Pelvic Floor Research Group (PFRG) Day 2010

Learning Objective: Improve prevention and treatment of women's pelvic floor disorders.

Target Audience: Faculty, staff, house officers, nurses, midwives, biostatisticians, research staff and students from across the UM Health System (e.g. Ob/Gyn, Urology, Radiology, Anesthesiology) and the University of Michigan campus interested in pelvic floor disorders.

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The University of Michigan Medical School designates this educational activity for a maximum of 4.75 *AMA PRA Category 1 Credit(s)*™. Physicians should only claim credit commensurate with the extent of their participation in the activity.

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Planner/Faculty Member	Nature of Relationship	Company
Janis M. Miller	Grant/Research Support (PI)	Pfizer
John DeLancey	Grant/Research Support (PI)	Johnson & Johnson
John DeLancey	Consultant	AMS
James Ashton-Miller	Grant/Research Support	Johnson & Johnson
John Wei	Consultant	Envisioneering
John Wei	Grant/Research Support	Beckman Coulter, Source MDX
Dee Fenner	Consultant & Grant/Research	AMS
Carolyn Sampselle	Consultant	Pfizer

Poster Overview

(First Author/Title)

Brincat, Cynthia
Postpartum Perineal Clinic: Experience from the First Year of a North American Clinic

Brincat, Cynthia
Predicting Post-Operative Voiding Dysfunction After Pelvic Floor Surgery

Clark, Natalie
Major Levator Ani Defect Effects on Pelvic Floor Structure and Function.

Kane-Low, Lisa
Mapping of Obstetrical Factors with Levator Ani Defects on MRI in the Early Weeks Post Complex Vaginal Birth in Primiparous Women: The EMRLD Pilot Study

Kim, Jinyong
An Investigation of Pubovisceral Muscle Enthesial Loading at the End of the Second Stage of Labor

Larson, Kindra
Anatomy of the perineal body as seen in MR images

Larson, Kindra
Locations of paravaginal anatomy in women with unilateral levator ani muscle defects.

Larson, Kindra
MRI-based 3-D model of anterior vaginal position at rest and maximal strain in women with and without prolapse: a pilot study investigating "what really occurs."

Lewicky-Gaupp, Christina
Fecal Incontinence in Older Women: Are Levator Ani Defects a Factor?

Lewicky-Gaupp, Christina
Racial Differences in Bother for Women with Urinary Incontinence in the Establishing Prevalence of Incontinence (EPI) Study

Lewicky-Gaupp, Christina
Structural position of the posterior vagina and pelvic floor in women with and without posterior vaginal prolapse.

Luo, Jiajia
In Vitro Material Properties of Apical Supports

Ramanah, Rajeev
Apical support: a preliminary anatomical, histological and MR study

Yousuf, Aisha
Pelvic Floor Recovery in Primiparous Women at 1 Month Compared to 7 Months After Vaginal Delivery

Yousuf, Aisha
The Correlation between Unsupported Anterior Vaginal Wall Length and the Most Dependent Bladder Point at Maximal Valsalva in MRI

Zielinski, Ruth

Measurement of Female Maximum Isometric Levator Ani Muscle Strength Unconfounded by Intraabdominal Pressure

What is SCOR?

(cited from http://www.niams.nih.gov/funding/Funded_Research/orwh_scor.asp)

Specialized Centers of Research on Sex and Gender Factors Affecting Women's Health

The Office of Research on Women's Health (ORWH) serves as a focal point to promote, stimulate, and support efforts to improve the health of women through biomedical and behavioral research at the National Institutes of Health (NIH). ORWH works in partnership with the NIH institutes and centers, and other federal agencies to ensure that women's health research is part of the scientific framework at NIH and throughout the scientific community. Through this partnership, the ORWH established eleven SCORs to promote institutional interdisciplinary research in an area important to women's health. The specialized centers are co-funded by the National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS), the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development (NICHD), the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), the National Institutes on Drug Abuse (NIDA), the National Institute of Mental Health (NIMH), and the National Institute of Environmental Health Sciences (NIEHS), and the Food and Drug Administration (FDA). The NIAMS provides administrative oversight for the centers.

Currently Funded SCOR Grants

Brigham and Women's Hospital
Fetal antecedents to sex differences in depression: a translational approach. Jill Goldstein, Ph.D., is the center director.

