



The Robert Larner, M.D.
College of Medicine

THE UNIVERSITY OF VERMONT

**Department of Orthopaedics and Rehabilitation
McClure Musculoskeletal Research Center**

***Research Day
Friday, June 15, 2018***

Continental Breakfast

7:00-7:30 am

Stafford 4th Floor Lobby

Research Day Program

7:30 am

Stafford 410

Visiting Professor:

Thomas A. DeCoster, M.D.

Professor Emeritus

Department of Orthopaedics & Rehabilitation

University of New Mexico School of Medicine

University of Vermont Resident Alumnus

1980-1985

Program

7:30 AM **Keynote Presentation: Thomas A. DeCoster, MD**
Introduction: **Claude E. Nichols, III, MD**

7:30 – 8:00 The 7 Deadly Sins of Femoral Nailing

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Lead Discussant: **Thomas A. DeCoster, MD**

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Award Presentation –

Raymond F. Kuhlmann, MD Resident Research Award
-Awarded to the Outstanding Presentation by a Chief Resident

Ankle Fracture Stability-Based Classification: a study of reproducibility and predictability

John Delaney, MD, PGY-5¹; Mark Charlson, MD¹; James Michelson, MD¹

¹University of Vermont Department of Orthopaedics and Rehabilitation

Introduction:

Rotational ankle fractures are common in orthopaedic surgery, however existing classification systems are mostly descriptive in nature and do not explicitly guide surgical decision-making. A Stability-Based classification was developed recently to provide a more prognostic classification. The purpose of this study was to compare the reproducibility of existing ankle fracture classifications, and determine the ability of the Stability-Based classification to predict clinical treatment.

Methods:

One hundred ninety-three consecutive ankle fractures treated at our institution were retrospectively analyzed. Rotational type injury patterns in patients >18 years old were included. None of the subjects were clinically treated or evaluated by the study authors. The fractures were treated by attending physicians who were unaware of the Stability-Based classification system. Pathologic fractures were excluded. Three observers classified injury radiographs using the Lauge-Hansen, Weber/AO, and Stability-Based classifications systems. Reproducibility (inter-observer variation) of each classification system was calculated using kappa statistics. Prognostic values were evaluated by calculating the area under the curve (AUC) for the ROC curves (using surgery as the positive outcome) for each classification.

Results:

The Stability-Based classification showed excellent reproducibility (kappa .938, 95% CI .921-.952), along with the Weber/AO classification (kappa .97, 95% CI .961-.976), while the Lauge-Hansen had the lowest reproducibility (kappa .74, 95% CI .664-.795). The AUC for the three classifications were .883 (95% CI .852-.914), .626 (95% CI .576-.675), and .698 (95% CI .641-.755), respectively (Figure 1). The AUC was significantly better for the Stability-Based classification compared to the other 2 classifications ($p < .001$).

Conclusions:

The AO/Weber classification had excellent reproducibility, but did not predict the need for surgical stabilization accurately. In contrast, the Stability-Based classification system was both highly reproducible (kappa .938) with excellent prognostic ability to identify patients who got surgery (AUC .883). Furthermore, there were no patients who were classified as stable who failed non-operative treatment. The Stability-Based classification was found to have superior prognostic capacity compared to both the Lauge-Hansen and AO/Weber classification systems. This extends earlier studies by showing the reproducibility of the Stability-Based classification system and directly demonstrating its prognostic superiority to other classification systems.

Business Modeling of Orthopaedic Trauma in the Emergency Department: An Untapped Revenue Stream?

Robert Jacobs, MD, PGY-5¹

¹University of Vermont Department of Orthopaedics and Rehabilitation

Introduction:

Emergency departments as well as emergency medicine and orthopaedic residencies can be faced with financial challenges caring while caring for patients. Resident performed procedures are a potentially viable source of revenue to make orthopaedic coverage of the emergency department a financially viable mission.

Methods:

A custom text-mining program was created and validated allowing evaluation of all orthopaedic resident notes. Procedures performed in the emergency department were quantified allowing for the calculation of professional fee billing data. The patients with distal radius fractures were followed after fracture reduction through final outpatient clinic follow-up to identify additional professional fee billing.

Results:

Over a one-year period, more than \$410,000 in uncaptured professional fees were identified in the 12 most common CPT codes for splint application and fracture reduction in the emergency department. There was more than \$395,000 of outpatient professional fees received for patients who had reduction of distal radius fractures in the emergency department.

Discussion:

A significant, previously unrecognized source of revenue was identified and quantified. Professional fee billing for distal radius fracture reduction in the emergency department did not have a negative impact on outpatient professional fee revenue received for these patients.

Cervical Bracing Practices after Degenerative Cervical Surgery: A Survey of Cervical Spine Research Society Members

David J. Lunardini, MD¹; Martin H. Krag, MD¹; Nathan S. Mauser MD¹; Joon Y. Lee MD²;
William H. Donaldson, MD²; James D. Kang, MD³

¹University of Vermont Department of Orthopaedics and Rehabilitation; Burlington, Vermont

²University of Pittsburgh Medical Center Department of Orthopedic Surgery; Pittsburgh, Pennsylvania

³Brigham and Women's Hospital Department of Orthopedic Surgery; Boston, Massachusetts

Background Context:

Prior studies have shown common use of post-operative bracing, despite advances in modern day instrumentation rigidity and little evidence of brace effectiveness.

Purpose: To document current practice patterns of brace use after degenerative cervical spine surgeries among members of the Cervical Spine Research Society (CSRS), to evaluate trends, and to identify areas of further study.

Study Design:

A questionnaire survey

Methods:

A 10 question survey was sent to members of the Cervical Spine Research Society to document current routine bracing practices after various common degenerative cervical spine surgical scenarios, including fusion and non-fusion procedures.

