

COA/CORS Combined Paper Session 4: Joints and Arthritis •

Moderators Paul-Edgar Beaulé, ON, and James A. Johnson, ON

28 –

Osteochondral Lesions of the Capitellum Do Not Affect Elbow Kinematics and Stability

Marlis Sabo, University of Western Ontario; Katherine Fay, University of Western Ontario; Louis Ferreira, University of Western Ontario; Colin McDonald, University of Western Ontario; James A. Johnson, University of Western Ontario; Graham J.W. King, University of Western Ontario

Purpose: Osteochondritis dissecans (OCD) of the capitellum most commonly affects adolescent pitchers and gymnasts, and presents with pain and mechanical symptoms. Fragment excision is the most commonly employed surgical treatment; however, patients with larger lesions have been reported to have poorer outcomes. It's not clear whether this is due to increased contact pressures on the surrounding articular surface, or if fragment excision causes instability of the elbow. The purpose of this study was to determine if fragment excision of simulated OCD lesions of the capitellum alters kinematics and stability of the elbow. **Method:** Nine fresh-frozen cadaveric arms were mounted in an upper extremity joint motion simulator, with cables attaching the tendons of the major muscle tendons to motors and pneumatic actuators. Electromagnetic receivers attached to the radius and ulna enabled quantification of the kinematics of both bones with respect to the humerus. Three-dimensional CT scans were used to plan lesions of 12.5% (mean 0.8cm²), 25%, 37.5%, 50%, and 100% (mean 6.2cm²) of the capitellar surface, which were marked on the capitellum using navigation. Lesions were created by burring through cartilage and subchondral bone. The arms were subjected to active and passive flexion in both the vertical and valgus-loaded positions, and passive forearm rotation in the vertical position. **Results:** No significant differences in varus-valgus or rotational ulnohumeral kinematics were found between any of the simulated OCD lesions and the elbows with an intact articulation with active and passive flexion, regardless of forearm rotation and the orientation of the arm ($p>0.7$). Radiocapitellar kinematics were not significantly affected during passive forearm rotation with the arm in the vertical position ($p=0.07-0.6$). **Conclusion:** In this in-vitro biomechanical study even large simulated OCD lesions of the capitellum did not alter the kinematics or laxity of the elbow at either the radiocapitellar or ulnohumeral joints. These data suggest that excision of capitellar fragments not amenable to fixation can be considered without altering elbow kinematics or decreasing stability. Further study is required to examine other factors, such as altered contact stresses on the remaining articulation, that are thought to contribute to poorer outcomes in patients with larger lesions.

29 –

Hip Abductor Muscle Strengthening in Persons With Knee OA: Effect on Knee Joint Loading During Gait

Elizabeth A. Sled, Queen's University; **Latif Khoja**, Queen's University; **Kevin J. Deluzio**, Queen's University; **Sandra J. Olney**, Queen's University; **Elsie G. Culham**, Queen's University

Purpose: Hip muscle weakness may result in impaired frontal plane pelvic control during gait, leading to greater medial compartment loading, as measured by the knee adduction moment, in persons with knee osteoarthritis (OA). The purpose of this study was to evaluate the influence of an 8-week home-based strengthening program for the hip abductor muscles on hip muscle strength and the external knee adduction moment during gait in individuals with medial knee OA compared to an asymptomatic control group. Secondary objectives were to determine if hip abductor strengthening exercises would improve physical function and knee symptoms in this sample of people with knee OA. **Method:** Forty participants with knee OA were age and gender-matched with an asymptomatic control group. Three-dimensional gait analysis was performed to obtain peak knee adduction moments in the first 50% of stance phase. Isokinetic concentric strength of the hip abductor muscles was measured using a Biodex Isokinetic Dynamometer. Functional performance was evaluated using the Five-Times-Sit-to-Stand test. The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) provided an assessment of knee pain. Following initial testing, participants with knee OA were instructed in a home program of hip abductor strengthening exercises. All participants were re-evaluated after 8 weeks. **Results:** There was no significant difference in isokinetic hip abductor muscle strength between groups at baseline or at follow-up. An improvement in hip abductor strength occurred in the OA group following the intervention ($p = 0.036$). The OA group had higher peak knee adduction moments than the control group ($p = 0.006$), but there was no change in the knee adduction moment over time in either group ($p > 0.05$). The OA group performed the sit-to-stand test more slowly than the control group ($p = 0.001$). At final testing, functional performance on the sit-to-stand test had improved in the OA group compared to the control group ($p = 0.021$). The OA group showed a trend towards decreased knee pain ($p = 0.05$). **Conclusion:** An 8-week home program of hip abductor muscle strengthening did not reduce knee joint loading, but improved function, in a group of participants with medial knee OA.

