexion contractures are a prevalent secondary consequence of spasticity in children with cerebral palsy. Anterior distal femoral hemiepiphysiodesis (ADFH) is an established procedure that constrains growth in the anterior portion of the distal femur correcting knee flexion contracture. ADFH is traditionally performed by inserting screws superior to the physis which can lead to many complications due to the difficulty of placing the screws parallel to the long axis of the femur. Our surgeons have developed a novel approach by inserting the screws from the inferior aspect of the physis (retrograde). This case report demonstrated that the approach yielded positive clinical outcomes without commonly associated complications.



Krajewski KT, Miller S, Dimovski R, Rhodes J, De S. Retrograde Insertion Approach for Anterior Distal Femoral Hemiepiphysiodesis Procedure: A Case Report. *JBJS Case Connect*. 2024;14(3):e24.00085. Published 2024 Aug 29. doi:10.2106/JBJS.CC.24.00085



JAMES CAROLLO, PhD

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Associate Professor, Physical Medicine & Rehabilitation



SAYAN DE, MD

Periop Medical Director

Assistant Professor, Orthopedics



JASON RHODES, MD

Associate Professor, Orthopedics



General Orthopedics Program

PROGRAM OVERVIEW

The General Orthopedics Program conducts research on a wide range of orthopedic conditions, including developmental dysplasia of the hip (DDH), Charcot-Marie-Tooth (CMT) disease and a variety of pediatric fractures. By exploring the causes, treatment options and long-term outcomes of these disorders, the program seeks to advance understanding of pediatric orthopedic health and ultimately improve outcomes for children affected by these common musculoskeletal conditions.



RESEARCH HIGHLIGHTS

"Outcomes of Simultaneous Lengthening and ACL Reconstruction in Fibular Hemimelia: A Retrospective Case Series"

Patients with complex fibular hemimelia often experience leg length discrepancies due to femoral and tibial deficiencies. While bone lengthening procedures address these discrepancies, these patients also frequently have soft tissue challenges, such as ACL/PCL deficiencies that affect knee stability. This study detailed a novel surgical technique that integrates long bone lengthening with ACL reconstruction into a single, cohesive procedure. Results demonstrated that the patients who underwent this combined surgery experienced fewer complications related to joint instability during intermedullary lengthening.



Reeves B, Roper B, Salton R, et al. Outcomes of Simultaneous Lengthening and ACL Reconstruction in Fibular Hemimelia: A Retrospective Case Series. *Iowa Orthop J.* 2024;44(1):93-98.

"Efficacy of 12 Weeks of Pavlik Bracing vs. Treatment to Normalization for Graf Type IIc Hips"

This randomized control trial aims to establish the non-inferiority of variable Pavlik harness bracing (Six weeks minimum, then discontinuation upon hip normalization) compared to the standard 12-week full-time Pavlik protocol. While the 12-week protocol is widely used, it may unnecessarily burden parents and providers and increase the risk of bracing complications. Enrollment for this randomized control trial is ongoing. Recent efforts to reemphasize the study's significance to baby hip providers have accelerated participation.

"Charcot-Marie-Tooth (CMT) Disease: Outcomes from the Children's Hospital Colorado Multidisciplinary Clinic"

The CMT Multidisciplinary Clinic, recognized by the CMT Association and Hereditary Neuropathy Foundation as one of the only CMT Centers of Excellence in the region, offers a unique opportunity to research this heterogenous disorder. Understanding the symptoms, progression and intervention timing for CMT is crucial given the wide range of unique CMT subtypes. We have made significant progress in data collection from these clinic patients with exciting developments on the horizon. These include a POSNA grant submission for establishing a multicenter database, studies on digital biomarkers at the upcoming CMTA conference and analysis of patient data to create subprojects on foot posture changes, early childhood indicators of CMT and the timing/effectiveness of orthopedic surgical interventions.



GAIA GEORGOPOULOS, MD
Associate Professor, Orthopedics



NANCY HADLEY-MILLER, MD
Professor, Orthopedics



MARGARET SIOBHAN MURPHY-ZANE, MD
Associate Professor of Clinical Practice, Orthopedics





Hand and Upper Extremity Program

PROGRAM OVERVIEW

Our research evaluates topics including congenital hand differences, hand and forearm fracture outcomes, healthcare costs and provider well-being. Our mission is to attain excellent health outcomes in upper extremity surgery using evidence-based data while keeping in mind that treatment should be personalized for every child's unique healing trajectory.