Medical University of South Carolina
Role of sex and gender differences in substance abuse relapse. Kathleen Brady, M. D., Ph.D., is the center director.

Northwestern University
Excess male hormones (androgens) as the key to explaining polycystic ovarian syndrome (PCOS). Andrea Dunaif, M.D., is the center director.

University of California, Los Angeles
A coordinated study of stress, pain, emotion, and sexual factors underlying the pelvic visceral disorders of irritable bowel disorder and interstitial cystitis. Emeran Mayer, M.D., is the center director.

University of California, San Francisco
Lower urinary tract function in women. Jeanette Brown, M.D., is center director.

University of Chicago
Sex steroids, sleep, and metabolic dysfunction in women. David Ehrmann, M.D., is the center director.

University of Miami
Sex and gender influences on addition and health: a developmental perspective. Emmalee Bandstra, M.D., is the center director.

University of Michigan, Ann Arbor
Birth, muscle injury, and pelvic floor dysfunction. John DeLancey, M.D., is the center director.

University of Missouri, Kansas City
Identifying the genes that put women at risk for osteoporosis. Hong-Wen Den. Ph.D.., is the center director.

Washington University
The molecular and epidemiologic basis of acute and recurrent urinary tract infections (UTI's) in women. Scott Hultgren, Ph.D., is the center director.

Yale University
Sex, stress, and substance use disorders. Rajita Sinha, Ph.D. is the center director.

Project Descriptions

SCOR2 on Sex and Gender Factors Affecting Women's Health
(Overview – SCOR2)

Principal Investigator: John O.L. DeLancey, M.D.

August 1, 2007 – August 31, 2012

This proposal seeks to improve care for the women who suffer the priority health conditions of pelvic floor dysfunction; problems that arise due to women's unique role in giving birth. It addresses the sex disparities that exist in these problems. Each year 3 million women deliver babies and 300,000 women need surgery for pelvic floor dysfunction. A lack of basic understanding of the mechanisms of birth-related injury and recovery during reproductive years and mechanisms of prolapse later in life block efforts to prevent damage, improve recovery, or improve treatment. We seek continued support for a broadly interdisciplinary group of researchers from 4 schools and 2 institutes to that has expedited development of new knowledge needed to improve treatment and prevention.

Project 1: "Birth Biomechanics" will test hypotheses concerning basic mechanisms of pelvic floor injury during vaginal birth; the single largest factor in causing pelvic floor dysfunction to identify specific situations may increase or decrease injury risk.

Project 2: "Injury Recovery" will identify risk factors associated with levator injury, test the hypothesis that these injuries are, in fact, related to vaginal delivery and determine early predictors of eventual recovery.

Project 3, "Mechanisms of Posterior Vaginal Prolapse" will use advanced imaging and deformation analysis to test hypotheses concerning the basic disease mechanisms responsible for posterior vaginal wall prolapse, one of the most common and strongly birth-associated pelvic floor dysfunction.

Core A: Administrative / Human Subjects / Biostatistics core provides project support by recruiting subjects, compiling and analyzing data and protecting subject safety. In Core A, two study groups will be formed concerning 1) Gender Impact and 2) Basic Science Futures to discuss expanding the issues raised by this research.

Core B: Measurement and Imaging core will provide technical support for the projects along with integrated analysis for 2 and 3 dimensional spatial data gathered across projects. This research will produce insights to address the women's health problem of pelvic floor dysfunction.

Biomechanics of Birth-Related Injuries
(SCOR2 Project 1)

Principal Investigator: James A. Ashton-Miller, Ph.D.

August 1, 2007 – August 31, 2012

The overall goal of this research is to better understand the mechanisms of maternal vaginal birth related injury at the end of the second stage of labor. The main factor affecting the resistance of the pelvic floor muscles to stretch as they resist the downward descent of the fetal head is their viscoelastic material properties. The effect of term pregnancy on these properties has never been documented, partly due to the difficulty of obtaining sample of undamaged human pelvic floor tissues during birth.

In AIM 1, therefore, we will use equi-biaxial testing and stepwise stress relaxation assays to characterize the effect of term pregnancy on the constitutive law and mechanical behavior of mammalian pelvic floor tissues in rat and squirrel monkey. Uniaxial failure tests will also be conducted to determine the effect of pregnancy and test direction on the ultimate tensile stress in these tissues.