30 –

Effect of a Patellar Brace on Three-dimensional Patellar Tracking in Subjects with Patellofemoral Osteoarthritis

Emily J. McWalter, UBC and Vancouver Coastal Health Research Institute; **David R. Wilson**, UBC and Vancouver Coastal Health Research Institute; **William F. Harvey**, Boston University School of Medicine and New England Baptist Hospital; **Kelly A. Lamb**, Boston University School of Medicine and New England Baptist Hospital; **Paula I. McCree**, Boston University School of Medicine and New England Baptist Hospital; **David J. Hunter**, Boston University School of Medicine and New England Baptist Hospital

Purpose: Patellar bracing is a common, mechanical-based treatment strategy for patellofemoral osteoarthritis (OA). It is thought that the brace corrects patellar tracking, however, this correction has not been quantified in the OA population. Through advances in magnetic resonance imaging (MRI), we can now assess patellar tracking in three-dimensions. **Method:** We assessed three-dimensional patellar tracking in ten subjects with symptomatic radiographic patellofemoral knee OA using a validated, quasi-static, MRI-based method. Four conditions were studied: 1) no knee brace, no load, 2) no knee brace, 15% bodyweight (BW) load, 3) knee brace, no load, 4) knee brace, 15% BW load. Patellar tracking (flexion, spin and tilt; proximal, lateral and anterior translation) was assessed. Comparisons were made at 1° increments over the coincidental range of knee flexion between the no-brace and brace conditions, at no load and 15% BW load, using a paired t-test with Bonferroni correction. **Results:** All subjects (7 female, 3 male, 60.9±1.3 yrs, 89.5±19.3 kg) had radiographic lateral patellofemoral OA and seven had concomitant tibiofemoral OA (KL grade≥2). Under no load, the brace extended (mean=2.7°, CI=[2.4°, 2.9°], P<0.001) and medially tilted (mean=-1.4°, CI=[-1.6°, -1.2°], P<0.001) the patellae and shifted them distally (mean=0.8mm, CI=[0.6mm, 0.9mm], P<0.001), medially (mean=0.5mm, CI=[0.5mm, 0.6mm], P<0.001) and posteriorly (mean=0.6mm, CI=[0.5mm, 0.6mm], P<0.001). Under 15% BW load, the brace extended the patella (mean=2.4°, CI=[2.1°, 2.8°], P<0.001) and shifted them distally (mean=1.3mm, CI=[1.1mm, 1.4mm], P<0.001), medially (mean=0.8mm, CI=[0.7mm, 0.9mm], P<0.001) and posteriorly (mean 0.6mm, CI=[0.5mm, 0.7mm], P<0.001). **Conclusion:** The brace extended the patellae for both loading conditions, suggesting that patellar flexion/extension is restricted by the brace. The brace tilted the patellae medially under no load only, suggesting when the quadriceps are active (15% BW load) the brace has little effect for tilt. While the effect of bracing on patellar tracking may appear small, the differences are of similar magnitude to those observed between normals and patients with patellofemoral pain, suggesting that braces may produce clinically significant changes in patellar tracking.

31 –

BMP-7 Gene Therapy for Mitigation of Post-traumatic Osteoarthritis in Sheep

Mark Hurtig, University of Guelph; Laurent Fischer, Merial Ltd.; Antonio Cruz, University of Guelph; Frederick David, Merial Ltd.

Purpose: To determine if an adenovirus vector expressing BMP-7 can alter the progression of post-traumatic osteoarthritis. **Method:** Preliminary dose-response studies were done in ovine metacarpal-phalangeal joints using 10⁹, 10¹⁰, and 10¹¹ virus particles (VP). In-vitro transfection efficiency studies were done using ovine synovial cells, chondrocytes and HEK293 cells. In-vivo studies were conducted in 16 sheep that underwent surgery to create bilateral contusive impact injuries to the medial femoral condyle. One week later 10⁹ VP were injected into one joint of each sheep, while four sheep remained untreated bilateral controls. Three months later the sheep were sacrificed for assessments including histological scoring, cartilage

