



Advancing innovative research.
Improving musculoskeletal health.™



HARVARD
ORTHOPAEDIC SURGERY

OREF NORTHEASTERN REGION
RESIDENT RESEARCH SYMPOSIUM
Friday, October 6, 2023

Brigham and Women's Hospital
Bornstein Family Amphitheater
45 Francis Street (CWN Building)
Boston, MA 02115

Hosted by:

James D. Kang, MD

Thomas S. Thornhill, MD, and Karen N. Thornhill Professor of Orthopaedic Surgery
Harvard Medical School
Chair, Department of Orthopaedic Surgery
Brigham and Women's Hospital

Shaina A. Lipa, MD

Clinical Instructor, Harvard Medical School
Division of Spine Surgery
Department of Orthopaedic Surgery
Brigham and Women's Hospital

Table of Contents

Resident Research Symposium Summary Agenda	5
Keynote Speaker	7
Judges.....	9
Detailed Agenda	11
Abstracts	15
Corporate Recognition	39

About OREF

The Orthopaedic Research and Education Foundation (OREF) is a charitable 501(c)(3) organization committed to improving lives by supporting excellence in orthopaedic research through its grant funding and research education programs. As an independent nonprofit, OREF strives to improve clinical care and patient outcomes by advancing innovative research, developing new investigators, and uniting the orthopaedic community in promoting musculoskeletal health. Visit oref.org or follow OREF on X (@OREFtoday).

*Excited about today's research? Share it with your colleagues!
Post on social media with #Orthosymposia*

**OREF NORTHEAST REGION RESIDENT RESEARCH SYMPOSIUM
SUMMARY AGENDA**
Friday, October 6, 2023

- 7:00 a.m. – 8:00 a.m. **Registration and Breakfast**
Brigham and Women’s Hospital
Carrie Hall Conference Room
15 Francis Street (Carrie Hall)
Boston, MA
- 8:00 a.m. 8:05 a.m. **Welcome and Introductions**
James D. Kang, MD
 Thomas S. Thornhill, MD, and Karen N. Thornhill
 Professor of Orthopaedic Surgery
 Harvard Medical School
 Chair, Department of Orthopaedic Surgery
 Brigham and Women’s Hospital
- 8:05 a.m. – 8:10 a.m. **OREF Welcome**
Mr. Lee Grossman
 Chief Executive Officer
 Orthopaedic Research and Education Foundation
- 8:10 a.m. – 8:45 a.m. **Session I – Resident Research Presentations & Discussion**
- 8:45 a.m. – 9:20 a.m. **Session II – Resident Research Presentations & Discussion**

Break – Please submit your scores from Sessions I and II to OREF Staff
- 9:30 a.m. – 10:10 a.m. **Session III – Resident Research Presentation & Discussion**
- 10:10 a.m.–10:50 a.m. **Session IV – Resident Research Presentations and Discussion**

Break – Please submit your scores from Sessions III and IV to OREF Staff
- 11:00 a.m.–11:05 a.m. **Keynote Speaker Introduction**
- 11:05 a.m.–11:50 a.m. **Keynote Address**
“Integration of Innovation: Adopting New Technologies in a Scientific Way”
Charla R. Fischer, MD, FAOA
 Associate Professor of Orthopedic Surgery
 NYU Langone Health
- 11:50 a.m. –11:55 a.m. **Awards Presentation and Closing Remarks**
Thank you to all sponsors!
Closing of program to OREF TV audience
- Noon – 1:00 p.m. **Lunch**
Carrie Hall Conference Room
15 Francis St. (Carrie Hall)

Excited about today’s research? Share it with your colleagues! Post on social media with #orthosymposia

KEYNOTE SPEAKER



Charla R. Fischer, MD, FAOA

Associate Professor of Orthopedic Surgery NYU Langone Health

Charla R. Fischer, MD, one of New York City's top minimally invasive spine surgeons, specializes in lumbar disc herniations, lumbar spinal stenosis, lumbar degenerative disc disease, instability and cervical spine degeneration. She is an expert in endoscopic minimally invasive spine surgery techniques such as endoscopic microdiscectomy, MIS lumbar fusions, robotic-assisted spine surgery and advanced MIS techniques. Her advanced skill in MIS helps her deliver accelerated patient recovery times with the least possible post operative pain. Dr. Fischer is committed to improving the care of all orthopedic patients as the Spine Division Director of Quality and Patient Safety for the Department of Orthopedics.

As an associate professor of spine surgery at NYU Langone Health, Dr. Fischer regularly teaches residents and medical students in the areas of compassionate patient care and minimally invasive spine surgery. She has received grants from the National Institutes of Health (NIH) and the Orthopaedic Research and Education Foundation (OREF). The funding helps her pursue the advancement of minimally invasive surgical techniques and quality of life improvements after spine surgery. She routinely publishes in the top peer-reviewed journals and presents her findings at internationally attended academic meetings.

Judges

Paul T. Appleton, MD
Beth Israel Deaconess Medical Center

James D. Kang, MD
Brigham and Women's Hospital

Mitchel B. Harris, MD
Massachusetts General Hospital

Augustus Mazzocca, MS, MD
Massachusetts General Hospital

Brian Snyder, MD, PhD
Boston Children's Hospital

Michael J. Weaver, MD
Brigham and Women's Hospital

OREF Northeast Region Resident Research Symposium
DETAILED AGENDA
Friday, October 6, 2023

- 8:00 a.m. – 8:05 a.m. **Welcome and Introductions**
James D. Kang, MD
Professor and Chair
Department of Orthopaedic Surgery
Brigham and Women’s Hospital
- 8:05 a.m. – 8:10 a.m. **OREF Welcome**
Lee Grossman
Chief Executive Officer
Orthopaedic Research and Education Foundation
- Session I – Resident Research Presentations & Discussion**
- 8:10 a.m. – 8:15 a.m. *The Learning Curve for Pedicle Screw Selection in Robotic-assisted and Intra-operative Navigation Guided Minimally Invasive Transforaminal Lumbar Interbody Fusion (MI-TLIF)*
Avani Vaishnav, MD, Boston University
- 8:15 a.m. – 8:20 a.m. *Single-cell RNA Sequencing Reveals FDA-drug Candidates for Enhanced Achilles Tendon Repair in a Murine Model*
Varun Arvind, MD, Columbia University – New York Presbyterian Hospital
- 8:20 a.m. – 8:25 a.m. *Utility of Computerized Tomography Hounsfield Unit Measurements to Predict Proximal Junctional Kyphosis in Adult Spinal Deformity Patients with Long Constructs*
Josephine Coury, MD, Columbia University – New York Presbyterian Hospital
- 8:25 a.m. – 8:30 a.m. *Clinical Outcomes of Particulated Juvenile Articular Cartilage Allograft Transplantation for Patellofemoral Defects*
Aaron Chen, MD, Columbia University – New York Presbyterian Hospital
- 8:30 a.m. – 8:35 a.m. *Risk Factors for Failure of Non-Operative Management of Ulnar Shaft Fractures*
Carew Giberson-Chen, MD, Harvard Combined Orthopedic Residency Program
- 8:35 a.m. – 8:40 a.m. *Outcomes of Adolescent T-condylar Fractures: Kids Don’t Always Make You Look Good*
Jason Young, MD, Harvard Combined Orthopedic Residency Program
- 8:40 a.m. – 8:50 a.m. **Question and Answer**