Results:

The overall bracing rate was 67%. This included 8.4% who used a hard collar in each scenario. Twenty-two percent of surgeons never used a hard collar, while 34% never used a soft collar, and 3.6% (3 respondents) did not use a brace in any surgical scenario. Bracing frequency for specific surgical scenarios varied from 39% after foraminotomy to 88% after multi-level corpectomy with anterior & posterior fixation. After one, two and three level anterior cervical discectomy & fusion (ACDF), bracing rates were 58%, 65% and 76% for an average of 3.3, 4.3 and 5.3 weeks, respectively. After single level corpectomy, 77% braced for an average of 6.2 weeks. After laminectomy and fusion, 72% braced for an average of 5.4 weeks.

Conclusions:

Significant variation persists among surgeons on the type and length of post-operative brace usage after cervical spine surgeries. Overall rates of bracing have not changed significantly with time. Given the lack evidence in the literature to support bracing, reconsidering use of a brace after certain surgeries may be warranted.

Key Words:

cervical spine, spine surgery, degenerative cervical spine, practice guidelines, bracing, immobilization, collar, Cervical Spine Research Society

Skeletal Muscle Viscoelastic Properties Following Anterior Cruciate Ligament Rupture and Surgical Repair

Michael J Toth, PhD¹, Mark S Miller, PhD², James R Slauterbeck, MD³, Rebecca Choquette, ATC³, Bruce D Beynon, PhD³, Timothy W Tourville, PhD, ATC⁴

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Patients who suffer severe knee trauma, such as an anterior cruciate ligament rupture, experience an accelerated progression of post-traumatic osteoarthritis (PTOA), whether they chose rehabilitation alone or surgical reconstruction (ACL-R) combined with rehabilitation. Muscle size, structure, function and neuromuscular control all undergo dramatic change following severe knee trauma, some of which may contribute to the development of PTOA. For example, evidence from ACL-R patients shows increased skeletal muscle fibrosis. This is a concern because increased fibrosis could affect gait kinematics and kinetics and, in turn, the magnitude and location of contact stress transmitted across the articular structures, leading to the onset and early progression of PTOA. To date, however, few studies have explored skeletal muscle fibrosis in ACL-R patients and none have examined how ACL-R affects skeletal muscle tissue viscoelastic properties. We studied skeletal muscle tissue viscoelastic properties in 15 patients (7 men, 8 women) 3 weeks following surgical reconstruction of their ACL. Skeletal muscle biopsies were taken from the vastus lateralis from both injured/surgically-reconstructed and contralateral, non-injured legs, with the latter serving as a within-subject control. Small bundles (~10-20 fibers) of chemically skinned, skeletal muscle fiber segments were dissected, tied to platinum tissue clamps and attached to a length motor and force gauge, which are mounted on a custom built system that measures displacements and forces during tensile testing. Under relaxed (ie, non-contracting) conditions (pCa 9 with 2,3-butanedione monoxime to prevent muscle contraction), an incremental stretch-relaxation protocol was employed, with length steps (0.2 μm) starting at a sarcomere length of 2.0 μm . Following relaxation and stabilization of the force signal, a small amplitude (0.125% of muscle length) sinusoidal length perturbation (250 Hz; 10 cycles) was applied for each length step to assess elastic and viscous moduli. The elastic modulus of the injured/surgical leg was significantly higher than the non-injured leg at longer sarcomere lengths (3.0 to 3.6 μm ; $P < 0.05$) when considering data from men and women together. Analysis of men and women separately, however, showed that these differences were driven by higher elastic modulus in men (2.8 to 3.6 μm ; $P < 0.05$), with no differences in women (NS; P -values: 0.25 to 0.92). Thus, in men, ACL-R is associated with increased muscle tissue elastic modulus that could affect gait kinematics/kinetics and alter knee joint loading and contact stress, whereas this effect is not observed in women. How increased skeletal muscle tissue extracellular matrix content or stiffness affects skeletal muscle biomechanics or physiology, however, is unexplored, and its significance for development of PTOA is unknown. Moreover, the nature of this sex-specific effect, or whether or how it differentially influences biomechanics or PTOA pathophysiology, is unstudied.

Perioperative Family Updates Reduce Anxiety and Improve Satisfaction: A Randomized Controlled Trial

Lindsay Howe, MS4, UVM COM Class of 2019¹, Daniel Wigmore BS, MS3 COM Class of 2020¹, Nathaniel Nelms MD², Patrick Schottel MD², Craig Bartlett MD², David Halsey MD², Martin Krag MD², David Lunardini MD², Robert Monsey MD², Bruce Beynnon PhD², Michael Blankstein MD²

¹University of Vermont Larner College of Medicine, ²University of Vermont Orthopaedics and Rehabilitation

Purpose:

Multiple studies have shown that perioperative communication is important in reducing family member anxiety and improving the overall experience of family members waiting for surgical patients. However, presently there is no agreed upon standardized time to deliver perioperative news to patients' families. We aimed to determine if frequent, standardized perioperative updates effect anxiety levels and overall satisfaction of the family members and loved ones in the waiting area. In addition, we aimed to determine which specific intra-operative updates family members desire. We hypothesized that frequent updates would enhance satisfaction and decrease anxiety levels of the family members in the perioperative period.

Method:

All patients undergoing elective and urgent trauma, arthroplasty and spine Orthopaedic procedures were eligible. Patients were excluded if they were under the age of 18, non-English speaking patients and/or families, and patients without family members present. Enrolled patients were randomly assigned to a communication pathway. In the control pathway, the surgeons communicated with the family only once near the completion of the surgical procedure. In the intervention group, the families received additional standardized electronic updates via pagers at three pivotal moments: 1) Initial skin incision has been made, 2) Critical part of the case is completed, and closure is about to begin, 3) Closure is complete, and patient will be transferred to the recovery room when ready. The surgeon communicated the final update near the end of the surgical procedure. Following the post-surgical surgeon consult, a member of the research team administered the post-operative survey rating their satisfaction and anxiety levels on a scale of 1-5. Basic demographic information of the family member completing the survey was collected as well.