In AIM 2.1 we will develop a subject-specific, 3-D finite element biomechanical model of the second stage of labor from Station +2 on with representations of the fetal head, five major pelvic floor muscles and related soft tissues, as well as the time-varying maternal expulsive force. In AIM 2.2 we will validate the model predictions by comparing them against the results of in vivo experiments in pregnant women. These involve the measured temporal displacement of a posterior weighted speculum at C-section, and the time course of the increase in vaginal diameter upon fetal head crowning.

In AIM 2.3 we will investigate the effect of (a) fetal head orientation, (b) cephalopelvic disproportion, (c) maternal sub- pubic arch angle, (d) epidural, (3) forceps use, and (f) episiotomy of the magnitude, direction and location of a maximum pelvic floor muscle tissue stress. The ration of that stress to the ultimate tensile stress I taken as a measure of the risk of tissue injury, and should lead to better methods of preventing these injuries.

Maternal Birth-Related Neuromuscular Injury and Recovery: Phase II (SCOR2 Project 2)

Principal Investigator: Janis M. Miller, Ph.D., RNC

August 1, 2007 – August 31, 2012

Magnetic resonance imaging data suggest a strong relationship between childbirth and structural pelvic floor injury, likely originating from stretch or crush of maternal tissues during the expulsive phase of labor. The pelvic floor muscle most vulnerable to injury is the striated pubovisceral muscle (PVM); 11-20% of parous women demonstrate a muscle defect at a year postpartum. A link between this defect and pelvic floor disorders has been found in our preliminary studies; women with prolapse and incontinence have a 4 fold- and 2 fold- higher rate of PVM defects respectively. This finding offers a plausible causal link between pelvic floor disorders and a structural injury that occurs at childbirth. The cause of the defect is not yet known; nerve or muscle injury might be the underlying mechanism. Serial MRI offers the ability to observe PVM defects over time and differentiate: 1) neurogenic injury (degeneration over time), 2) myogenic injury (early and permanent avulsion), or 3) fully recoverable injury. Injury type can then be correlated with obstetric risk factors and functional recovery. This study's aims are to: 1) Establish the validity of factors used to identify women with greatest likelihood of PVM injury by estimating the probability of each injury outcome classified at 6 months postpartum in a sample (n=125) enriched for risk factors of long duration of 2nd stage, instrumented delivery, 3rd or 4th degree perineal lacerations, macrosomic infant. 2) Establish that PVM injuries are associated with vaginal births vs. pregnancy by comparing our 125 women who birthed vaginally to 50 women who birthed by elective Caesarean. 3) Determine the extent to which an array of clinical parameters observed at 6 weeks postpartum will predict long term (6 months) muscle outcomes. To do so, we will obtain MRI's at 2 weeks and 6 months postpartum and perform functional PVM testing at the standard 6-week postpartum evaluation. We will classify putative injury types and correlate with risk factors and functional parameters. We will try to address the knowledge gaps identified at the March 2006 NIH convened State-of-the-Science Conference: Cesarean Delivery on Maternal Request, which highlighted the need for understanding the mechanisms and risk factors for PVM injury. The short-term goal is new insights on injury mechanism. The long-term goal is prevention of and better treatment for pelvic floor disorders.

Mechanisms of Posterior Vaginal Prolapse (SCOR2 Project 3)

Principal Investigator: John O.L. DeLancey, M.D.