OREF Northeast Region Resident Research Symposium
DETAILED AGENDA
Friday, October 6, 2023

Session II – Resident Research Presentations & Discussion

- 8:50 a.m. – 8:55 a.m. *Effect of Vitamin D in Prevention and Treatment of Pediatric Fractures*
David S. Liu, MD, Harvard Combined Orthopedic Residency Program
- 8:55 a.m. – 9:00 a.m. *Biceps Tenotomy vs Tenodesis in Patients with Partial Thickness Rotator Cuff Tears Undergoing Concurrent Transtendinous Repair*
Trevor J. McBroom, MD, Harvard Combined Orthopedic Residency Program
- 9:00 a.m. – 9:05 a.m. *Longer Time to Anterior Cruciate Ligament Reconstruction is Associated with Greater Incidence of Medial Meniscus and Cartilage Injury but No Difference in Outcomes: A Systematic Review and Multiple Meta-Regression*
Elyse J. Berlinberg, MD, Harvard Combined Orthopedic Residency Program
- 9:05 a.m. – 9:10 a.m. *Identifying Anterior Cruciate Ligament Injuries Through Automated Video Analysis of In-Game Motion Patterns*
Gergo Merkely, MD, PhD, Harvard Combined Orthopedic Residency Program
- 9:10 a.m. – 9:15 a.m. *Do Commonly Used Geographically Based Social Determinant of Health (SDoH) Indices Measure the “Same Thing,” and Which is Best in Orthopaedic Surgery?*
David N. Bernstein, MD, Harvard Combined Orthopedic Residency Program
- 9:15 a.m. – 9:20 a.m. *Cutout of Hip Fracture Fixation is Associated with Earlier Time to Conversion Total Hip Arthroplasty, Longer Length of Stay, and Greater One Year Mortality Compared to Other Mechanisms of Fixation Failure*
Phil Grisdela, MD, Harvard Combined Orthopedic Residency Program
- 9:20 a.m. – 9:30 a.m. **Question and Answer**
- Break**

Excited about today’s research? Share it with your colleagues! Post on social media with #orthosymposia

OREF Northeast Region Resident Research Symposium
DETAILED AGENDA
Friday, October 6, 2023

Session III – Resident Research Presentation & Discussion

- 9:30 a.m. – 9:35 a.m. *Are There Differences in Case Volume Between Male and Female Orthopaedic Residents?*
Rafa Rahman, MD, The Hospital for Special Surgery
- 9:35 a.m. -9:40 a.m. *Evaluation of Racial, Ethnic, and Socioeconomic Disparities an Indication for Carpal Tunnel Release*
Troy Amen, MD, The Hospital for Special Surgery
- 9:40 a.m. – 9:45 a.m. *Lateral Extra-Articular Tenodesis is Associated with Improved Graft Maturity on MRI Two Years Following Anterior Cruciate Ligament Reconstruction with Quadriceps Tendon Autograft in Skeletally Immature Athletes*
Julie Retzky, MD, The Hospital for Special Surgery
- 9:45 a.m. – 9:50 a.m. *Identifying Risk Factors for Prolonged Opioid Use After Thumb Basal Joint Arthroplasty Using the Prescription Drug Monitoring Program*
Alexander J. Adams, MD, Thomas Jefferson University/Rothman Institute
- 9:50 a.m.– 9:55 a.m. *Liposomal Bupivacaine Does Not Decrease Post-Operative Pain in Patients with Intracapsular Femoral Neck Fracture Treated with Hemiarthroplasty: A Double-Blinded Randomized, Controlled Trial*
Mitchell Ng, MD, Maimonides Medical Center
- 9:55 a.m.– 10:00 a.m. *Patient Reported Outcomes Following Arthroscopic Treatment of Symptomatic Discoid Meniscus in Pediatric and Adolescent Populations*
Steven M. Henick, MD, Montefiore Medical Center
- 10:00 a.m.–10:10 a.m. **Question and Answers**

Excited about today's research? Share it with your colleagues! Post on social media with #orthosymposia

OREF Northeast Region Resident Research Symposium
DETAILED AGENDA
Friday, October 6, 2023

Session IV – Resident Research Presentations & Discussion

- 10:10 a.m.–10:15 a.m. *Primary Open Latarjet versus Arthroscopic Remplissage and Bankart Repair for Anterior Shoulder Instability*
Cody Hansen, MD, University of Pennsylvania
- 10:15 a.m.–10:20 a.m. *Defining In Vitro and In Situ Thresholds for Tension Activated Repair Patches*
Bijan Dehghani, MD, University of Pennsylvania
- 10:20 a.m.–10:25 a.m. *The Spine Trifecta: An Analysis of Patients Who Have Undergone Lumbar Decompression/Fusion, Spinal Cord Stimulator Placement, and Sacroiliac Joint Fusion*
Akhil Sharma, MD, St. Luke’s University Health Network
- 10:25 a.m.–10:30 a.m. *Failure Following Revision Total Hip Arthroplasty After Cobalt-Chrome Femoral Heads are Placed on a Retained Femoral Stem*
Thomas M. Zink, MD, Tufts Affiliated Hospitals Orthopaedic Surgery Residency Program
- 10:30 a.m.–10:35 a.m. *The Prevalence and Predictors of Patient Dissatisfaction 5-years After Primary Total Hip Arthroplasty*
Forrest Rackard, MD, University of Massachusetts
- 10:35 a.m.–10:40 a.m. *Localization of the Adductor Tubercle the Skeletally Immature: A Computed Tomography Study with Patellofemoral Surgical Implications*
Sahir S. Jabbouri, MD, Yale New Haven Hospital
- 10:40 a.m.–10:50 a.m. **Question and Answers**
- 10:50 a.m.–11:00 a.m. **Break**
- 11:00 a.m.– 11:05 a.m. **Introduction of Keynote Speaker**
- 11:05 a.m.–11:50 a.m. **Keynote Address**
“Integration of Innovation: Adopting New Technologies in a Scientific Way”
Charla R. Fischer, MD, FAOA
Associate Professor of Orthopedic Surgery
NYU Langone Health
- 11:50 a.m. –11:55 a.m. **Awards Presentation and Closing Remarks**
Thank you to all sponsors!
Closing of program to OREF TV audience
- Noon – 1:00 p.m. **Lunch**
Carrie Hall Conference Room
15 Francis St. (Carrie Hall)