Result:

A total of 115 surveys were completed, with 58 subjects randomized into the control group, and 57 subjects in the intervention group. The level of overall satisfaction did not differ significantly between the two groups ($p=0.654$). The level of anxiety was significantly lower in the intervention group ($p = 0.049$). Satisfaction with perioperative updates was significantly higher in the intervention group ($p < 0.001$). In regards to update frequency, 47.1% of subjects in the control group, versus 10% of subjects in the intervention group, stated that the updates were too infrequent. We found that the majority of subjects in both groups would like to be updated when the patient is entering the OR (50.9%), when the critical part of the case is complete and closure is about to begin (77.7%), when the closure is complete (69.6%), and when the patient is leaving the OR (65.2%).

Conclusion:

Anxiety and satisfaction with perioperative updates were significantly improved by additional perioperative updates. Overall satisfaction, however, was independent of the frequency of perioperative updates. Surveyed family members indicated a desire for updates at additional critical time points. The results of this study indicate that family updates at strategic time points during the procedure, such as when the surgery is about to begin and the critical part of the case is complete, can reduce anxiety and are also preferred by a majority of patient families

A poster summarizing the AAOS knee osteoarthritis clinical practice guidelines is a powerful tool for patient education: a randomized controlled trial

Monique Squiers, MD; Nathaniel J Nelms, MD; David A Halsey, MD; David M Lisle, MD; James R Slauterbeck, MD; Nathan K Endres, MD; Alan T Davis, PhD; Claude E Nichols, MD; Michael Blankstein, MD

University of Vermont Medical Center

Background:

In May 2013, the AAOS published the 2nd edition evidence based clinical practice guidelines (CPG) on the non-arthroplasty treatment options for patients with knee osteoarthritis (OA). The purpose of this study was to evaluate the effectiveness of an educational poster outlining the AAOS knee OA CPG on patient knowledge assessment and satisfaction in the clinical setting.

Methods:

This study was a prospective two-armed randomized controlled trial. Patients were eligible if they were age 40-85, had mild to severe degenerative osteoarthritis of at least one knee, did not consent for surgery at the initial clinical visit, and were English-speaking/reading. Patients were randomized to non-poster (standard care) and poster rooms. In both groups, knee OA treatment options were described to the patient verbally; however, in the poster room, the poster was simultaneously presented as a visual teaching tool. The main outcomes were knowledge score on a comprehensive survey and patient-reported satisfaction scores (scale 0-10, high score 10).

Results:

Of the 105 patients eligible, 51 (48.6%) were randomized to usual care (Control group) and 54 (51.4%) to the intervention (Poster Group). Data collection yielded a 100% knowledge survey completion rate with less than 3% missing items. Patients exposed to the poster outperformed the Control Group with an average of $55.3\% \pm 16.7\%$ (mean \pm SD) compared to $39.5\% \pm 13.3\%$ ($p < 0.001$). The majority (66.7%) of Poster Group patients and a minority (29.4%) of Control Group patients achieved an adequately informed status with $>50\%$ performance on the exam ($p < 0.001$; 50.5% overall). There was a 99% overall visit satisfaction completion rate with an average of 9.4 ± 1.0 in the Poster Group and 9.2 ± 1.7 in the Control Group ($p = 0.50$).

Conclusions:

Patients exposed to the poster showed a statistically significant improvement in comprehensive knowledge assessment and achieved a significantly higher adequately informed rate. No difference existed in clinical visit satisfaction ratings between the two groups. Therefore, the poster offers a low-cost effective patient educational tool that significantly enhances patient knowledge assessment and can be used as an adjunct to informed patient care.

Retrograde Nailing for Periprosthetic Fractures above Total Knee Replacements: Does range of motion, implant size and polyethylene type affect the starting point?

Brandon Lentine, MD, PGY-3¹

¹University of Vermont Department of Orthopaedics and Rehabilitation

Introduction:

Fractures around the femoral component of a total knee arthroplasty are common with a predilection toward osteopenic female patients. Retrograde femoral nailing is a preferred treatment for early weight bearing, high union rate and minimal soft tissue dissection. Malunion, directly related to the starting point and acceptance of nail diameter through the box of various implants has been described. Further challenges to this technique are present with increasing use of dished and ultra-congruent polyethelene inserts with a taller anterior build. Our aim is to determine if dished polyethylene components will permit the ideal starting point, passage of a retrograde nail and if success is dependent on the amount of knee flexion or implant size determined during preoperative planning.

Methods:

An anatomic study will be performed with nine paired whole leg fresh frozen cadaveric specimens comprising a total of 18 knees without pre-existing lower extremity trauma or pathology. Specimens will be prepared for total knee arthroplasty using a standard medial parapatellar approach. Cruciate retaining, posterior stabilizing and dished trial components will be placed and the arthrotomy closed. A transtendinous approach will be performed for retrograde nailing and the starting point evaluated radiographically, passage of a nail through the range of available sizes 9-14mm will be recorded and the amount of knee flexion required will be noted.

Results:

Results will be prepared during the summer months and available for presentation. We anticipate that knees with dished polyethylene components will require a greater degree of knee flexion and not all sizes will permit use of retrograde nailing.

Conclusions:

We believe our results will serve as a benchmark for preoperative planning as the use of dished components increases and drive appropriate patient selection for retrograding nailing of fractures around the femoral component of a total knee arthroplasty.

Identifying the Source of Neck Pain with Single Photon Emission Computed Tomography/ Computed Tomography (SPECT/CT)

John Nolan, MD, PGY-3¹; Martin H. Krag, MD¹; David Lunardini, MD¹

¹University of Vermont Department of Orthopaedics and Rehabilitation

Introduction:

Diagnosing and treating neck pain remains difficult. While multiple conventional imaging modalities exist (roentgenograms (x-rays), computed tomography (CT) scans, magnetic resonance images (MRI)), none reliably diagnose the source of neck pain. Further, facet injections, medial branch blocks and radiofrequency ablations are variably diagnostic. SPECT/CT scans (hybrid imaging of single photon emission computed tomography and roentgenogram computed tomography) may assist in identifying sources of neck pain. This study evaluates the diagnostic potential of SPECT/CT in patients with neck pain.