August 1, 2007 – August 31, 2012

Posterior vaginal wall prolapse (PVP), including enterocele and rectocele, is an enigmatic condition whose pathophysiology is poorly understood. ORWH, NICHD and NIDDK have each identified that female pelvic floor disorders such as PVP are in critical need of pathophysiology research. Competing hypotheses have been proposed relating to the causal roles of endopelvic fascia or levator ani muscle failure. However, data to resolve these conflicts are not available and are needed to establish the relative contributions of fascial and muscular abnormalities to PVP. This study will test the mechanistic hypothesis that the occurrence of PVP is not explained by a single mechanism but involves the interaction between fascial and muscle abnormalities. To test these hypotheses, we will recruit 75 cases with PVP and 75 controls of similar age and race. Aim 1, "Fascia", we will use mid-sagittal MR images made during maximal Valsalva to document the posterior wall location and morphology in 4 regions influenced by fascial support: 1) location of the posterior vaginal apex, 2) length of the posterior vaginal wall, 3) changes in the inclination of the distal vaginal wall, and 4) location of the perineal body. By comparing measurements between cases and controls, we will determine the contributions of abnormalities in each region to the occurrence and size of PVP. Aim 2, "Muscle", we will use multiplanar proton density MR scans to compare 1) presence of visible defects in the levator ani muscles, 2) cross sectional areas of the muscle, as well as measuring and 3) pelvic muscle contraction force during a maximal contraction. Using these data we will determine the contribution of muscular abnormalities. We will then use statistical modeling to determine the relative contributions of fascial versus muscular abnormalities. Aim 3, "Rectocele vs. Enterocele", we will test the strength of association between the 4 fascial and 3 muscle abnormalities and the two types of PVP using general linear modeling. Aim 4, "Biomechanical Modeling", we will use biomechanical analyses of fascia and muscle interactions in computer-based models to investigate patterns of muscle and connective tissue support site failures that lead to PVP. These insights are needed to advance our understanding of disease mechanisms so that we can reduce the 30% recurrence rate of prolapse after surgery, and develop preventative strategies to reduce the need for surgery in 200,000 women each year.

Core A - Administrative, Human Subjects, Biostatistics (SCOR2)

Principal Investigator: John O.L. DeLancey, M.D.

August 1, 2007 – August 31, 2012

Core A will be responsible for the following four services to unify, support, and coordinate the 3 projects in this SCOR. Aim 1 Administration: Core A will provide administrative support to Projects 1, 2 and 3 for recruitment, subject scheduling, forms generation, IRB issues, organization and confidential filing. In addition, it will file group renewal reports, generate, manage and plan project budgets, schedule group meetings, discussion groups, and seminars. Aim 2: Fostering Sex and Gender Research: Core A will seek to stimulate further research with the following activities 2a) *Gender Impact Studies Group* discussion to consider the personal and societal impact of these problems unique to women, 2b) Support, maintain and expand the *SCOR Pelvic Floor Disorders Databank* of over 12,000 images of over 600 research subjects from prior and ongoing projects 2c) convene an annual *campus wide SCOR sponsored Pelvic Floor Research Day* to foster interdisciplinary discussion 2d) Sponsor a *National Workshop in Future Directions in Pelvic Floor Basic Science Research* at the American Urogynecologic Society meeting. Aim 3 Biostatistics: Core A will manage data and work with project investigators to properly test study hypotheses. This will include overseeing data forms, data entry and management, biostatistical analysis and data quality control. Aim 4 Human Subjects: The core will assure Human Subject safety through active involvement with our IRB committee. This involvement will assure compliance with institutional and national regulations, tracking and assessing subject safety by monitoring adverse events, providing information to our outside subject safety committee as necessary. Core A will prepare regular reports from centralized logs concerning adverse events across all projects to increase detection of infrequent events that may occur in different projects.

Core B –Measurement and Imaging (SCOR2)

Principal Investigator: James A. Ashton-Miller, Ph.D.

August 1, 2007 – August 31, 2012

The Measurement and Imaging Core will assist with measurements of perineal geometry during the late second stage of labor in 50 women, and of pelvic floor load-displacement behavior in 32 women using a posterior weighted speculum at the time of pelvic surgery. The Core will assist with clinical measurements and standardized data sets from magnetic resonance (MR) imaging to be made on the 175 and 150 women completing Projects 2 and 3, respectively. In Projects 2 & 3, subject-specific pelvic floor model geometries will be developed from reconstructing the magnetic resonance (MR) images. Additionally, in Project 2 the post natal recovery of normal MR signal intensity will be tracked over time in the pubovisceral muscles. In Project 3, MR measurements of posterior vaginal wall geometry will be made. Lastly, the Core will provide bioengineering and technical support to each project. For Projects 2 & 3 it will provide technical support for all urethral pressure measurements ($MUCP_R$ and $MUCP_{MVC}$) to be made using 8F catheter, maintain the hardware and software of the instrumented speculum used to measure levator ani contractile properties (LA_R and LA_{MVC},), and analyze and provide cleaned data sets to Core A for statistical analysis.

Mechanisms of Anterior Wall Support Failure (OPAL2)

Sponsor: NIH

Principal Investigator: John O.L. DeLancey, M.D.