Excited about today’s research? Share it with your colleagues! Post on social media with #orthosymposia

The Learning Curve for Pedicle Screw Selection in Robotic-assisted and Intra-operative Navigation Guided Minimally Invasive Transforaminal Lubar Interbody Fusion (MI-TLIF)

Avani Vaishnav, MD
Boston University

Purpose: To assess the learning curve for pedicle screw selection for intraoperative navigation (ION) and robotic navigation in spine surgery.

Significance: Image-guidance for minimally invasive TLIF (MI-TLIF) has evolved from fluoroscopy to navigation to robotics. Pedicle screw size is linked to construct stability, and consequently fusion rates and outcomes. Thus, the goal is to place the largest possible screw.

Methods: Retrospective review of consecutive elective single-level MI-TLIF. Chronologic case number was plotted against screw size. The derivative was solved to find the plateau in learning.

Results: 154 patients (77 in each group) were included; no differences in demographics or comorbidities. Larger screws were placed with robotic navigation: Median diameter 7.42mm [IQR 6.5-7.88] vs 6.5 [IQR 6.5-6.5] for ION, $p < 0.0001$; median length 47.5mm [IQR 45-50] vs 45 [IQR 43.75-47.5] for ION, $p < 0.0001$. There were no intraoperative complications.

For ION, there was no learning curve ($p > 0.05$).

For robotics, proficiency was at case#20 for screw diameter (median 6.5mm before proficiency vs 7.5mm after, $p < 0.0001$) and case#15 for screw length (median 45mm before proficiency vs 48.75mm after, $p = 0.139$)

Conclusion: Robotic navigation may allow for safe placement of larger screws compared to intraoperative navigation, but this benefit is apparent after an initial learning curve of 15-20 cases.

Single-cell RNA Sequencing Reveals FDA-drug Candidates for Enhanced Achilles Tendon Repair in a Murine Model

Varun Arvind, MD

Columbia University – New York Presbyterian Hospital

Purpose: To identify FDA-approved drugs for enhanced tendon repair based on single-cell RNA sequencing (scRNAseq) from regenerative (neonatal) and non-regenerative (adult) murine models of Achilles tendon-healing.

Significance: T-cell mediated inflammation is a known driver of regenerative versus fibrotic Achilles tendon repair in neonatal and adult mice, respectively. Given the vast library of FDA-approved drugs, utilization of scRNAseq may predict FDA-approved drug candidates for enhanced tendon repair based on known effects.

Methods: Post-natal-day-5 (P5) and adult (P120-180) mice underwent Achilles transection without repair. Tendons were harvested at 14 days-post-injury (DPI), and live CD3+ T-cells were isolated using flow cytometry for scRNAseq. 21,304 drugs were screened with known transcriptomic responses from the LINCS-L1000 project. Drug-scores were calculated based on pro-fibrotic gene reversal, relative to responsive-cell proportion. Higher drug-scores predict improved tendon healing. Candidate drugs were identified with a false-discovery-rate < 0.05 and drug-score > 0.5.

Results: 8,376 CD-3+ cells were sequenced from the neonatal and adult tendon. Four clusters were identified including gamma-delta T-cells, memory T-cells, effector T-cells, and Tregs. The top ten drugs were: vorinostat, trichostatin-a, geldanamycin, and tacrolimus all having known anti-fibrotic effects.

Conclusion: scRNAseq can be used to screen drug libraries to identify select FDA-approved drugs that may enhance Achilles tendon repair through possible inhibition of T-cell mediated fibrosis.

Utility of Computerized Tomography Hounsfield Unit Measurements to Predict Proximal Junctional Kyphosis in Adult Spinal Deformity Patients with Long Constructs

Josephine Coury, MD

Columbia University – New York Presbyterian Hospital

Purpose: This study aims to investigate the association between low computerized tomography Hounsfield units (CTHU) and osteoporotic postoperative complications in adult spinal deformity (ASD) patients undergoing deformity correction with long constructs. Specifically, it evaluates the relationship between CTHU at the upper instrumented vertebra (UIV), level above UIV (UIV+1), and two levels above UIV (UIV+2) with postoperative proximal junctional kyphosis (PJK).

Significance: Identifying CTHU thresholds can help identify patients at risk of osteoporosis-related complications, optimizing bone health before surgery.

Methods: A retrospective analysis of 152 ASD patients who underwent spinal reconstructive surgery between 2015 and 2020 was conducted. Long constructs had a minimum UIV of L2 fused to the pelvis. Statistical analysis was performed with SAS and $p < 0.05$ significance.

Results: Patients with PJK had significantly lower CTHU (161) at T7-T12 levels than those without PJK (213), $p = 0.016$. For thoracic UIV patients with PJK, UIV+1 and UIV+2 CTHU decreased by -17 HU/level, while those without PJK increased by 12, $p < 0.00001$.

Conclusion: The study established a CTHU threshold under 160 HU for the thoracic spine and identified UIV+1 and UIV+2 CTHU as significant PJK predictors. Decreasing HU in vertebral bodies proximal to UIV increases the risk of PJK in long fusion constructs.

Clinical Outcomes of Particulated Juvenile Articular Cartilage Allograft Transplantation for Patellofemoral Defects

Aaron Chen, MD

Columbia University – New York Presbyterian Hospital

Purpose: The purpose of the study is to report clinical outcomes of patients undergoing particulated juvenile allograft cartilage (PJAC) transplantation for patellofemoral articular cartilage defects.