SARAH SIBBEL, MD

Surgical Director of the Brachial Plexus Clinic

Associate Professor, Orthopedics



RESEARCH HIGHLIGHTS

"Establishing the Role of Inflammatory Markers in the Diagnosis and Treatment of Acute Hand Infections in the Pediatric Population"

Blood tests for inflammatory markers have shown promise to help predict the severity of certain pediatric musculoskeletal infections. However, our new research shows that these blood tests were not correlated with either severity or specific diagnoses of pediatric hand and wrist infections. Thus, they should continue to be used in tandem with symptomology, physical examinations, radiographic findings, patient history and clinical judgement to determine diagnosis and treatment response.



Schutz J, Lalka A, Williams MA, Sibbel SE, Sinclair MK. Establishing the Role of Inflammatory Markers in the Diagnosis and Treatment of Acute Hand Infections in the Pediatric Population. *J Pediatr Orthop*. 2023;43(10):649-653. doi:10.1097/BPO.0000000000002508

"Outcomes of Pediatric Proximal Phalanx Base Fractures"

Pediatric proximal phalanx fractures are a common injury generally resolved with non-operative management. We conducted a multi-site retrospective chart review to identify the incidence of closed reduction and surgical management, the parameters that are frequently associated with those treatment modalities and the incidence of rotational malalignment. Surgical management occurred in 2.2% of the cohort, while non-operative closed reduction occurred in 23.5%. The incidence of rotational malalignment was rare at 0.93%. Overall, these injuries rarely heal with detrimental range of motion impacts, and we successfully described parameters that can guide closed reduction and surgical management.



Schutz J, Korrell H, Look N, et al. Outcomes of Pediatric Proximal Phalanx Base Fractures. *J Am Acad Orthop Surg*. 2024;32(9):e434-e442. doi:10.5435/JAAOS-D-22-00940



Hip Preservation Program

PROGRAM OVERVIEW

The Hip Preservation Program at Children’s Colorado focuses on understanding and treating hip conditions across childhood and adolescence. We have research and clinical expertise related to the following hip conditions: developmental dysplasia of the hip, slipped capital femoral epiphysis, Legg-Calve-Perthes disease, adolescent onset dysplasia and Femoroacetabular impingement (FAI). Current projects examine patient predisposition, long-term effects, progression of hip problems and effective interventions to extend the preservation of hip function and cartilage.



RESEARCH HIGHLIGHTS

"The Optimal Age for Surgical Management of DDH Differs by Treatment Method"

We compared clinical outcomes among patients who underwent closed reduction (CR), open reduction (OR) or open reduction with concomitant pelvic osteotomy (ORP) for management of a dislocated hip. Age at index surgical procedure was correlated with both clinical and radiographic outcomes. Age at index procedure did impact the risk of further corrective surgery (FCS), particularly in the CR and ORP groups. Based on our analysis, CR should be considered before 9.9 months of age and OR considered before 11.5 months of age to minimize the risk of FCS during childhood. This work highlights the importance of considering age-related heterogeneity in developmental dysplasia of the hip treatment outcomes.



Martino R, Carry P, Adams J, Brandt A, Sink E, Selberg C. The Optimal Age for Surgical Management of DDH Differs by Treatment Method. *J Pediatr Orthop*. 2024;44(1):7-14. doi:10.1097/BPO.0000000000002569

POSNA Presentation: Temporary In-Situ Pinning is a Safe Alternative to Primary Modified Dunn *(manuscript in progress)*

Adams J, Zalneraitis B, Whiting G, Archer J, Smith H, Selberg C

We demonstrated no difference in complication rate in patients with moderate/severe slipped capital femoral epiphysis (SCFE) treated with primary Modified Dunn (MD) compared to temporary in-situ pinnin (ISP) with subsequent conversion to MD. Both groups had low complication rates, with a 10% avascular necrosis (AVN) rate for the study population overall. Our small sample size demonstrates that a staged approach in the surgical correction of SCFE may be a safe alternative to primary MD if an experienced hip preservation surgeon is not immediately available. This also allows additional time for the patient and family to understand the risk/benefit ratio for the MD surgery prior to conversion.