April 1, 2005 – March 31, 2010

Anterior vaginal wall prolapse (AVP), clinically known as cystocele, is the most common form of pelvic organ prolapse. The NICHD Female Pelvic Floor Disorders workgroup and NIDDK'S Bladder Progress Review Group have identified a critical need for pathophysiology research in these conditions. Competing hypotheses have been proposed to explain how anterior vaginal wall connective tissue support (CTS) failure results in AVP; midline stretching of the vaginal wall vs. peripheral detachment in the paravaginal and apical areas of support. However, these theories do not incorporate observations from our previous funding cycle that pubococcygeal muscle (PCM) damage is 4 times more common in women with prolapse. This study proposes to test mechanistic hypotheses that the occurrence and magnitude of AVP is not explained by a single mechanism but involves the interaction of different connective tissue failures sites and also PCM impairment. We will use MRI techniques and novel 3-D computer modeling to individually measure and compare the status of each site of support in 150 women with AVP and 150 controls. In Aim 1 we will: a) measure origin to insertion distances for paravaginal and apical supports and longitudinal and transverse diameters of the vaginal wall at maximum Valsalva to determine the contribution of CTS failures at these sites to the presence of AVP, b) determine the sites where each individual with AVP has measures outside the normal range found in controls and c) use linear regression models to determine how the number of CTS site defects and severity of CTS failure at each site affects AVP size. In Aim 2 we will: a) determine how muscle impairment interacts with CTS failure in explaining the occurrence and size of AVP by measuring muscle structure and function in both groups, b) examine the role that PCM impairment plays in determining AVP severity beyond the contribution of the CTS and c) determine whether patterns of CTS failure (e.g. single failure, multiple failures or different combinations of failure) relate to PCM impairment. Aim 3 will use biomechanical analysis of muscle and connective tissue interactions in computer-based models of CTS and PCM to investigate patterns of muscle and connective support site failures that lead to AVP. These insights are needed to advance disease mechanisms research in order to reduce the 30% recurrence rate with surgery, and develop preventative strategies to lessen the need for surgery in 400,000 women a year.

Defining Measures and Events of Normal Delivery to Predict Pelvic Floor Damage (DiMEND)

Sponsor: MICHR

Principal Investigator: Lisa Kane Low, PhD, CNM, FACNM

Over 200,000 women require surgery annually for prolapse, making it the most common pelvic floor dysfunction requiring surgery. Despite compelling evidence that vaginal birth is the most important modifiable etiologic factor for prolapse, potentially causal events have not been identified to explain the 4- to 11-fold increase in prolapse after vaginal birth.

Two factors have impeded the research into potentially causal events for prolapse. The first factor was the long lag time between exposure to events during vaginal birth and symptoms of prolapse later in life. Recent research using magnetic resonance imaging (MRI) has partially resolved the first factor by providing evidence of the type of muscle defect that occurs to the support muscles of the pelvic organs, specifically the levator ani, that results from vaginal birth. Birth induced damage to the levator ani muscle is a primary cause of prolapse 60% of the time later in life. With this surrogate marker, it is now feasible to study contemporaneously the potential birth events underlying the injury that are associated with the expected later development of prolapse.

A second factor impeding the research: the paucity of detail about the events of second stage when levator damage occurs. At the bedside, nurses and other health care providers make multiple clinical assessments of the progress that a woman is making in 2nd stage. Yet the details of these physical events and care responses largely go undocumented. The dynamics of the 2nd stage are typically summed up as a length of time. Without detailed documentation of 2nd stage events, it is not possible to determine the specifics of when and how injury occurred. Thus, the specific aim of this study is to:

AIM 1: Develop a set of precise measures for 2nd stage labor events and

1.a Determine the reliability of the measures and validity of a subset of measures.

A prospective, observational, clinical investigation will be conducted, recruiting 25 primigravida women at 36 weeks gestation, to achieve a planned final sample size of 20 women after vaginal birth. The events of second stage will be quantified and characterized using observational techniques and reliability of the measures and validity of selected measures will be confirmed.

If the incidence of prolapse can be prevented by even 20%, that would reduce the number of women who experience surgery by 25,000 annually, thereby sparing women the pain and health systems the significant costs.

BRinging simple urge Incontinence DiaGnosis & treatment to providers (BRIDGES)

Sponsor: Pfizer Inc.