Significance: While multiple surgical treatment options exist for the management of cartilage lesions of the patellofemoral joint, superiority of any one technique has not yet been established.

Methods: A retrospective review was performed of all patients who received PJAC transplantation for patellofemoral articular cartilage defects at a single institution from 2014 to 2022. Clinical outcomes recorded included complications, return to sport, PROMIS Pain Interference (PI) and Physical Function (PF), and Kujala knee scores. Descriptive statistical analysis was performed.

Results: Fifty-three knees (48 patients) with a mean age of 23.6 years and mean follow up of 24.5 months were included. The mean respective post-operative PROMIS PI, PROMIS PF, and Kujala knee scores were 47.4 ± 7.7 , 53.3 ± 8.9 , and 81.8 ± 15.6 . The overall return to sport rate was 95.0% (19 out of 20). During follow up, 13 knees (24.5%) developed a complication, including 6 reoperations (11.3%).

Conclusion: Excellent patient reported outcome measure scores and return to sport rates can be obtained for patients undergoing PJAC transplantation, highlighting the overall effectiveness of the technique.

Risk Factors for Failure of Non-Operative Management of Ulnar Shaft Fractures

Carew Giberson-Chen, MD

Harvard Combined Orthopedic Residency Program

Purpose: To investigate radiographic and patient-specific risk factors for failure of non-operative management of isolated ulnar shaft fractures.

Significance: Isolated ulnar shaft fractures are frequently managed non-operatively. However, risk factors for failure of non-operative management are not well-described.

Methods: A retrospective review was performed of adult patients with isolated ulnar shaft fractures initially treated non-operatively at two tertiary referral centers over a 19-year period from 2001 to 2020. Patient- and injury-related variables, surgical interventions, and plain radiographic measurements were recorded. Bivariate statistical analysis was performed to determine associations of patient-specific and radiographic variables with conversion to surgical management after failure of nonoperative treatment.

Results: One hundred fifty-two patients were included. Eight patients (5%) converted to surgery. Increased initial fracture gap and active employment were associated with conversion to surgery. Among patients with an initial fracture gap ≥ 4 mm, 80% developed complications, 40% developed nonunion, and 40% converted to surgery.

Conclusion: While the majority of ulnar shaft fractures heal non-operatively, a small percentage of fractures fail to heal appropriately and require surgical treatment. Patients with increased initial fracture gap and patients who are currently employed are at increased risk for failure of non-operative management and should be counseled accordingly.

Outcomes of Adolescent T-condylar Fractures: Kids Don't Always Make You Look Good

Jason Young, MD

Harvard Combined Orthopedic Residency Program

Purpose: We sought to assess how functional outcomes and range of motion (ROM) are affected by patient and surgical factors after surgical fixation of T-condylar fractures. We hypothesized younger patients undergoing a triceps sparing approach and pediatric-style fixation would have better outcomes postoperatively.

Significance: Optimal strategies for surgical management of T-condylar fractures remain poorly understood.

Methods: We assessed demographics, radiographs, postoperative ROM, complications, and functional outcomes for T-condylar fractures from a single center between 2003 and 2021. Comparison of functional outcomes across surgical approaches was performed with a Cochran-Armitage test for trend.

Results: Fifty-two T-condylar fractures were identified. In our cohort, 46% achieved good outcomes based on Jarvis ROM criteria and 42% achieved good to excellent results based on Roberts functional criteria. We observed a complication rate of 54%. Patients undergoing adult-type plate fixation had better postoperative range of motion at 6 weeks (ROM loss 52 vs 80 degrees, $p=0.03$) and 3 months (10 vs 35 degrees $p=0.004$). Surgical approach and skeletal maturity did not impact functional outcome scores or complication rates.

Conclusion: Surgical fixation of pediatric T-condylar fractures achieved a good to excellent functional outcome in only a minority of patients with a high rate of postoperative complications.

Effect of Vitamin D in Prevention and Treatment of Pediatric Fractures

David S. Liu, MD

Harvard Combined Orthopedic Residency Program

Purpose: While Vitamin D supplementation is not preventative of fragility fractures in post-menopausal women, few studies have evaluated the effect of vitamin D on fracture occurrence in growing children. We investigate whether vitamin D levels affect pediatric fracture occurrence.

Significance: Results may shift clinical practice to recommend supplementary vitamin D as a safe, cost-effective intervention to prevent pediatric fractures.

Methods: A retrospective cohort study was conducted to determine the effect of Vitamin D levels on fracture occurrence using an aggregate electronic health record network of >95 million patients (Figure 1). A preliminary single-institution prospective cohort of 32 patients was performed to assess seasonal differences, mechanism-of-injury, and fracture type categorized by age and anatomic location.

Results: Vitamin D-deficiency was associated with increased fracture occurrence in all age groups, with the largest effect in peripubertal patients ages 10-14 (Table 1). This observation was supported by the prospective cohort: fracture patients had lower vitamin D levels compared to those without fracture (22.2 vs 30.3 ng/ml, $p=0.02$). There was no difference in fracture occurrence when comparing vitamin D-supplemented patients versus vitamin D-adequate patients (Table 2).

Conclusion: Low vitamin D is associated with increased fracture risk in pediatric patients. Vitamin D supplementation may decrease fracture risk in deficient children.

Biceps Tenotomy vs Tenodesis in Patients with Partial Thickness Rotator Cuff Tears Undergoing Concurrent Transtendinous Repair

Trevor J. McBroom, MD

Harvard Combined Orthopedic Residency Program.

Purpose: To compare postoperative shoulder active range of motion (AROM) and complications after primary transtendinous rotator cuff repair (RCR) with concurrent long head of the biceps (LHB) tenodesis or tenotomy.

Significance: Patients with partial-thickness rotator cuff tears (PTRCT) often have concurrent LHB pathology. However, no studies have compared LHB tenotomy and tenodesis in the context of transtendinous RCR for PTRCT.

Methods: Patients were divided into cohorts based on receipt of LHB tenotomy, tenodesis, or no biceps procedure (control), and propensity-matched 1:1:1 for age, sex, and smoking status. The outcomes assessed included postoperative AROM, the occurrence of severe stiffness, and rates of rotator cuff retear.