COURTNEY SELBERG, MD

Associate Professor, Orthopedics

Director, Hip Preservation Program



Miller Scoliosis Lab

PROGRAM OVERVIEW

The Miller Scoliosis Lab is a critical meeting point between clinical research and basic science. They utilize clinical specimens to achieve a goal of broadening the scientific community's knowledge of the complex molecular underpinnings, including the genetics, of idiopathic scoliosis. Lab research includes maintenance and analysis of over 1,000 clinical specimens collected over decades, with the goal that understanding this condition fully at the molecular level may one day lead to new detection, prevention and treatment options for the estimated 2% of the worldwide population with idiopathic scoliosis (IS).

The lab is directed by Nancy Hadley-Miller, MD, professor and pediatric orthopedic surgeon at the University of Colorado and Children's Colorado. As a clinician scientist, she specializes in the study of idiopathic scoliosis, having persistently researched the etiology of this complex genetic disorder over the span of her career.

RESEARCH HIGHLIGHTS

Developing genetic profiles for families

The Miller Scoliosis Lab works to understand how genetics impacts the mechanism of adolescent idiopathic scoliosis (AIS). Thanks to our extensive familial idiopathic scoliosis biobank, we have been able to perform exome sequencing on multigenerational families, with the aim of developing a genetic profile in families affected with AIS.

This data has shed light on the importance of a cellular structure called cilia. Kif7 is one of the many genes regulating cilia, and it has been found to be mutated in several individuals in our dataset and confirmed in a collaborator's dataset. We are in the midst of understanding how mutations in this gene affect cilia structurally, and how it affects other important biological pathways including Sonic Hedgehog pathway and estrogen signaling. We hope to understand the mechanistic aspect of AIS through studying this human mutation in mouse cells.

The Miller Lab received an SRS-Cotrel Foundation Basic Science award grant to support this important and promising work. An abstract on this project was submitted to the American Society for Human Genetics 2024 Annual Meeting.



NANCY HADLEY-MILLER, MD

Professor, Orthopedics





Musculoskeletal Tumor Program

PROGRAM OVERVIEW

The Tumor Program's research focuses on the development, quality of life and treatment outcomes for patients experiencing cancer of the musculoskeletal system. The goal is to improve functional ability and patient satisfaction as a result of innovative surgical interventions. Results from our studies will be used to inform doctors, clinical staff and patients about potential new treatments that improve post-cancer standard of living.

RESEARCH HIGHLIGHTS

"Spine Involvement and Vertebral Deformity in Patients Diagnosed with Chronic Recurrent Multifocal Osteomyelitis"

Chronic recurrent multifocal osteomyelitis (CRMO) is an inflammatory disease of the bone. For patients who have spinal involvement, CRMO can cause compression deformities, varying in severity. This retrospective study examined the prevalence of spinal involvement and vertebral deformity in patients with CRMO. This cohort of 170 patients, seen in clinic from January 2003 to December 2020, 28.2% had spinal involvement. It was found that 48% of the patients with spinal involvement have vertebral body height loss. Whole-body imaging can be beneficial in detecting vertebral lesions and deformities, as this disorder has a relapsing and remitting course.



Rogers ND, Trizno AA, Joyce CD, Roberts JL, Soep JB, Donaldson NJ. Spine Involvement and Vertebral Deformity in Patients Diagnosed with Chronic Recurrent Multifocal Osteomyelitis. *J Pediatr Orthop.* 2024;44(9):561-566. doi:10.1097/BPO.0000000000002743



NATHAN DONALDSON, DO

Associate Professor,
Orthopedics



STEVEN THORPE, MD

Director, Musculoskeletal
Oncology Program
Associate Professor,
Orthopedics

"Database for patients who have undergone surgical resection of bone and soft tissue sarcomas"

This study is designed to create a comprehensive clinical database of all patients who have undergone surgical resection of bone and soft tissue sarcomas to gain a better understanding of their quality of life after surgical treatment. We follow patients for up to 20 years, assessing their quality of life and functional outcomes.