Parent Study PI: Jeanette Brown, MD, UCSF

University of Michigan Site PI: Janis Miller, PhD ANP-BC

January 1, 2009 – February 28, 2011

Primary care clinicians and general obstetrician gynecologists remain unfamiliar and uncomfortable with diagnosing and treating Urge Urinary Incontinence (UUI), yet the prevalence of UUI is growing as “baby boomers” age. We believe this multi-center randomized controlled study of 636 women will demonstrate that a simple 3-item questionnaire will result in feasible and efficacious treatment through fast case-finding and safe immediate follow-up, as would be practical in the primary care setting. The study will take place at 14 clinical sites in the US, with a randomized controlled trial to 12 weeks. The treatment arm will receive fesoterodine and the control arm a placebo. Participants who complete the 12-week RCT will be offered open label fesoterodine for an additional 9 months to further demonstrate that case-finding use of the 3IQ and f/u with pharmacological treatment results in improvement in symptoms and does not result in harm to patients. Outcome measures include diary of incontinence episodes, self-reported incontinence outcomes (perception of bladder condition, urinary urgency, quality of life, and satisfaction with treatment). In the 9-month open-label portion of the study, we will also evaluate changes in the total amount and pattern of fluid intake using the Questionnaire based Voiding Diary (QVD). Economic outcomes as changes in patient costs for incontinence management (routine care costs) within each intervention arm will be assessed. The significance of the study is its potential for rapid translation into the primary care setting, with efficacious treatment available to address the epidemic proportions of UUI.

A Bladder Health Program for Reducing Urinary Incontinence in Women - Development of a Class-to-Computer (DVD) Program

Sponsor: MICHR

Principal Investigator: Carolyn Sampselle, PhD

August 01, 2008 – July 31, 2009

In surveys of US women, the overall prevalence of urinary incontinence (UI) is at least 34% among Caucasians, 28% among Hispanics, and 21% among African Americans. UI extracts very heavy financial costs on women's physical and emotional well-being. Our Random Clinical Trial (RCT) with older women on a UI self-management program, presented an array of effective strategies - Pelvic Floor Muscle Training (PFMT), Bladder Training (BT) and the "squeeze trick" (a preemptive contraction to decrease stress UI and/or suppress the UI urge). We found high & sustained adherence to PFMT: 82% at 3 months post instruction and 68% at 12 months (footnote 14); sustained adherence of 70% at 4-years was predicted by early self-efficacy. Moreover, we demonstrated a two-fold UI prevention effect (footnote 16). In addition to higher PFMT adherence rates, we have observed synergistic effects between PFMT and BT, which suggests this combined intervention has added benefits. This innovative combination of self-management practices may enable women to adopt and sustain efficacious bladder health practices. The purpose of this project is test reliability of the conversion of a proven Bladder Health class to a computer-formatted program.

In light of growing evidence of the efficacy of conservative strategies for the self-management of UI, we believe the time is right to translate this face-to-face intervention to a computerized DVD format. Using PowerPoint slides and 2 short videos, we will condense and enhance already-successful material from the original Bladder Health Class. The presentation will discuss the features and benefits of Bladder Training, Pelvic Muscle Exercise and the use of "the squeeze trick" (This "squeeze trick" is a modified version of the "Knack" treatment used in earlier studies.)

We will use the University of Michigan's Engage website as well as strategically-posted fliers to recruit 20 community partners. These partners will include persons from under-represented groups and will include (predominantly African Americans and Latinas) to assist with program development. Community partners will review iterations of the program, enabling us to assure that the content is understandable and engaging.

Self-Care to Prevent Birth-Related UI in Diverse Women (PERL IV)