Results: Our analysis included 72 patients. Compared to tenodesis patients, those who underwent tenotomy had higher AROM at 3 months in forward flexion ($p=0.004$), abduction ($p=0.019$), and external rotation ($p=0.014$), and higher AROM at 6 months in forward flexion ($p=0.009$). No differences were observed in AROM improvement, rates of severe postoperative stiffness ($p=0.066$), or symptomatic retears between groups ($p=0.458$). However, transient stiffness complications were more common in smokers.

Conclusion: Despite differences in absolute AROM between groups, LHB tenotomy or tenodesis did not differentially impact rates of complications or AROM recovery. Overall, postoperative stiffness is likely influenced by multiple patient- and procedure-specific factors.

Longer Time to Anterior Cruciate Ligament Reconstruction is Associated with Greater Incidence of Medial Meniscus and Cartilage Injury but No Difference in Outcomes: A Systematic Review and Multiple Meta-Regression

Elyse J. Berlinberg, MD

Harvard Combined Orthopedic Residency Program

Purpose: To quantify the relationship between time to anterior cruciate ligament reconstruction (ACLR) and (1) incidence of meniscal or cartilage injury and (2) clinical outcomes.

Significance: Prior meta-analyses demonstrate variable relationships between the timing of ACLR and concurrent intra-articular injuries, complications, and outcomes. In these studies, “early” versus “delayed” surgeries were inconsistently defined.

Methods: Cochrane systematic review and random-effects multiple meta-regression of level I-III studies published through April 2022.

Results: Sixty-two studies (n=21,986, 35% females, median age=27 [interquartile range (IQR)=26-30]) were included. Increased time to ACLR was associated with medial meniscal injury (p<0.001), cartilage injury (p=0.046), and meniscectomy (p<0.001), but not lateral meniscal injury (p=0.714) or meniscal repair (p=0.270). ACLR within 1 week was associated with higher likelihood of infection, VTE, MUA, and revision ACLR (p<0.001), but there was no significant difference in complications with further delays. ACLR delay was not associated with poorer PROMs.

Conclusion: ACLR delay of 3 weeks after injury is associated with a 25% higher likelihood of medial meniscal and cartilage injuries, compared to ACLR within a week of injury. However, the risk of complications was highest within one week of injury. Therefore, for patients undergoing ACLR, intervention between 1-3 weeks after injury may be optimal.

Identifying Anterior Cruciate Ligament Injuries Through Automated Video Analysis of In-Game Motion Patterns

Gergo Merkely, MD, PhD

Harvard Combined Orthopedic Residency Program

Purpose: To develop an automated video analysis system that uses AI to identify biomechanical patterns associated with ACL injury.

Significance: We demonstrated the feasibility of using AI to automatically evaluate in-game video footage and identify dangerous motion patterns.

Methods: 91 ACL injury and 38 control movement scenes from online available match recordings were analyzed. Videos were processed to identify and track athletes and to estimate their 3D poses. Geometric features, including knee flexion, knee and hip abduction, and foot and hip rotation, were extracted from the athletes' 3D poses. Further analysis examined whether providing clinical experts with the reconstructed 3D poses and their derived signals can increase their diagnostic accuracy.

Results: Our model decision interpretability and good performance ($F1 = 0.66 \pm 0.01$, $ROC\ AUC = 0.88 \pm 0.01$). The experiment examining two orthopaedic surgeons demonstrated improved diagnostic accuracy for ACL injury recognition when provided with system data, resulting in a 0.08 increase in combined F1 scores.

Conclusion: We successfully reconstructed the 3D motion of athletes from a single camera view and derived geometry-based biomechanical features from pose sequences. Our trained model can automatically detect ACL injuries with good performance and pre-label and highlight regions of interest in video footage.

Do Commonly Used Geographically Based Social Determinant of Health (SDoH) Indices Measure the “Same Thing,” and Which is Best in Orthopaedic Surgery?

David N. Bernstein, MD

Harvard Combined Orthopedic Residency Program

Purpose: To determine whether the Area Deprivation Index (ADI), Neighborhood Stress Score (NSS), and Social Vulnerability Index (SVI) are concurrently valid and each as strongly associated with physical and mental health.

Significance: Geographically based SDoH indices are commonly used in musculoskeletal research and policy; while seemingly used interchangeably, it is unclear if they are equivalent.

Methods: This was a retrospective observational study of new orthopaedic patients at an academic medical center from 2016-2021. PROMIS Global-10, ADI, NSS, and SVI values were determined. Spearman correlation coefficients were calculated. Regression analyses were used to assess the strength of each index with physical and mental health.

Results: 26,684 patients were included. Poor correlation existed between the ADI and NSS ($\rho=0.34$; $p<0.001$), and good correlations existed between the ADI and SVI ($\rho=0.43$; $p<0.001$) and NSS and SVI ($\rho=0.59$; $p<0.001$). All correlations between PROMIS scores and SDoH indices were poor ($\rho<0.3$). The ADI demonstrated the largest association with physical health (RC:-0.13 [95%CI: -0.14- -0.12]; $p<0.001$) and mental health (RC:-0.13 [95%CI:-0.14- -0.12]; $p<0.05$), as confirmed by partial r-squared values.

Conclusion: We suggest using the ADI as the geographically based SDoH index in orthopaedic surgery in the United States, and caution against comparing findings if different SDoH indices are used.

Cutout of Hip Fracture Fixation is Associated with Earlier Time to Conversion Total Hip Arthroplasty, Longer Length of Stay, and Greater One Year Mortality Compared to Other Mechanisms of Fixation Failure

Phil Grisdela, MD

Harvard Combined Orthopedic Residency Program

Purpose: What are the risks of mortality and perioperative complications following conversion to total hip arthroplasty (cTHA) following mechanical or early failure of hip fracture fixation?

Significance: Less is known regarding complications following cTHA after early mechanical failure (cut-out, implant breakage, nonunion) of hip fracture fixation.

Methods: This retrospective cohort study included patients over 18 years of age with cTHA following surgical fixation of proximal femur fractures within 6 months of surgery or for cut-out, nonunion or implant breakage. Patients with pathologic fracture, and less than 12-month follow-up after their arthroplasty were excluded.

Results: 112 patients with 113 fractures (one bilateral injury) were included, 80 (71%) were female, mean age was 71 years. The majority of patients had intertrochanteric fractures (66, 58.4%) and the most common mechanism of fixation was intramedullary nailing (58 fractures, 51%). Overall complication rate was high (21%). Previous fixation method was not associated with post-cTHA complications or mortality. Implant cutout was associated with shorter time to conversion arthroplasty (median 3.4 months) and higher one-year mortality than patients with nonunion with or without hardware failure.