Pediatric Orthopedic Society of North America Annual Meeting, "Long-Term Outcomes for Total Joint Arthroplasties in Pediatric and Young Adult Populations" National Harbor MD. May 2024

A growing number of pediatric and young adult patients are undergoing total joint arthroplasties (TJA) for reasons including degenerative, congenital and rheumatic disease. A retrospective cohort study on patients who underwent total hip arthroplasty (THA) and total knee arthroplasty (TKA) between 2000 and 2022 where functional outcomes and quality of life outcomes were assessed. Study data suggests that patients under the age of 25 experience significant improvement in both quality of life and functional outcomes by 6 months following TJA procedures. These improvements are sustained for up to 10 years. This is one of the largest single institution samples to systemically track long-term functional and implant survivorship outcomes and one of the first to track quality of life for pediatric and young adult TJA procedures.



Skeletal Health and Dysplasia Program

PROGRAM OVERVIEW

The Skeletal Health and Dysplasia Program is led by Klane White, MD, the Rose Brown Endowed Chair of Pediatric Orthopedic Surgery and head of the Skeletal Dysplasia Program at Children's Colorado. Research in the Skeletal Dysplasia Program focuses on the understanding of genetic disorder of bone in children. The research is currently involved in multiple multicenter studies investigating pediatric achondroplasia, the mucopolysaccharidoses and osteogenesis imperfecta (OI) treatment across the world.

CLINICAL TRIALS

Over the last year, the industry research team has initiated, recruited and maintained several pivotal prospective clinical trials for achondroplasia and osteogenesis imperfecta (OI). Within the skeletal dysplasia program, we have seven patients currently enrolled across four different studies. Collaborating with international sites and sponsors, we are one of the several hand selected sites throughout the world to manage these clinical trials. We currently have patients participating in baseline anthropometric data collection for prospective studies, as well as patients receiving investigational medications.

For achondroplasia these investigational products include TransCon CNP, a weekly injection, and Infigratinib, a daily oral medication. We are similarly slated to start an investigational trial for patients with hypochondroplasia expanding options available for patients with skeletal dysplasia.

Within the OI program, we have two patients currently enrolled to evaluate Setrusumab, an anti-sclerostin monoclonal antibody infusion administered monthly aiming to decrease the rate of fractures in patients with OI. This is a worldwide study, with our involvement being one of approximately 30 sites across the world.

RESEARCH HIGHLIGHTS

"Achondroplasia Biobank"

Achondroplasia is a bone growth disorder resulting in short stature and other skeletal differences of the spine and legs. This research study aims to allow scientists to study variations in the health of people with achondroplasia by developing a biobank containing biological samples from patients with achondroplasia as well as their family members. This will assist scientists in learning more about what causes variation in health outcomes in achondroplasia, how to prevent them and how to treat them.

"Fast spin MRI in screening for evaluation of foramen magnum stenosis in infants with achondroplasia"

Foramen magnum stenosis is a life-threatening condition for infants with achondroplasia warranting MRI screening at a very young age. Fast spin MRI sequencing is a new technique with the potential to offer a new standard of care for the achondroplasia patient population. Fast spin MRI sequence provides the opportunity for infants with achondroplasia to receive MRIs without the need for general anesthesia and the associated risks. The goal of this study is to determine the effectiveness of fast spin MRI sequences in identifying clinically significant foramen magnum stenosis in infants with achondroplasia.



KLANE WHITE, MD, MSc
Chair, Pediatric Orthopedics



Dr. K. White, MD, MSC
Orthopedic Surgery



Spine Program

PROGRAM OVERVIEW

Research in the Spine Program focuses on the management of spinal deformity in children. Research efforts are directed toward evaluating and improving quality and safety outcomes in spine surgery, especially minimizing blood loss, surgical site infections and other complications. The Spine Program is also dedicated to investigating the effectiveness and quality of life outcomes of non-invasive treatments such as bracing, casting and observation. Recent initiatives include the implementation of electronic patient-reported outcome tools through PatientIQ — as well as evaluating the effectiveness of robotic-assisted spine procedures and long-term clinical outcomes.