Sponsor: NIH - NINR

Principal Investigator: Carolyn Sampselle, PhD

September 30, 2007 – May 31,2012

Despite compelling evidence that pelvic floor muscle training (PFMT) reduces childbearing women's risk of urinary incontinence (UI) by up to 39-59% 1;2;3, too few childbearing women adopt and sustain this practice. Recent review reaffirms PFMT as recommended practice during pregnancy/postpartum 4, but only 20-52% of childbearing women report its use 5;3;6. Moreover, virtually all previous trials of self-care to prevent UI have been with Caucasian women. Our RCT with older women testing the UI prevention efficacy of a combined PFMT and bladder training (BT) self-management program applied Bandura's 7 self-efficacy theory: the intervention was taught in an intensive class and demonstrated a two-fold preventive effect 8. Furthermore, adherence to PFMT was high (82% at 3 months post instruction) and sustained (68% at 12 months) 9. These results encourage us to extend our current study (NIH R01 NR07618, PI C. Sampselle) with this competing continuation. To assure adequate racial/ethnic representation, we will over sample African American and Hispanic women using community-based sites that serve diverse patients. Aim 1 will determine the efficacy of an intensive antenatal Bladder Health Class to prevent UI at 12 months postpartum in a diverse sample of African American, Caucasian, and Hispanic childbearing women. Aim 2 will examine the capacity of adherence to mediate the association of self-efficacy with UI incidence. Aim 3 will explore the attitudes and strategies among 3 racial/ethnic groups that facilitate or deter adherence. Aim 4 will explore the efficacy of the Bladder Health class at 3 years post index birth. To accomplish Aims 1 and 4, we will conduct a single-blind RCT following intention-to-treat assumptions taking race/ethnicity into account. To accomplish Aim 2, we will assess the role of adherence as a mediator of the relationship between self-efficacy and UI. If Aim 1 hypotheses are supported, an intensive Bladder Health Class could become the standard of care for maternity patients. Aim 2 & 3 results will provide insights re: the mediating role of adherence and about facilitators/barriers to self-management. Aim 4 results will yield much needed long term data regarding the potential benefit of these UI preventive self-care practices. Ultimately we intend to mount an effectiveness RCT, which will be informed by the results of the study proposed here

Pelvic Floor Disorders Network (PFDN)

Principal Investigator Data Coordinating Center: Cathie Spino, D.Sc.

In July 2001, the Pelvic Floor Disorders Network (PFDN) was formed to improve the care and daily lives of women with pelvic organ prolapse and bladder and bowel control problems. The network includes 7 clinical sites throughout the US and a Data Coordinating Center (at the University of Michigan's Department of Biostatistics in the School of Public Health). Funded by the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development, the Network's efforts includes randomized clinical trials in stress incontinence, urge incontinence, and pelvic organ prolapse, and cohort studies including voiding function, childbirth and pelvic floor symptoms, post-partum MRI and ultrasound, and one-year follow-up after colpocleisis

Current Research

The CARE Study: Colpopexy and Urinary Reduction Efforts

The E-CARE Study: Extended Follow-up of Patients Enrolled into CARE

The CAPS Study: Childbirth and Pelvic Symptoms

The CAPS Imaging Study: Anatomic Characterization of the External/Internal Anal Sphincter at Six Months Postpartum

The ATLAS Study: Ambulatory Treatments for Leakage Associated with Stress. Pessary versus Pelvic Floor Muscle Therapy versus Combined Therapy: A randomized Controlled Trial of Non-Surgical Treatment for Stress Urinary Incontinence

The Colpocleisis Study: Pelvic Symptoms and Patient Satisfaction After Colpocleisis

The Voiding Study: Voiding Function in Women with Pelvic Organ Prolapse and Urinary Incontinence

For more information: www.pfdnetwork.org

Poster Abstracts

Postpartum Perineal Clinic: Experience from the first year of a North American Clinic

Cynthia Brincat, MD, PhD, Christina Lewicky-Gaupp, MD, Melissa Abernethy-Smith, MD, Dee Fenner, MD

Perineal trauma is common with vaginal birth. Complications of such trauma, including fistulas, fecal and urinary incontinence, and perineal pain, can be potentially devastating for new mothers. In July, 2007 we established a post-partum perineal clinic to identify and treat such women. This study describes the presentation, patient profile, and treatment of the women that presented to the clinic.

We reviewed the charts of patients presenting from July 2007-June 2008, abstracting demographic and treatment variables.