glycosaminoglycan assays, and immunostaining for Col2 3/4 short collagen fragments that are generated by metalloproteinases during OA progression. **Results:** Transfection with 10^9 VP produced slightly longer expression than higher concentrations of VP. HEK293 cells expressed BMP-7 quickly but synoviocytes and chondrocytes expressed this protein at 48 and 96 hours. Knee joints that received Ad5-BMP-7 produced up to 2.5 ng of BMP-7 between day seven and 21. These joints had reduced cartilage degeneration at the injury sites and less centrifugal progression of OA across the femoral condyle. Histological scores were reduced as was Col2 C3/4 short immunostaining. **Conclusion:** BMP-7 has a homeostatic role in cartilage and can be used therapeutically (1). Ad5-BMP-7 transfection of synovial tissue produced sufficient BMP-7 to stop the progression of degenerative changes after trauma that would usually lead to OA. Adenoviral vectors can create inflammation and neutralizing antibodies but these complications were minimized by using a low (10^9) dose. Human trials using similar vectors are ongoing and the outcome of these will determine whether gene therapy will become a useful tool when patients are at risk of post-traumatic OA. References: 1) Chubinskaya S, Hurtig M, Rueger D. OP-1/BMP-7 in cartilage repair. *Int Orthop.* 2007 Dec;31(6):773-81.

32 –

Comparison Between CT-TOMASD and CT-OAM for Assessing Osteoarthritic and Normal Tibiae

James D. Johnston, University of Saskatchewan; **Bassam A. Masri**, UBC; **David R. Wilson**, UBC

Purpose: Subchondral cortical and trabecular bone mineral density (BMD) may increase and/or decrease during different stages of osteoarthritis (OA) disease progression. 2D in-vivo imaging studies examining direct associations between increased proximal tibial BMD and knee OA offer conflicting results, which may be due to the inherent limitations of 2D BMD imaging tools. Our objective was to compare existing and novel 3D imaging techniques for distinguishing subchondral bone properties in OA and normal cadaveric tibiae. **Method:** Eight intact cadaver knees from five donors (4M:1F; age: 77+/-10) were repositioned and scanned three times using QCT (0.5mm isotropic resolution, 0.15mSv dosage). BMD was assessed using 1) computed tomography absorptiometry (CT-OAM) which uses maximum intensity projections to assesses peak density values within subchondral bone, and 2) our novel computed tomography topographic mapping of subchondral density (CT-TOMASD) technique, which uses surface projections to assess both cortical and trabecular bone density at specific depths from the subchondral surface. Average BMD at normalized depths of 0-2.5mm, 2.5–5.0mm, and 5.0-10mm from the surface were assessed using CT-TomasD. Regional analyses were performed consisting of: (1) medial/lateral (M/L) BMD ratio, and (2) BMD of a 10mm diameter core identified as having the maximum regional BMD. Each bone was assessed for OA using a modified-KL scoring system: Normal (mKL=0); Early-OA (1-2); and Late-OA (3-4). **Results:** OA was identified in four compartments of three tibiae (1 late OA+valgus, 1 late OA+varus, 1 early OA+neutral). Larger

density differences between OA and normal knees were noted using CT-TOMASD compared with CT-OAM. CT-TomasD demonstrated that the two knees with late OA demonstrated M/L BMD ratios differing by more than 3.4 SD compared with normals, with peak cores higher than normals across all depths. The knee with early OA and neutral alignment demonstrated M/L ratios less than normals while core differences were highest proximally, with density becoming lower than normals with increasing depth. **Conclusion:** CT-TomasD demonstrated larger differences between OA and normal subjects when compared with CT-OAM differences. This may be due to CT-OAM primarily assessing peak density within the thin subchondral cortical endplate; a region demonstrating fairly uniform peak densities within a limited range.

33 –

In Vitro Activity of Fusidic Acid and Vancomycin in PMMA Bone Cement for the Treatment of Methicillin-resistant Staphylococcus Aureus