RESEARCH HIGHLIGHTS

“Actuator size of magnetic controlled growth rod (7 cm vs. 9 cm) is not predictive of unplanned return to the operating room: a retrospective multi-center comparative cohort study”

Magnetic controlled growth rods (MCGR) are the most common type of implants utilized for operative treatment of patients with early onset scoliosis (EOS). Rods can have either a 7cm actuator, allowing 2.8 cm of potential expansion or a 9cm actuator which allows 4.8 cm potential expansion. We hypothesized that the rate of unplanned return to the operating room (UPROR) will be increased when the 9cm actuator is implanted into smaller patients. In addition, we aimed to identify a cutoff for spine length between planned upper and lower instrumented MCGR levels that best differentiated between patients having a high versus low risk of UPROR. Conclusion: MCGR actuator size is not a significant factor in predicted UPROR — smaller height, fewer anchors and caudal apex increased UPROR risk.



Garg, Sumeet MD*; Heffernan, Michael MD†; Feddema, Tyler BS*; Luhmann, Scott MD‡; Sturm, Peter MD§; Vitale, Michael MD||; Andras, Lindsay MD†; White, Klane MD*. The Pediatric Spine Study Group; Carry, Patrick PhD*. Actuator Size of Magnetic Controlled Growth Rod (7 cm vs. 9 cm) is Not Predictive of Unplanned Return to the Operating Room: A Retrospective Multicenter Comparative Cohort Study. *Journal of Pediatric Orthopaedics* 44(10):p 586-591, November/December 2024. | DOI: 10.1097/BPO.0000000000002806

“Dermatitis after spine fusion caused by liquid adhesive (2-Octyl cyanoacrylate)”

Findings and importance: Dermatitis from the use of 2-Octyl cyanoacrylate liquid wound closure adhesives after scoliosis surgery is believed to be allergic reactions to some components of wound closure systems. Previous exposure to the closure system can increase the risk of allergic dermatitis with subsequent exposures. Two cases of allergic contact dermatitis in pediatric patients who underwent posterior spine fusion surgery using 2-Octyl cyanoacrylate wound adhesive are reported here. Successful management can include a protocol developed of topical corticosteroids, mupirocin, emollient ointment and antihistamines. In severe cases, tapered oral steroids can be administered to treat diffuse allergic dermatitis. Awareness of potential risks is essential, and health care providers should be proficient in managing dermatitis related to this closure system.



Miller F, Fulweiler B, Feddema T, Shah SA, Garg S. Dermatitis after spine fusion caused by liquid adhesive (2-Octyl cyanoacrylate), *Journal of the Pediatric Orthopaedic Society of North America*, Volume 7, 2024, 100045, ISSN 2768-2765, <https://doi.org/10.1016/j.jpogna.2024.100045>.



MARK ERICKSON, MD
Director, Spine Program
Fellowship Director



SUMEET GARG, MD
Director, Quality and
Patient Safety
Professor Orthopedics



KLANE WHITE, MD, MSc
Chair, Pediatric Orthopedics

Patient IQ

Funded by a grant from the Tai Foundation, the Spine Team has implemented a process to collect patient-reported outcomes (PROs) in the Orthopedics Institute for both clinical and research purposes. The project has been live since July 2022 and has been collecting PROs for over two years. The Orthopedic Institute has been utilizing PatientIQ, a secure and HIPPA compliant platform, to securely send and store the PROs collected from the provider and disease-specific pathways.

KEY TAKEAWAYS

100%

Orthopedic provider groups onboarded

30

Active providers

13,000+

Patients enrolled

31,000+

PROs collected

40

Provider and disease-specific pathways



Sports Medicine Center

PROGRAM OVERVIEW

The Sports Medicine Center at Children's Colorado leads the region in state-of-the-art treatment for developing athletes. The fully integrated team of physicians, athletic trainers, physical therapists, dieticians and specialists deliver a full-service care experience geared exclusively to growing bodies. Through our research program, we seek to positively influence clinical practice through high quality scientific work with clinical relevance. Through this work, we strive to be an established center of excellence for research in pediatric sports medicine. Research activities aim to reduce the risk of pediatric and adolescent athletic injuries and to improve treatment outcomes so that athletes may prepare, perform, recover and repeat. Projects include retrospective outcomes studies, prospective randomized trials and observational investigations.



RESEARCH HIGHLIGHTS

"The Diagnostic Utility of Cervical Spine Proprioception for Adolescent Concussion"

Many individuals who sustain a concussion experience cervical spine pain or disruption as well, but few detailed assessments of cervical spine function are typically used for concussion evaluations. We used a relatively simple test of cervical spine proprioception to compare the degree of disruption among a group of adolescents with a recent concussion and uninjured controls. We found that cervical spine proprioception is significantly worse after a concussion relative to uninjured adolescents, indicating that it may be a clinically valuable assessment to incorporate within comprehensive concussion assessments.