Materials/ Methods:

One hundred and seventy-nine patients were identified with neck pain and SPECT/CT scans as part of their workup between 2009-2015. One hundred and thirteen of these had no prior intervention at the level of interest and met inclusion criteria. All of them were referred to our Pain Center by our institution's orthopaedic and neurosurgical spine providers for intervention at specified cervical levels based on their interpretation of the SPECT/CT imaging. Ultimately, the site of intervention was determined by the Pain Center providers based on their clinical examination and image interpretation. Groups were formed based on whether intervention occurred a level identified on SPECT/CT. A positive response was defined as a fifty percent reduction in pain within twenty-four hours of facet injection, medial branch block or radiofrequency ablation. Data was analyzed using a Chi square statistic. SPSS (IBM Corp. IBM SPSS Version 24.0) was used for all analyses.

Results:

Of our one hundred and thirteen patients, Group 1 consisted of ninety with an intervention occurring at the level identified on SPECT/CT. Group 2 consisted of twenty-three patients with an intervention at a level not indicated by SPECT/CT. Sixty-two of ninety patients (68.9%) in Group 1 positively responded to intervention whereas only six of twenty-three patients (26.1%) in Group 2 did ($p=0.0002$).

Conclusion:

Interventions based on SPECT/CT scan results were more successful in pain reduction than those which were not. This suggests a role for SPECT/CT in diagnosing therapeutic targets for neck pain.

Correlating Image Findings in Patients with Neck Pain: Does it Improve Diagnosis?

John Nolan, MD, PGY-3¹; Martin H. Krag, MD¹; David Lunardini, MD¹

¹University of Vermont Department of Orthopaedics and Rehabilitation

Introduction:

Identifying a source of neck pain with current imaging studies remains difficult. Roentgenograms (X-rays) and Magnetic resonance images (MRIs) are not reliably diagnostic. However, our previous study demonstrated that single photon emission computed tomography/ computed tomography (SPECT/CT) identified a statistically significant treatable source of pain in 68.9% of patients, whereas only 26.1% of patients had an improvement in pain with intervention at a level discordant with SPECT/CT ($p=0.0002$). This study evaluates the correlation between SPECT/CT, MRI and X-ray findings in patients with neck pain and whether a correlation in findings is related to pain relief after intervention.

Materials/ Methods:

One hundred and seventy-nine patients were identified with neck pain and SPECT/CT scans as part of their workup between 2009-2015. One hundred and thirteen had no prior intervention at the level of interest and were included for analysis. MRI and X-ray imaging was variably attained in the population. All patients were referred to our Pain Center by our spine providers. Level of intervention was determined by the Pain Center providers based on their clinical examination and imaging interpretation. Retrospectively, we identified the most severely diseased cervical level for each imaging study. This was based on degree of arthritis or degenerative change on X-ray and MRI as well as uptake intensity on SPECT-CT.

Two cohorts were formed: 1) all one hundred and thirteen patients 2) all ninety patients with an intervention at a level concordant with SPECT/CT. The two cohorts were subdivided into four groups each: 1) SPECT/CT + MRI, 2) SPECT/CT + X-ray, 3) MRI + X-ray, 4) SPECT/CT + MRI + X-ray. Statistical correlations were then made descriptively.

All included patients received an intervention by our Pain Center and a positive response was defined as a fifty percent reduction in pain within twenty-four hours of facet injection, medial branch block or radiofrequency ablation. Pain response was analyzed between all groups using a Chi square statistic. The analysis was performed amongst the total cohort of one hundred and thirteen patients as well as amongst the ninety patients with an intervention at their SPECT/CT indicated level. SPSS (IBM Corp. IBM SPSS Version 24.0) was used for all analyses.

Results:

Table 1 summarizes the correlations between the imaging tests for all patient cohorts. While the MRI and SPECT/CT more often correlated than other image groupings, this correlation did not improve with intervention at the SPECT/CT level nor amongst those patients who experienced pain relief after intervention. In both Cohorts 1 and 2, correlations between imaging findings did not lead to statistically significant pain relief after intervention (Table 2).

Conclusion:

The ability to localize treatable sources of pain is not enhanced with the addition of MRI or X-ray imaging to SPECT/CT. Further, intervention at levels that correlate between any two or all three of the tests did not result in statistically significant pain relief. We have previously shown that SPECT/CT has successfully identified a treatable source of pain in 68.9% of patients ($p=0.0002$). This indicates a diagnostic role for SPECT/CT and suggests that MRI and X-ray serve to confound identification of therapeutic targets.

Table 1: Correlation between imaging modalities

Cohort	Group	Number of Patients	Correlation between imaging findings
1	SPECT/CT + MR	94	$52.18 \pm 10.15\%$
	SPECT/CT + X-ray	109	$30.28 \pm 8.67\%$
	MRI + X-ray	90	$33.33 \pm 9.79\%$
	All Imaging	90	$23.33 \pm 8.79\%$
2	SPECT/CT + MR	73	$57.53 \pm 11.42\%$
	SPECT/CT + X-ray	86	$34.88 \pm 10.13\%$
	MRI + X-ray	69	$31.88 \pm 11.08\%$
	All Imaging	69	$26.09 \pm 10.44\%$

Table 2: Percentage of patients with pain resolution after injection at image correlated level