Fay Leung, UBC; Clive P. Duncan, UBC; Helen Burt, UBC; John Jackson, UBC

Purpose: This study investigates the synergistic use of fusidic acid with vancomycin, and linezolid in polymethylmethacrylate (PMMA) cement for the treatment of orthopedic MRSA and MRSE infections. Alone, Vancomycin is typically eluted in limited quantities from cement. The purpose of this study was to 1) combine FA and Vancomycin, and Linezolid alone in PMMA cement and characterize antibiotic elution, and 2) to improve drug release using polyethylene glycol (PEG) and NaCl in PMMA cement. **Method:** Standardized 1g pellets of Palacos cement were manufactured containing Vancomycin and FA or Linezolid at increasing concentrations in three batches: without additive, with increasing concentrations of PEG, and with increasing concentrations of NaCl. The pellets were incubated in phosphate buffered saline and sampled at regular intervals. Drug analysis was performed with high pressure liquid chromatography. **Results:** Total drug release at 2.5% loading of Vancomycin alone was 0.84% and of FA was 2.35%. Linezolid showed comparable release profiles. Vancomycin and FA combined yielded Vancomycin release of 6.2% and FA of 8.4%. The addition of 30% PEG increased release of Vancomycin and Fusidic Acid by six-fold. The addition of 18% NaCl increased total Vancomycin release by 11-fold but had no effect on FA release. **Conclusion:** Linezolid, Vancomycin and FA can be combined in PMMA and have favorable release profiles. The addition of PEG and NaCl dramatically increases the release of antibiotics, with the exception of FA and NaCl. These strategies may be useful in the management of MRSA/MRSE infections.

34 –

Prevalence of CAM Type FAI Morphology in 200 Asymptomatic Volunteers

Paul-Edgar Beaulé, University of Ottawa; Kalesha Hack, University of Ottawa; Gina DiPrimio, University of Ottawa; Kawan Rakhra, University of Ottawa

Purpose: A growing body of literature confirms that idiopathic OA is frequently caused by subtle, and often radiographically occult, abnormalities at the femoral head-neck junction or acetabulum that result in abnormal contact between the femur and acetabulum. This condition, known as femoroacetabular impingement, is a widely accepted cause of early OA of the hip. MRI is the imaging modality that is most sensitive in detecting cam morphology. There is currently little published data regarding the prevalence of abnormalities of the femoral head-neck junction in patients without hip pain or previous hip pathology. The primary aim of this project is to examine the incidence of cam morphology in a population without hip pain or pre-existing hip disease using non-contrast MRI. **Method:** Two hundred asymptomatic volunteers underwent magnetic resonance imaging targeted to both hips. Subjects were examined at the time of MRI to document internal rotation of the hips at 90 degrees flexion and to assess for a positive impingement sign. The mean age was 29.4 years (range 21.4-50.6); 77.5% were Caucasian and 55.5% female. The Nötzli alpha angle was measured on oblique axial images through the middle of the femoral neck for each hip. A value greater than 50 degrees was considered consistent with cam morphology. Measurements were performed independently by two musculoskeletal radiologists. **Results:** Twenty-six percent of volunteers had at least one hip with cam morphology: 20% had an elevated alpha angle on either the right or the left side, and 6% had bilateral deformity. The average alpha angle was 42.6 degrees on the right (SD=7.9) and 42.4 degrees on the left (SD=7.7). Internal rotation was negatively correlated with alpha angle ($p<.05$). Patients with an elevated alpha angle on at least one side tended to be male ($p<.01$). **Conclusion:** The high prevalence of cam morphology in asymptomatic individuals is critical information in determining the natural history of FAI as well as establishing treatment strategies in patients presenting with pre-arthritis hip pain.

35 –

Prevalence of Associated Deformities in Patients with Cam Type Femoroacetabular Impingement

Paul-Edgar Beaulé, University of Ottawa; David Allen, University of Ottawa; Steve Doucette, University of Ottawa; Othman Ramadan, University of Ottawa

Purpose: Femoroacetabular impingement (FAI) has recently been described as a cause of adult hip pain and a precursor of hip osteoarthritis. Pincer type is secondary to acetabular retroversion or coxa profunda and Cam type is secondary to lack of concavity/offset of the antero-lateral femoral head-neck junction. Purpose of this study was to determine the prevalence of bilateral deformity in patients with cam type FAI as well as the presence of associated acetabular abnormalities. **Method:** One hundred and thirteen patients with symptomatic cam impingement (alpha (α) angle of Notzli $> 55.5^\circ$) of at least

one hip were evaluated. Eighty-two males, 31 females with an average age of 37.9 yrs (16-55). Standardized AP pelvis and bilateral Dunn views were reviewed. Alpha angle of Notzli was measured on Dunn views. Cam impingement was defined by α angle >55.5 on the Dunn view and Pincer impingement was defined by the presence of either acetabular retroversion or coxa profunda. Statistical analysis was done using the two tailed paired t-test, chi-square test and intra-class correlation coefficient. Odds Ratios were calculated using conditional logistic regression. **Results:** Eighty-eight patients (77.8%) had bilateral deformity and 27% had symptoms in both hips. Mean α angles were higher for bilateral impingement deformity than for the impingement side only when unilateral deformity was present (72.10 versus 64.50, $p<0.001$). Forty-four percent of hips with an impingement deformity also had a pincer deformity, either acetabular retroversion or coxa profunda. Painful hips had a statistically significant higher mean alpha angle than asymptomatic ones (69.70 versus 63.10, $p<0.001$). Comparing hips with α angles of 61-70 with those < 60 found an odds ratio of being painful of 2.59 (95% CI: 1.32-5.08, $p=0.006$). Hips with α angles >71 had an odds ratio of being painful of 2.54 (95% CI: 1.3-4.96, $p=0.007$). **Conclusion:** The majority of patients with cam type FAI have bilateral deformities and an associated acetabular deformity less commonly. The severity of the deformity at the femoral head neck junction is a significant determining factor for the development of hip symptoms. This information is important as we better define the natural history of this deformity as well as devise effective treatment strategies.