Smulligan KL, Magliato SN, Keeter CL, Wingerson MJ, Smith AC, Wilson JC, Howell DR. The diagnostic utility of cervical spine proprioception for adolescent concussion. *Clin J Sport Med.* 2024; July 2. doi:10.1097/JSM.0000000000001243. Epub ahead of print. PMID: 38953712.

"Postconcussion Moderate to Vigorous Physical Activity Predicts Anxiety Severity among Adolescent Athletes"

Physical activity can be an important part of overall health, including mental health. Following a concussion, athletes used to be told to avoid strenuous activity. Over recent years, however, evidence has shifted toward encouraging activity following concussion to facilitate optimal healing. Our team found that engaging in higher intensity physical activity (moderate-to-vigorous physical activity) after a concussion may play a vital role in helping teenagers feel less anxious while recovering. Addressing anxiety in the concussion recovery process can have an impact on schoolwork, relationships and general well-being. Thus, physical activity-based interventions may help to manage anxiety and promote improved mental health after concussion.



Smulligan KL, Wingerson MJ, Magliato SN, Rademacher JG, Wilson JC, Howell DR. Postconcussion Moderate to Vigorous Physical Activity Predicts Anxiety Severity among Adolescent Athletes. *Med Sci Sports Exerc.* 2024;56(5):790-795. doi:10.1249/MSS.0000000000003368



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"Association of Grit With Postoperative Knee Outcomes and Physical Function After ACL Reconstruction in Adolescent Athletes"

Grit is defined as the passion and perseverance to pursue long-term goals despite challenges or setbacks. Among athletes who are undergoing ACL reconstruction and a long recovery back to full strength, rehabilitation may require grit. Our work found that those with higher preoperative grit achieved greater physical function and activity levels over time than those with lower grit. This indicates that grit, especially soon after ACL injury, may be a useful predictor of success during recovery and should be discussed within the context of how to establish expectations and goals during rehabilitation.



Armento A, Keeter C, Gagliardi A, et al. Association of Grit With Postoperative Knee Outcomes and Physical Function After ACL Reconstruction in Adolescent Athletes. *Am J Sports Med.* 2023;51(11):2900-2907. doi:10.1177/03635465231187040



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Trauma Program

PROGRAM OVERVIEW

Research in the Trauma Program focuses on the management of complex orthopedic conditions resulting from traumatic accidents in children and adolescents. Specific areas of interest include outcomes after pelvic fractures, treatments for femur fractures in young children and physal (growth plate) injuries. The program also studies musculoskeletal infection and quality improvement in critically ill orthopedic patients. The Trauma Program is involved in several multi-center study groups including CORTICES and IMPACCT.

RESEARCH HIGHLIGHTS

Limb Difference Fair and Recreational Well-Being Survey

The Limb Difference Fair gives patients with limb differences and their families an opportunity to connect with each other and be introduced to resources such as adaptive sports teams and mental health resources. The Recreational Well-Being Survey was successfully distributed at the June 2024 fair, asking about each patient's well-being, recreational participation and mental health. This survey allows us to gain insight into how limb differences affect well-being and recreational participation in children and to identify barriers within this community.

"Understanding Pediatric Pelvic Fracture Morphology"

Pediatric pelvic fractures are uncommon but associated with significant morbidity and demonstrate differing fracture patterns when compared to the adult population. Our team plans to enroll patients who were previously treated for a traumatic pelvic injury at Children's Colorado and have since reached skeletal maturity. These patients will undergo a CT scan to assess their current pelvic morphology and compare it with their initial injury CT scan using 3D modeling software. We will also be gathering patient reported outcomes in this cohort. This ongoing research will allow for a more comprehensive understanding of pediatric pelvic fractures, remodeling and the clinical manifestations of asymmetry at skeletal maturity.

"Femoral Overgrowth in Diaphyseal Femur Fractures: How Fast and How Far?"