Conclusion: Mechanism of failure following surgical fixation of proximal femur fractures has implications for time to cTHA and complications following surgery.

Are There Differences in Case Volume Between Male and Female Orthopaedic Resident?

Rafa Rahman, MD

The Hospital for Special Surgery

Purpose: To evaluate differences in case numbers between male and female orthopaedic surgery residents.

Significance: Gaining operative proficiency requires adequate case volume in residency. Numerous other surgical fields including otolaryngology, ophthalmology, general surgery, and cardiothoracic surgery have demonstrated male residents graduating with higher case numbers and more autonomy in cases than female residents.

Methods: Accreditation Council for Graduate Medical Education case logs were reviewed for orthopaedic residents between 2010 and 2023 at a single institution. Overall residency case numbers and case numbers by post-graduate year (PGY) were compared between male and female residents using t-tests, assessed at $\alpha=0.05$. Power analysis to detect an overall 20% difference in case numbers between genders, assuming $\alpha=0.05$, $\text{power}=0.8$, the national average for case numbers, and known female to male ratio in the program, required at minimum 13 females and 46 males for adequate power.

Results: 111 residents (22 female, 89 male) were included, with females recording a mean of 1,865.6 (SD=239.0) over the course of residency versus males recording 1,861.0 (SD=301.6) ($p=0.95$). During PGY4, females averaged 430.3 cases (SD=123.1) versus males with 370.0 (SD=97.4) ($p=0.015$).

Conclusion: There is no difference in case numbers overall through orthopaedic residency between male and female residents, while females have higher volume during PGY4.

Evaluation of Racial, Ethnic, and Socioeconomic Disparities an Indication for Carpal Tunnel Release

Troy Amen, MD

The Hospital for Special Surgery

Purpose: This study aimed to examine the impact of sociodemographic factors on treatment recommendation by hand surgeons for carpal tunnel syndrome of similar disease severity.

Significance: Racial disparities in orthopaedic surgery have been extensively reported, yet their underlying causes including provider recommendation for surgery have not been explored.

Methods: Patients with electrodiagnostic study (EDS)-confirmed CTS were evaluated at a single institution between 2016 and 2020. The primary outcome was the recommended treatment by the hand surgeon at the first clinic visit according to patient race/ethnicity and the Social Deprivation Index (SDI). Secondary outcomes included the treatment selected by patients (nonsurgical or surgical) and time to surgery.

Results: Across all categories of EDS severity, surgeons were less likely to recommend surgery to patients with a higher SDI. When surgery was recommended, patients in the highest SDI quintile were less likely to proceed with surgery ($p = 0.032$). There was no association between patient race/ethnicity and the treatment selected by the patient or time to surgery ($p > 0.05$ for both).

Conclusion: Patients experiencing higher levels of social deprivation were less likely to be recommended for CTS surgery and were less likely to proceed with surgery, regardless of patient race/ethnicity.

Lateral Extra-Articular Tenodesis is Associated with Improved Graft Maturity on MRI Two Years Following Anterior Cruciate Ligament Reconstruction with Quadriceps Tendon Autograft in Skeletally Immature Athletes

Julie Retzky, MD

The Hospital for Special Surgery

Purpose: We aimed to evaluate ACL graft maturity using signal intensity ratios (SIR) on MRI at 6-months, 1-year, and 2-years postoperatively in patients undergoing ACLR with quadriceps tendon autograft (QTA)±lateral extra-articular tenodesis (LET). We hypothesized that LET+ACLR group would have lower average SIR values versus ACLR-only group.

Significance: Addition of LET to ACLR reduces risk of ACL re-tear. SIR values on MRI may serve as a surrogate for ACL graft maturity.

Methodology: Records of patients ≤18-years-old who underwent ACLR between 2015-2021 were retrospectively reviewed. Skeletally immature patients undergoing QTA ACLR with 2-year follow-up were included. Patients were excluded if MRI ordered due to new injury. SIR values were measured on sagittal MRI as: (average of 3 regions of interest along the ACL graft)/PCL signal. Statistical analysis evaluated differences in SIR values in ACLR-only versus ACLR+LET groups.

Results: Twenty-nine patients were included. There were no differences in SIR values between ACLR-only versus ACLR+LET groups at 6-months or 1-year; however, the median SIR of the ACLR+LET group was significantly lower than that of ACLR-only group at 2-years postoperative on univariate (1.33 versus 1.86, respectively, $p=0.0012$) and multivariate regression analysis ($p=0.029$).

Conclusion: LET+ACLR is associated with lower SIR values 2-years postoperatively versus ACLR-only.

Identifying Risk Factors for Prolonged Opioid Use After Thumb Basal Joint Arthroplasty Using the Prescription Drug Monitoring Program

Alexander J. Adams, MD

Thomas Jefferson University/Rothman Institute

Purpose: We sought to identify risk factors for excess postoperative opioid use after thumb basal joint arthroplasty (BJA). We hypothesized preoperative opioid use would show association with greater postoperative opioid use.

Significance: Thumb BJA is a common hand surgery often requiring opioids postoperatively; this study uniquely presents prescription drug monitoring program (PDMP) data to improve opioid stewardship.

Methods: We retrospectively reviewed consecutive primary thumb BJA patients at a single institution. Demographic, clinical, and opioid prescription data was extracted using state PDMP. Statistical analyses identified risk factors for excess postoperative opioid use (i.e. second opioid prescription or filling prescription >6 months postop).

Results: Of 110 included patients, 26% filled an opioid prescription preoperatively, 42% filled a second postoperative prescription, and 15% were still consuming opioids over 6 months postop. Patients using preoperative opioids had 7-fold higher odds of filling a second opioid prescription and 37-fold odds of prolonged use. Only 9% of supplemental opioid prescriptions were prescribed by the surgeon's office.

Conclusion: Thumb BJA patients showed high opioid use despite appropriate surgeon-provided postoperative analgesia. Only prior opioid exposure was associated with excess postoperative opioid use. This study's results could assist surgeons with patient selection, counseling, and analgesia strategy for thumb BJA.

Liposomal Bupivacaine Does Not Decrease Post-operative Pain in Patients with Intracapsular Femoral Neck Fracture Treated with Hemiarthroplasty: A Double-Blinded Randomized, Controlled Trial

Mitchell Ng, MD
Maimonides Medical Center

Purpose: This study aims to evaluate the effect of liposomal bupivacaine on patients with intracapsular hip fractures undergoing hemiarthroplasty on 1) post-operative pain, 2) function and 3) overall hospital course.