Cohort	Group	Number of Patients	Pain resolution with correlation	Pain resolution without correlation	p-value
1	SPECT/CT + MR	94	32 (34.0%)	24 (25.5%)	0.237
	SPECT/CT + X-ray	109	23 (21.1%)	41 (37.6%)	0.125
	MRI + X-ray	90	16 (17.8%)	36 (40%)	0.546
	All Imaging	90	13 (14.4%)	39 (43.3%)	0.662
2	SPECT/CT + MR	73	31 (42.5%)	20 (27.4%)	0.392
	SPECT/CT + X-ray	86	22 (25.6%)	36 (41.9%)	0.393
	MRI + X-ray	69	13 (18.8%)	34 (49.3%)	0.271
	All Imaging	69	12 (17.4%)	35 (50.7%)	0.878

Post-Discharge Opioid Prescribing and Use after Common Surgical Procedures

Mayo H. Fujii, MD, MS¹; Ashley C. Hodges, BA, BS²; Ruby L. Russell², BA; Kristin Roensch, MD³; Bruce Beynon, PhD³; Thomas P. Ahern, PhD, MPH¹; Peter Holoch, MD¹; Jesse S. Moore, MD, FACS¹, S. Elizabeth Ames, MD³; Charles D. MacLean, MD⁴

¹University of Vermont Department of Surgery, ²University of Vermont Larner College of Medicine, ³University of Vermont Department of Orthopaedics and Rehabilitation, ⁴University of Vermont Department of Medicine

Background:

The number of deaths from prescription opioids in the US continues to increase and remains a major public health concern. Opioid-related deaths parallel prescribing trends, and postoperative opioids are a significant source of opioids in the community. Our objective was to identify opioid prescribing and use patterns after surgery to inform evidence-based practices.

Study Design:

Data from a 340-bed academic medical institution and its affiliated outpatient surgical facility included retrospective medical record data and prospective telephone questionnaire and medical record data. Retrospective data included patients discharged after 1 of 19 procedure types, from July 2015 to June 2016 (n = 10,112). Prospective data included a consecutive sample of general and orthopaedic surgery and urology patients undergoing 1 of 13 procedures, from July 2016 to February 2017 (n = 539). Primary outcomes were the quantity of opioid prescribed and used in morphine milligram equivalents (MME), and the proportion of patients receiving instructions on disposal and nonopioid strategies.

Results:

In the retrospective dataset, 76% of patients received an opioid after surgery, and 87% of prescriptions were prescribed by residents or advanced practice providers. Median prescription size ranged from 0 to 503 MME, with wide interquartile ranges (IQR) for most procedures. In the prospective dataset, there were 359 participants (67% participation rate). Of these, 92% of patients received an opioid and the median proportion used was 27%, or 24 MME (IQR 0 to 96). Only 18% of patients received disposal instructions, while 84% of all patients received instructions on nonopioid strategies.

Conclusions:

Median opioid use after surgery was 27% of the total prescribed, and only 18% of patients reported receiving disposal instructions. Significant variability in opioid prescribing and use after surgery warrants investigation into contributing factors.

The Effects of ACL Injury and Reconstruction on Articular Cartilage Thickness of the Patella, Femur and Tibia is Sex Specific

Mack Gardner-Morse, MS, PE, Kendra Lennon, BS, Ethan Leveillee, MS, Erin Argentieri, BS, Timothy Tourville, PhD, ATC, James Slauterbeck, MD, Daniel Sturnick, MS, and Bruce Beynon, PhD

University of Vermont Larner College of Medicine

Background:

Our prior work identified increases in female medial tibial articular cartilage thicknesses soon after anterior cruciate ligament (ACL) injury¹ and in female tibial, femoral and trochlear cartilage thicknesses at four years following ACL reconstruction². Similarly, changes in tibial, femoral and trochlear cartilage thicknesses have been reported at one, two and five years following ACL injury^{3,4}. However, there is little known about how this injury and reconstruction affects the patella articular cartilage.

Objectives:

The objectives of this research are: 1) to characterize how ACL injury and reconstruction affects articular cartilage thicknesses of the patella, femur and tibia using the 95% confidence interval of uninjured controls, and 2) determine if the response is similar for males and females.

Methods:

Subjects provided written informed consent prior to participation in this Institutional Review Board (IRB) approved case-control study⁵. There were 31 subjects (16 male and 15 female: mean age 32.2 ± 12.6 years) that suffered their first ACL injury, underwent ACL reconstruction with a bone-patellar tendon-bone autograft, rehabilitation and were followed for an average 4.0 ± 0.9 years. All ACL reconstructed subjects returned to pre-injury activities, were pain free, and had no radiographic evidence of post traumatic osteoarthritis (PTOA) (Kellgren and Lawrence grades of 0 or 1)⁵. These subjects were matched with 26 control subjects (13 males and 13 females) that had normal knees and no history of significant trauma. Data were acquired from a subset of these subjects (see *Table 1*). A 3-T Phillips Achiva MRI system was used to obtain 3-dimensional, T1-weighted, fast field echo (1.2 mm slice thickness, within plane resolution 0.3 mm x 0.3 mm) sequences bilaterally at the 4-year follow-up. Manual segmentation of the patellar, femoral and tibial articular cartilage and subchondral bone surfaces were performed using a Cintiq® digitizing tablet and OsiriX® software. A 1 mm by 1 mm grid was fit to the patellar and tibial surfaces and a 1 mm by 2° grid was fit to the femoral surfaces. Cartilage thickness was measured at each grid location. ACL reconstructed-to-uninjured contralateral (or matched legs for controls) side differences in cartilage thickness were calculated for the patella, femur and tibia. Articular cartilage thickness differences for males and females were analyzed separately. Significant side-to-side differences were determined using a two-step statistical method. In the first step, side-to-side difference in thickness magnitudes that were less than the lower 95% confidence limits (95% CL) of the control subjects' side-to-side differences were considered as significant decreases in cartilage thicknesses. Using the same approach, side-to-side difference in thickness magnitudes that were greater than the upper 95% CL of the control subjects' side-to-side differences were considered significant increases in cartilage thicknesses. In the second step, the areas with significant decreases and increases in cartilage thicknesses

were determined, and the mean differences in cartilage thicknesses over these corresponding areas were calculated. Comparisons between the ACL reconstructed and control subjects were then made using a two sample Student's T-tests with unequal variance with statistical significance set *a priori* at 0.05.