Julia S. Sanders, MD; Tiffany Phan; Sarah R. Purtell; Michael J. Heffernan, MD; Tyler A. Tetreault, MD; Jonas Owen, MD; Lindsay Andras, MD

At this year's POSNA conference, Dr. Sanders gave a podium presentation on her team's study. Stimulation of growth following pediatric femoral shaft fractures is a well-recognized occurrence; however, most literature on this topic does not differentiate between "catch-up growth" and overgrowth. To further examine this topic, radiographs were analyzed up to one year after injury in pediatric patients with diaphyseal femur fractures treated with either a spica cast or functional brace. Overall, femoral overgrowth occurred at a rate of 0.5mm/month following fracture, and this rate was more than doubled in those with greater shortening. These numbers can be helpful to guide parental and provider expectations following femur fractures in patients ages 6 months to 4 years.



JULIA SANDERS, MD

*Director of Pediatric Orthopedic Trauma
Associate Professor, Orthopedics*



Training future generations: Postdoctoral Research Fellow Program

The Orthopedics Institute at Children's Colorado welcomed two full-time postdoctoral fellow clinical researchers to its team in 2024. Dr. Krajewski joined the Musculoskeletal Research Center as the MRC's first post-doctoral researcher. Under the mentorship of research and clinical faculty in the MRC, the goal of this position is to provide an opportunity for continued training in clinical orthopedic research while developing an independent line of investigation. Dr. Donahue joined the Colorado Concussion Research laboratory, a team of researchers within the Sports Medicine Center at Children's Colorado. Under the mentorship of Dr. David Howell, PI of the Colorado Concussion Research Lab, Dr. Donahue role will continue to develop her independent line of research and will contribute to ongoing studies including multi-site randomized clinical trials, observational studies, biomarker investigations, advanced MRI techniques, mental health outcomes and sleep health.



CATHERINE DONAHUE, PhD, ATC
Concussion Program

Catherine (Cat) Donahue, PhD, ATC, graduated with her PhD from the University of Virginia (UVA) in 2023 and is now a postdoctoral research fellow in the Department of Orthopedics with a research focus on sports concussions. Prior to her PhD at the University of Virginia, she completed her master's degree in 2016 also at UVA, and her bachelor's degree at Point Loma Nazarene University in 2012. Dr. Donahue brings over 12 years of research and clinical experience as a certified athletic trainer, working in a variety of settings including athletics, military and performing arts. Her research focuses on the sequelae of sports concussions, specifically the role of sleep and sleep-related factors.



KELLEN KRAJEWSKI, PhD, CSCS
Pediatric Orthopedics

Kellen Krajewski, PhD, CSCS, earned his PhD from the University of Pittsburgh in Rehabilitation Sciences with an emphasis in biomechanics and motor control. Prior to joining the MRC, Dr. Krajewski completed a postdoc in neurophysiology of reflex excitability in stroke survivors at MetroHealth Hospital, Case Western Reserve University. Dr. Krajewski employs a multi-dimensional approach to examine functional movement outcomes following orthopedic interventions to improve treatment and inform rehabilitative strategies. His research in the MRC aims to disentangle the role of spasticity and dynamic physical activity in tibial bone microarchitecture of children with cerebral palsy.

Give to a healthier future

As a nonprofit organization, Children's Hospital Colorado is fueled by donors. Together, we are catalysts for change partnering to create a brighter future for every child who needs us. From the world-class care we provide to the groundbreaking discoveries we make, none of our work would be possible without donor support. For the children and families that we serve every day, philanthropy makes all the difference.

With your help we can continue to provide children with the care, support, and research breakthroughs they need to thrive. Under the leadership of Dr. White, Chair of Pediatric Orthopedics at Children's Colorado, we are prioritizing fundraising efforts within the Musculoskeletal Research Center to establish an endowed chair in memory of Lori Karol, MD. Our goal is to realize Dr. Karol's vision for the MRC, honor her legacy and most importantly, recognize her incredible impact on the field of pediatric orthopedics.

Over the past several years, orthopedic team members have actively participated in fundraising efforts, including the Children's Colorado Courage Classic Bike Tour, that have helped us make significant strides towards achieving this goal. With your support, we can further advance the mission of the MRC by driving cutting edge research that will transform care for pediatric patients with orthopedic and musculoskeletal conditions. We invite you to consider your own support of the MRC through a personal donation or by joining Team Bony Express at the 2025 Courage Classic July 19-20.

To learn more, please contact Jacqueline Lindley at jlindley@childrenscoloradofoundation.org.

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