Significance: Liposomal bupivacaine is a long lasting local anesthetic agent developed for use in the surgical setting to decrease post-operative pain.

Methods: This was a single center, randomized prospective double-blinded study of 50 patients with isolated intracapsular femoral neck fractures from 2018-2022 treated with hip hemiarthroplasty. The study group included 25 patients treated with intra-operative Exparel/bupivacaine injections, while control included 25 patients treated with intra-operative bupivacaine injection only. Primary outcomes were visual analogue scale (VAS) pain, total morphine milligram equivalents (MME), delirium and time-to-ambulate with physical therapy.

Results: There was no significant difference found in any outcomes measured between liposomal bupivacaine relative to controls. There was no difference in average post-operative pain scores (2.26 vs 2.7 VAS; $p=0.34$), MMEs (11.73 vs 9.98 MME; $p=0.71$), and post-operative day of discharge (4.00 vs 3.88 days; $p=0.82$).

Conclusion: Our results suggest liposomal bupivacaine is not associated with improved postoperative pain, function or shorter hospital course following hip hemiarthroplasty. Given the cost of liposomal bupivacaine over standard pain modalities, it is worth re-evaluating its use.

Patient Reported Outcomes Following Arthroscopic Treatment of Symptomatic Discoid Meniscus in Pediatric and Adolescent Populations

Steven M. Henick, MD
Montefiore Medical Center

Purpose: To evaluate the outcomes of saucerization and meniscus stabilization versus saucerization alone with respect to complication rates and PROS.

Significance: It is unclear whether meniscus instability and its required stabilization negatively affects complication rates and functional outcomes for patients undergoing arthroscopic saucerization for discoid meniscus.

Methods: A retrospective review was undertaken. Patients either had stable discoid menisci who underwent saucerization (group 1) or unstable discoid menisci and saucerization and repair (group 2). PROS were collected preoperatively and postoperatively. ANOVA and paired t-test compared groups and pre- and postoperative PROS, respectively. Logistic regression analyzed risk factors for meniscus instability.

Results: Fifty-seven patients had a mean 12y (3-18y) and BMI 24.9 (15.1-44.4). Patients under 10y and who were skeletally immature had an OR=1.5 for meniscus instability. There were no significant differences in complication (15% vs 8%, $p=0.34$) or reoperation rates (5% vs 5%, $p=0.89$) between groups. PROS were significantly improved post-operatively compared to pre-operatively including on IKDC (50.4 vs 74.7; $p=0.01$), KOOS symptom (60.9 vs 84.5; $p=0.01$), and KOOS pain (55.3 vs 84.1; $p=0.01$). Comparative analysis demonstrated no significant differences in PROS regardless of meniscus stability.

Conclusion: PROS significantly improved following arthroscopic treatment of symptomatic discoid meniscus regardless of meniscus stability.

Primary Open Latarjet versus Arthroscopic Remplissage and Bankart Repair for Anterior Shoulder Instability

Cody Hansen, MD
University of Pennsylvania

Purpose: To compare the intermediate-term recurrence rates and reoperations between open Latarjet and arthroscopic remplissage with Bankart repair (ARB) for patients undergoing first-time stabilization procedures.

Significance: Anterior glenoid bone loss is a known risk factor for failure following arthroscopic stabilization surgery for anterior shoulder instability.

Methods:

- Retrospective study: ARB vs. open Latarjet (2014 – 2023)
- Exclusion criteria: <1 year follow-up, previous surgery, seizure history, multi-directional instability, concurrent rotator cuff repair, or absence of pre-op MRI or CT.
- Glenoid bone loss and width of Hill Sachs lesions measured.
- Patients categorized into 3 groups based on glenoid bone loss: <13.5%, 13.5%-20%, and >20%
- R statistical software version 4.1.2 for data analysis

Results:

- 76 patients: 12 open Latarjet and 64 ARB
- Latarjet group was younger on average (22.3 years vs. 30.4 years, $p=0.02$)
- Greater mean glenoid bone loss observed in the Latarjet group (18.4% vs 10.4%, $p = 0.01$)
- No significant difference in Hill-Sachs lesion size (14.2mm for Latarjet vs. 15.1mm for ARB, $p=0.61$)
- Rates of recurrent subluxation or dislocation were similar between Latarjet and ARB (33.3% vs 21.9%, $p=0.46$)
- No significant differences were found when patients were categorized by glenoid bone loss (<13.5%, 13.5-20%, >20%)
- Reoperations significantly more common in the Latarjet group (25.0% vs 4.7%, $p = 0.04$)

Conclusion: Arthroscopic remplissage and Bankart repair could both be viable for primary instability surgery, even in patients with greater glenoid bone loss than previously considered.

Defining In Vitro and In Situ Thresholds for Tension Activated Repair Patches

Bijan Dehghani, MD
University of Pennsylvania

Purpose: There is a need for annulus fibrosis (AF) repair strategies that quell inflammation, prevent matrix loss, and retain disc function. Our team has developed drug delivery devices in the form of fibrous scaffolds containing mechano-activated microcapsules (MAMC) that rupture (activate), releasing their inner contents when experiencing load - we termed them tension activated repair patch (TARP).

Significance: In this study we defined in vitro and in situ load dependent release profile for TARPs.

Methods: We performed cyclic tensile loading of the TARPs at physiological strain intervals (1800 cycles; 2%, 4%, 6%, 8% strain) (Fig. 1A and B). We also performed cyclic compression of a goat cervical spinal motion segment with a TARP sutured to the AF (1800 cycle, 300N force) (Fig. 2A and B). MAMC activation was manually counted using a top-down fluorescent microscope.

Results: Tensile loading of the TARP at 2%, 4%, 6%, and 8% strain resulted in activation of 15.1%, 31.4%, 39.1%, and 61.2% (normalized) respectively (Fig. 1C). In situ loading of the TARPs resulted in 28.0% activation of MAMC (Fig. 2C).

Conclusion: We demonstrated a load-dependent relationship between strain and MAMC activation *in vitro*. We also demonstrated proof of concept that this relationship translates *in situ*.