Results:

The mean (and standard deviation) of the significant areas of cartilage thickness differences and mean thickness differences over the corresponding areas, along with the p-values for the T-tests are shown in *Table 1*.

For the male patellas, there were no significant differences in cartilage thicknesses between the ACL reconstructed and control subjects. In contrast, for the female patellas, ACL reconstructed subjects had less than 50% of the decreased thickness area and 69% more increased thickness area than control subjects. The female ACL reconstructed subjects also had an 11% greater mean increase in thickness in comparison to the controls, but this was not significant. The female patellas had a large area of increased thicknesses (*Figure 1*).

For the male femurs, the ACL reconstructed subjects had no significant differences in thicknesses compared to the controls. The femurs of the female ACL reconstructed subjects had a 43% greater mean increase in cartilage thicknesses than control subjects. The area with increased thicknesses was also 45% greater in the ACL reconstructed subjects, but this was not significant. The increased thicknesses are mainly in the trochlear region of the femur and in the tibial contact area (*Figure 1*).

In the lateral compartment of the tibia, male ACL reconstructed subjects had a 74% greater area with increased thicknesses. In the medial compartment of the tibia, both male and female ACL reconstructed subjects had 55% and 33% greater mean increased thicknesses than controls. The females also had 53% greater area with increased thicknesses. This increased thicknesses was located slightly anterior to the tibiofemoral contact region (*Figure 1*).

Conclusions:

Following ACL injury, reconstruction, rehabilitation and 4-year follow-up, study participants did not report symptoms of PTOA; however, significant increased articular cartilage thicknesses were observed. The pattern of increased cartilage thicknesses was different between females and males. The changes were considered clinically and biomechanically significant as the mean thickness differences in the injured subjects were up to 55% greater than the normal patella cartilage thickness differences, and approximately 10% of the normal cartilage thicknesses. An early finding associated with the onset of osteoarthritis is thickening (swelling) of articular cartilage, thus, the increases in cartilage thickness we have observed may represent an early sign of the onset of PTOA that occurs prior to the development of symptoms. The different pattern of response in changes of cartilage thicknesses between males and females indicates that sex specific analysis should be considered in studies of PTOA.

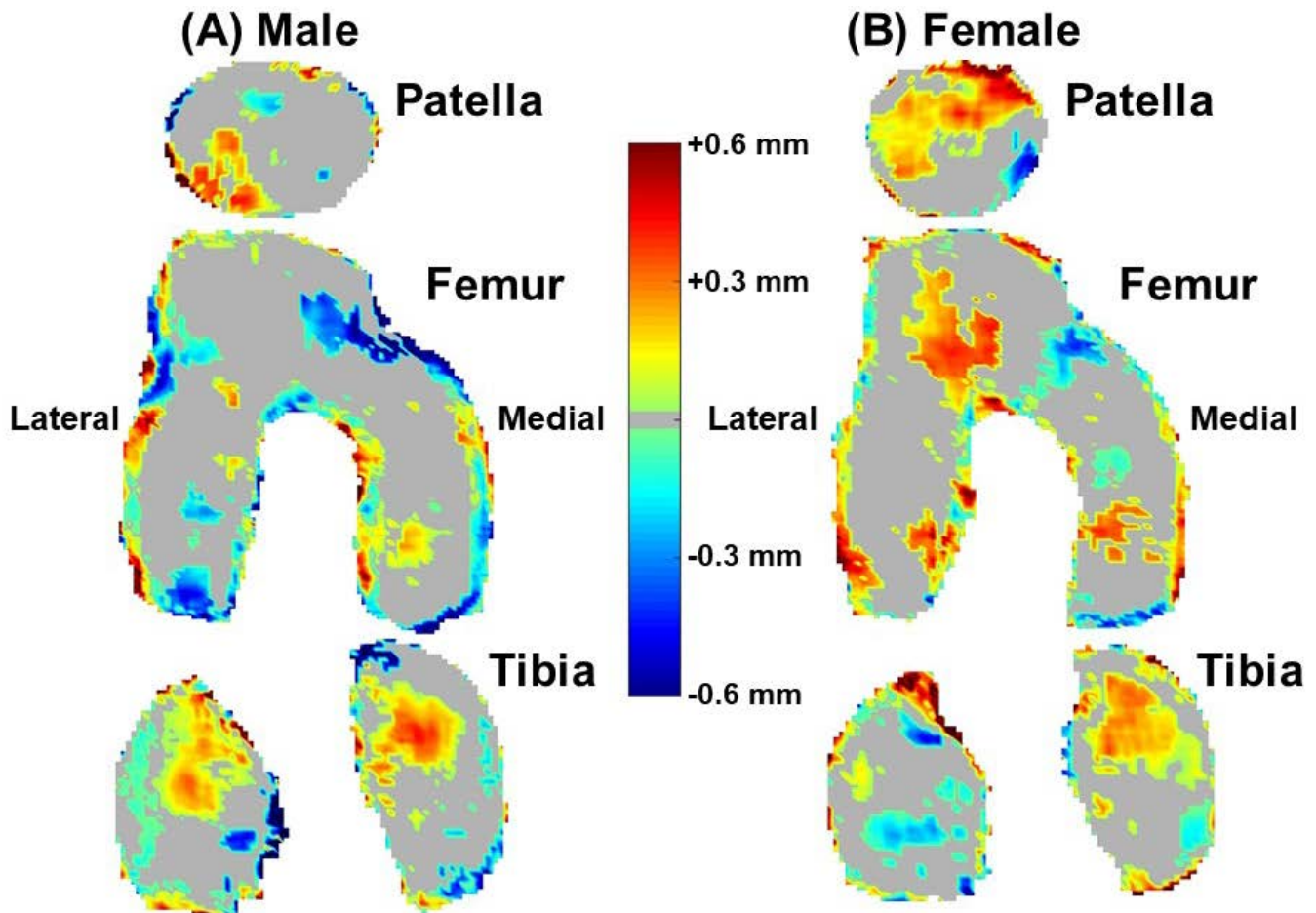
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Table 1 Number of subjects (N), cartilage area with significant decreases in cartilage thickness (Decrease Area), mean decrease in cartilage thickness over the cartilage area with significant decreases (Mean Decrease), cartilage area with significant increases in cartilage thickness (Increase Area) and mean increase in cartilage thickness over the cartilage area with significant increases (Mean Increase) for the patella, femur and lateral and medial compartments of the tibia for ACL reconstructed subjects (Cases) and normal knee subjects (Controls) with $p < 0.05$.