36 –

Direct Anterior Femoroacetabular Osteoplasty for Anterior Femoroacetabular Impingement

Javad Parvizi, Rothman Institute; Luis Pulido, Rothman Institute; Madih Matar, Rothman Institute; Nicole Marchetto, Rothman Institute; Bora Og, Rothman Institute

Purpose: Femoroacetabular impingement (FAI) is recognized as an etiological risk factor for hip arthritis. The potential for joint preserving surgical techniques that may delay the progression to early arthritis and retard the possibility of arthroplasty at a young age is promising. This study presents the outcome of surgical treatment of FAI through a less invasive technique performed through a modified Smith-Peterson approach without hip dislocation, or arthroscopy. **Method:** Using an institutional database, a total of 72 patients (80 hips) with radiographic and clinical diagnosis of FAI who underwent direct anterior femoroacetabular osteoplasty (FAO) were identified. Preoperative and postoperative functional evaluation was performed on these patients. The operative findings were recorded in detail and evaluated with regard to outcome. **Results:** Intraoperative diagnosis of labral tear and osteochondral lesions in the anterosuperior acetabulum was confirmed in all cases. The surgical approach provided adequate access to allow labral repair and osteoplasty of the femoral neck and the acetabulum, whenever needed. There were no intra-operative complications. All patients experienced a significant improvement in function as measured by modified

Harris hip and SUSHI scores. Majority (85%) of the patients were satisfied with the outcome of the surgery. In addition, Health Survey SF-36 showed most patients felt their health had improved significantly. The predictors of poor outcome were previous hip scope, lack of labrum for repair, large chondral lesions, and workman's compensation status. **Conclusion:** This study presents the early results of a less invasive surgical treatment for femoroacetabular impingement. This ongoing study shows that the described technique seems to be a viable approach for treatment of this painful condition in the young.

37 –

Hip Arthroscopy May Cause Chondrolysis

Javad Parvizi, Rothman Institute; Orhan Bican, Rothman Institute; Kevin Bozic, University of California; Chris Peters, University of Utah

Purpose: Hip arthroscopy has been used at an increasing frequency over the last few years. Majority of patients undergoing hip arthroscopy are young and active individuals who seek definitive therapy for a painful hip condition and wish to avoid undergoing a hip replacement. Although relatively successful, complications following hip arthroscopy occur. This multi-institutional study presents a worrisome and previously unrecognized complication of hip arthroscopy, namely chondrolysis that lead to accelerated development of end-stage arthritis. **Method:** Using the computerized database in each institution, patients undergoing total hip arthroplasty between 1999-2008 who had received hip arthroscopy prior to arthroplasty were identified. 39 patients were identified to have undergone at least one hip arthroscopy on the affected hip prior to arthroplasty. There were 21 female and 18 male patients. The mean age of patients at the time of hip arthroscopy was 45.9 years. Data regarding demographics, comorbidities, preoperative diagnosis, number of previous procedures, and the details of the surgical procedure were compiled. Radiographs were evaluated.

Results: The median time from arthroscopy to arthroplasty was 14.8 months (range 2.2 months to 7 years). Fourteen patients (35%) underwent THA within 12 months of a previous hip arthroscopy and in nine of these patients the indication for hip arthroscopy was labral tear debridement. These patients despite having none to minimal arthritis at the time of arthroscopy developed accelerated arthritis within a year that necessitated hip replacement. **Conclusion:** Hip arthroscopy can cause accelerated degenerative arthritis of the hip in some patients. We believe the subset of our patients who developed arthritis so early after hip arthroscopy may have suffered chondrolysis and/or chondral injury during the arthroscopy that resulted in progressive and aggressive arthritis of the hip within 12 months. Hip arthroscopy should be reserved for a select group of patients. All measures to minimize the possibility of chondrolysis and/or chondral injury should be exercised.