The Spine Trifecta: An Analysis of Patients Who Have Undergone Lumbar Decompression/Fusion, Spinal Cord Stimulator Placement, and Sacroiliac Joint Fusion

Akhil Sharma, MD

St. Luke's University Health Network

Purpose: 28% of adults suffer from chronic low back pain. Spinal cord stimulators have been employed as salvage-procedures for failed back syndrome with mixed results in literature.

Significance: This is the first study to analyze patients with chronic LBP exposed to all three modalities (lumbar fusion, SI fusion, SCS).

Methods: Retrospective analysis was performed for individual procedures from 2012-2022. Demographic data, opioid documentation, smoking status, functionality, and VAS score were collected.

Results: Females underwent surgery 2.1 years earlier than men. 10 patients underwent all surgeries within two years; 2 had three surgeries. 80% were males, no rheumatologic conditions. 14 patients had surgeries between 2-4 years; 7 underwent three surgeries. Four patients started with lumbar fusion, then SI fusion and finally SCS. One patient had rheumatologic conditions. 16 patients had surgery more than four years apart; 3 had three surgeries. Two started with lumbar fusion, then SI fusion, ending with SCS. Three patients had rheumatologic conditions. Rheumatologic patients had mean improvement of VAS 2.67 points greater than other patients.

Conclusion: The most common index surgery was lumbar fusion. Half of patients with second surgery had SCS placed. Among patients with three surgeries, half started with lumbar fusion, progressed to SI fusion, and ended with SCS.

Failure Following Revision Total Hip Arthroplasty After Cobalt-Chrome Femoral Heads are Placed on a Retained Femoral Stem

Thomas M. Zink, MD

Tufts Affiliated Hospitals Orthopaedic Surgery Residency Program

Purpose: We sought to assess outcomes of revision THA using cobalt chromium (CoCr) heads placed on a retained femoral stem. We hypothesized a high rate of re-revision.

Significance: CoCr heads in primary THA has been linked with trunnionosis and implant failure; however, outcomes of CoCr heads used in revision THA have not been described and may have important implications in isolated acetabular revisions or head/liner exchanges.

Methods: We retrospectively reviewed revision THAs implanted with either a C-taper (n=90) or V-40 taper (n=107) CoCr head placed on a retained femoral stem.

Results: 30 patients (15.2%) required repeat revision. All-cause re-revision was more common in the V40 group compared to the c-taper group (22.4% vs 6.7%, respectively). Titanium-molybdenum-zirconium-iron (TMZF) stems carried increased odds of revision compared to titanium stems (OR=3.3, 95% CI=1.4-7.7). When excluding TMZF stems (only available with a V-40 taper), multivariate analysis demonstrated V-40 heads were a significant risk factor for re-revision (OR=6.3, 95% CI=1.2-34.8), but not BMI, head size, head offset, femoral fixation, or stem material.

Conclusion: Use of CoCr heads in revision THA carries increased risk of re-revision and alternatives such as ceramic heads should be considered, especially when retaining a TMZF or V-40 taper stem.

The Prevalence and Predictors of Patient Dissatisfaction 5-years After Primary Total Hip Arthroplasty

Forrest Rackard, MD
University of Massachusetts

Introduction: Total hip arthroplasty (THA) is a highly successful treatment option for end stage hip arthritis; however, a small percentage of patients report dissatisfaction postoperatively. Data regarding predictive factors for long term dissatisfaction after THA is lacking. The purpose of this study is to identify the prevalence and predictors for dissatisfaction five years after THA.

Methods: Prospective demographic and clinical data on primary unilateral THA patients were collected through the FORCE-TJR database, including diverse multicenter data from across 23 states in the United States. Data collected pre-op, 1-year and 5-years post-op included HOOS (HOOS-12 and HOOS-JR) and the SF-12 with physical component score (PCS) and mental component score (MCS). Patient satisfaction was measured at 1 and 5 years using a single item satisfaction questionnaire. A univariate analysis evaluating the difference between satisfied and dissatisfied patients was performed. Independent predictors of dissatisfaction were identified using a multivariate logistic regression analysis with a 95% confidence interval (CI).

Results: 2768 THA patients were evaluated. 10.2% of patients were dissatisfied at 1-year and 7.6% were dissatisfied at 5-years. In the multivariate regression analysis, patient dissatisfaction was statistically significantly associated with age <65 (OR 1.745, p=0.043), non-white race (OR 2.972, p=0.0001), and 3 other painful joints at the time of surgery (OR 2.052, p=0.0344). Patients with higher preoperative PCS (OR 0.965, p=0.0077), higher preoperative MCS (OR 0.983, p=0.0262), and private insurance (OR 0.456, p=0.0047) were less likely to be dissatisfied.

Discussion: Dissatisfaction after THA was 10.2% at 1-year and dropped to 7.6% at 5-years. Factors associated with dissatisfaction after THA should be considered in the preoperative shared decision-making process, with the goal of improving expectation management and long-term satisfaction in patients at high risk for dissatisfaction.

Localization of the Adductor Tubercle the Skeletally Immature: A Computed Tomography Study with Patellofemoral Surgical Implications

Sahir S. Jabbouri, MD
Yale New Haven Hospital

Purpose: Identify the location of the adductor tubercle relative to the distal femoral physis in skeletally immature individuals and gain insight regarding optimal graft anchor placement for medial patellofemoral ligament (MPFL) and quadriceps tendon femoral ligament (MQTFL) reconstruction. We hypothesize that the adductor tubercle is distal to the distal femoral physis.

Significance: The adductor tubercle is utilized as an anatomic landmark to identify graft anchor placement during MPFL and MQTFL reconstruction but its location relative to the physis has not been well defined.

Methods: This descriptive laboratory study utilized computed tomography of 37 male cadaveric specimens (age, 4-16 years) from the New Mexico Decedent Database to identify the adductor magnus tendon and its insertion (adductor tubercle). Insertion point to physis distance (from proximal-distal) was measured and descriptive analysis was used.

Results: The adductor magnus tendon insertion was at the physis in 30 specimens, distal to the physis in all specimens ≥ 15 years old (n=6, mean distance 2.73 mm) and distal to the physis in one 8-year-old cadaveric specimen (1.1 mm).

Conclusion: The adductor tubercle is likely at or distal to the physis. This suggests a distal graft anchor placement will help restore patellofemoral isometry which conflicts with studies proposing a more proximal location.

OREF gratefully acknowledges these Corporate Associates



Smith+Nephew



ZIMMER BIOMET
Your progress. Our promise.™

For supporting the OREF Resident Research Symposia



oref.org