		N	Decrease Area (mm ²)	Mean Decrease (1/mm)	Increase Area (mm ²)	Mean Increase (1/mm)
			Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Patella						
Males	Cases	11	213.5 (100.5)	-0.606 (0.144)	267.4 (154.3)	0.521 (0.170)
	Controls	10	232.0 (139.3)	-0.646 (0.120)	232.5 (194.2)	0.398 (0.092)
	p-values		N.S.	N.S.	N.S.	N.S.
Females	Cases	11	118.9 (69.9)	-0.531 (0.150)	413.6 (136.9)	0.446 (0.182)
	Controls	11	243.5 (123.8)	-0.598 (0.100)	244.0 (97.8)	0.400 (0.084)
	p-values		0.0104	N.S.	0.0036	N.S.
			(mm-degrees)	(1/degrees)	(mm-degrees)	(1/degrees)
Femur						
Males	Cases	10	327.1 (136.3)	-0.535 (0.167)	439.1 (238.0)	0.501 (0.079)
	Controls	5	490.8 (286.3)	-0.429 (0.091)	376.8 (316.4)	0.377 (0.158)
	p-values		N.S.	N.S.	N.S.	N.S.
Females	Cases	13	408.8 (267.3)	-0.361 (0.111)	281.6 (212.4)	0.572 (0.118)
	Controls	5	210.2 (203.5)	-0.316 (0.135)	193.4 (253.2)	0.399 (0.042)
	p-values		N.S.	N.S.	N.S.	0.0003
			(mm ²)	(1/mm)	(mm ²)	(1/mm)
Tibia						
Lateral						
Males	Cases	16	154.3 (84.0)	-0.805 (0.154)	390.3 (162.6)	0.355 (0.176)
	Controls	13	204.8 (127.2)	-0.779 (0.111)	223.5 (130.8)	0.247 (0.154)
	p-values		N.S.	N.S.	0.0049	N.S.
Females	Cases	15	240.9 (151.9)	-0.472 (0.181)	177.9 (136.8)	0.416 (0.126)
	Controls	13	151.5 (79.9)	-0.382 (0.095)	156.8 (78.4)	0.403 (0.193)
	p-values		N.S.	N.S.	N.S.	N.S.
Medial						
Males	Cases	16	203.3 (112.7)	-0.559 (0.141)	356.9 (153.5)	0.362 (0.115)
	Controls	13	242.4 (178.0)	-0.507 (0.147)	241.5 (149.1)	0.233 (0.096)
	p-values		N.S.	N.S.	N.S.	0.0027
Females	Cases	15	153.6 (83.2)	-0.322 (0.053)	288.0 (108.3)	0.355 (0.078)
	Controls	13	176.5 (104.6)	-0.317 (0.105)	188.1 (107.1)	0.266 (0.057)
	p-values		N.S.	N.S.	0.0215	0.0019

Figure 1 Mean anterior cruciate ligament reconstructed cartilage thickness differences between the injured and uninjured knee within subjects greater than the 95% confidence interval (95% CI) for the differences in control subjects with healthy knees for (A) male and (B) female subjects. Areas within the 95% CI are shaded gray. The numbers of subjects for each bone are given in *Table 1*.



Operational Implications of Surgical Coaching

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Background:

In this study, we examined the impact of surgical coaching on operating room (OR) efficiency. Coaching is a component of Engaged Interdependence, a professional development model that allows surgeons to expand their technical and managerial skills.

Methods:

Data was collected using Wise OR, and efficiency was assessed on four fronts: OR workload (patient time in room plus turnover time), operating time, over-utilized time, and under-utilized time. As surgeon RM began coaching surgeon DL on 2/1/2017, data was split into a *Before* and an *On/After* group, allowing for statistical and graphical comparison.

Results:

A paired-samples t-test revealed a significant reduction in OR workload hours for the *On/After* group (M=3.93, SD=2.02) compared to the *Before* group (M=4.60, SD=1.94); (t(24)=2.53, $p<.05$), and another significant reduction in operating time hours for the *On/After* group (M=2.81, SD=1.76) compared to the *Before* group (M=3.69, SD=1.91); (t(24)=2.79, $p<.05$). Pareto charts indicated an overall decrease in over-utilized time, and an overall increase in under-utilized time.

Conclusion:

Surgical coaching represents a low-cost, high-value intervention that can substantially improve OR efficiency. While a somewhat subjective process, coaching can net healthcare systems significant return on investment, and bolster a surgeon's operational and organizational decision-making.

A Dedicated Orthopaedic Trauma Room Increases Operating Room Throughput Without Increasing After-Hours Utilization Minutes

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Title:

A Dedicated Orthopaedic Trauma Room Increases Efficiency by Increasing Operating Room Throughput Without Increasing After-hours Utilization

Introduction:

Operating after-hours is associated with increased costs, inferior clinical outcomes, and higher levels of provider (surgeons, anesthesia, nursing, ancillary) burnout. In this study, we examine the efficiency of a dedicated orthopaedic trauma operating room (OTOR) using operating room utilization data as a surrogate for financial analyses.

Methods:

The orthopaedic trauma service (OTS) at a rural ACS level 1 center was allocated two additional elective OR blocks per week. This allowed the OTS to offload elective cases from regular OR trauma time in order to improve access for acute trauma cases by establishing dedicated orthopaedic trauma time. Unused elective time was either released to the OR or utilized for additional trauma cases. Two orthopaedic traumatologist (Surgeons A and B) were granted access to this additional block time. Surgeon C, a separate traumatologist, did not receive additional block time, and their schedule remained unchanged. Using WiseOR® (Palo Alto, CA), we extracted the total number of cases, after-hours utilization minutes, and opportunity-unused minutes for the orthopaedic trauma service and the dedicated OTOR for the nine months prior to this change (December 2015 – August 2016) when surgeons A & B started operating within the service and for the twenty months after the change (October 2016 – May 2018). For each month, we analyzed the data for the orthopaedic traumatologists individually (Surgeons A, B, and C) and for the OTS collectively. As each minute of after-hours utilization demands a higher cost compared to allocated block time, the cost per minute of after-hours utilization was calculated using Childers et al.'s inpatient OR costs as a guideline. After-hours utilization represents a variable cost. Pareto frontiers were calculated for the appropriate variables and Pareto optimality was graphically represented using GraphPad Prism (La Jolla, CA).

Results:

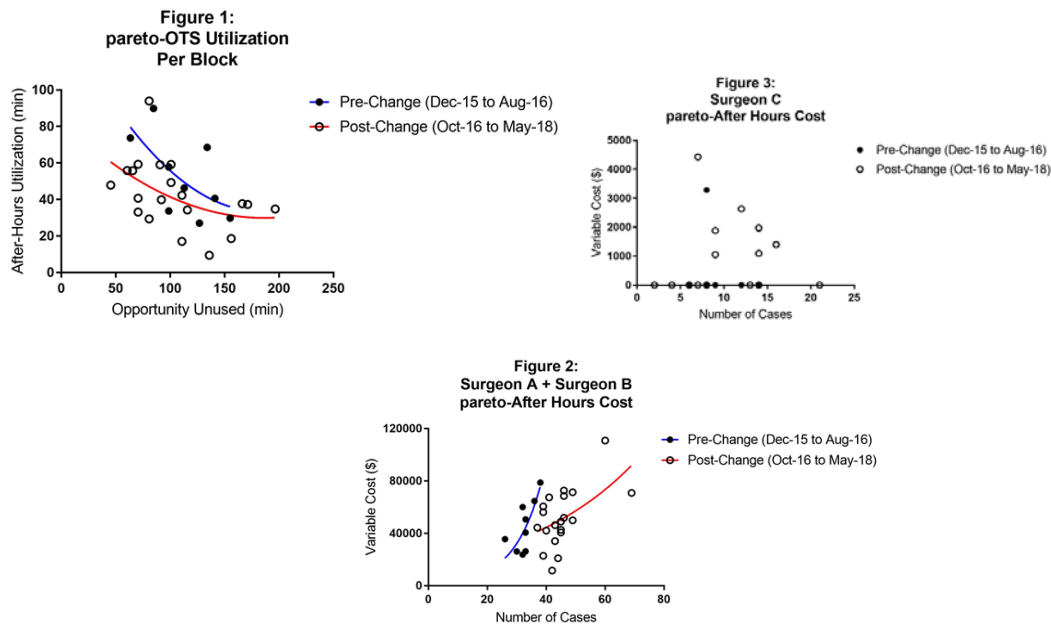
There was a significant increase in total case volume per month for the surgeons (A and B) who were assigned to the additional dedicated OTOR blocks (32.2 vs 45.4 cases per month, $p = 0.0001$). There was no significant difference in the total case volume performed by the surgeon (C) whose operating schedule had not changed (10.2 vs. 9.8 cases per month, $p = 0.804$). There was no significant difference in the number of after-hours utilization minutes per month by Surgeons A and B (1030 min. vs. 1180 min., $p = 0.452$) or by the unaffected traumatologist (8.3 min. vs. 16.5 min., $p = 0.455$). Pareto efficiency (Figure 1) and cost efficiency (Figures 2 and 3) were both increased by establishing a dedicated OTOR. There was no significant difference in monthly associated after-hours utilization costs (\$41,752 vs. \$51,722, $p = 0.2510$). This equated to an estimated marginal variable cost of \$9,970 per month. There was no significant difference in opportunity-unused minutes after establishing a dedicated OTOR (2530 min. vs. 2912 min., $p = 0.4101$).

Conclusion:

In this study, we demonstrate that operating room utilization data can be used as a surrogate for financial analyses and that the establishment of a dedicated OTOR can increase OR efficiency by increasing OR throughput without increasing after-hours utilization.

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Radial Tunnel Syndrome: Diagnostic work-up and Effectiveness of Decompressive Surgery

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Radial tunnel syndrome (RTS) is a neuropathy caused by compression of the posterior interosseous nerve (PIN), most frequently at the arcade of Frohse of the supinator muscle. It is clinically characterized by pain approximately 5 cm distal to the lateral epicondyle that radiates down the dorsal forearm and is primarily a clinical diagnosis. Using nerve conduction studies and magnetic resonance imaging (MRI) in the diagnosis of RTS has been shown to be controversial. As far as the utility of electromyography in the diagnosis of RTS, there seems to be little to no data. Treatment of RTS can begin with conservative measures (splints, rest, activity modification, physical therapy, NSAIDs, steroid injections). However, these interventions may not provide long-term relief of symptoms. Surgical decompression of the PIN is largely believed to be effective in providing symptom relief for patients, though success rates vary widely. The purpose of this study is to suggest that EMG can be used in the diagnostic work-up of RTS and to show that surgical decompression of the PIN is effective in RTS treatment. We will perform retrospective analyses on patient medical records of those diagnosed with RTS using EMG and treated with surgical PIN decompression.