Forty patients were seen. The median time from delivery to the first visit was 5 weeks (range of 1-72). Twenty-three percent (n=9) of the patients were referred from an outside institution. The mean age was 31 ± 5years, mean BMI 27 ± 5 kg/m^2, and median parity was 1 (range 1-3). All patients had undergone a vaginal delivery; 15% (n=6) of these were forceps-assisted and 5% (n=2) were vacuum-assisted. Half of the patients were referred for follow-up of a third degree laceration. Seven (17.5%) were seen following a fourth degree laceration. The remainder were seen for urinary incontinence (20%, n=8) and perineal pain (7.5%, n=5). The mean number of visits per patients was 2 ± 1.5 and 17.5% ultimately required operative intervention (n=7). Of the 20 patients referred for a third degree laceration, the vast majority were symptomatic (85%, n=17); 9 had pain, 5 had bowel symptoms, and 3 had urinary complaints. Of the patients referred for a fourth degree laceration, 4 required surgical intervention for rectovaginal fistula or breakdown of repair. Of those referred for perineal pain, treatment included steroid injection, physical therapy, management of bowel symptoms and removal of granulation tissue. Of the 8 patients with urinary incontinence as their presenting symptom, stress urinary incontinence predominated, with only 1 case of urge incontinence and 1 case of mixed incontinence. Treatment included placement of a tension-free vaginal tape in those patients who had completed child-bearing (25%), fitting with an incontinence pessary (37.5%), and pelvic floor exercises (37.5%). At follow-up, 75% reported symptom resolution while 25% reported an improvement in symptoms.

A postpartum perineal clinic offers an opportunity for early assessment and treatment of pelvic floor dysfunction. A dedicated clinic provides easy referral and centralized care for a unique patient population. Most women responded to physical therapy and noninvasive care; nearly a fifth of patients required surgical intervention. It is hoped that this model of care can be used to improve peripartum care and reduce the morbidity of untreated perineal trauma.

Predicting Post-Op Voiding Dysfunction After Pelvic Floor Surgery

Cynthia Brincat, MD, PhD, Tatnai Burnett, MD, Divya Patel, MD, MPH, Mitchell Berger, MD, Dan Morgan, MD, Dee Fenner, MD, John DeLancey, MD

Objectives: Although the likelihood that a woman will not be able to void the day after surgery is known for incontinence operations, similar data are not available for women undergoing prolapse surgery. We sought to determine occurrence and predisposing factors for women requiring catheter drainage after the first postoperative day.

Methods: As part of an ongoing project, we reviewed post operative voiding during a four month period, on cases where the primary indication for the surgery was pelvic floor dysfunction and longer catheterization was not planned (e.g., fistula, PV sling). Post operative voiding dysfunction was defined as post void residual (PVR) >75cc, after retrograde fill on the first postoperative day.

Demographic, diagnostic, and treatment data were abstracted from the medical record. Chi-square, Fisher's exact test, ANOVA tests were used as appropriate to evaluate associations of variables with post-operative voiding status.

Results: There were 121 cases analyzed. The median age of patients was 59 years (SD 13) with a median BMI of 28.2 (SD 5.3). Eighty-seven percent of the operations were performed vaginally. Of the remaining 13%, half were done abdominally and half laparoscopically. The median number of concomitant procedures was 2 (SD 1.3). One-fourth of the patients had one procedure, 28% had two procedures, 22% had three procedures, and 25% had 4-6 procedures. The median number of medical comorbidities was 3 (SD 2.4). The median position of POP-Q point Ba was +1 (SD 2.9), Bp was 0 (SD 3.0) and the apex (C or D) was -3 (SD 5). Median estimated blood loss (EBL) was 100cc (SD 120).

Forty percent of patients were not able to void without having a PVR > 75cc. This was associated with older age (p=.013). The median age of those without elevated PVR was 57 years (SD 13.5), while the median age of those women who were required to perform intermittent self catheterization (ISC) was 61 years (SD 11.4) and those who required a foley catheter was 71 years (SD 10.2). Number of procedures was significantly associated with voiding dysfunction (p=.03); at 5 procedures, more patients required ISC than did not (73%). Of the 40% with voiding dysfunction, 39 patients were discharged requiring ISC and 10 went home with an in-dwelling foley catheter for management. Twenty patients were empirically treated for a urinary tract infection (uti), all of which were in the voiding dysfunction group. Postoperative voiding status was not significantly associated with surgeon, type of anesthesia, number of medical problems, EBL, preoperative position of Ba, Bp, apex, concomitant anterior colporrhaphy or incontinence procedure. All women were able to resume spontaneous voiding during the 4 month study period.

Conclusions: Older women and those with multiple procedures undergoing surgery for pelvic floor dysfunction are more likely to require ISC or management with a foley catheter.

Major Levator Ani Defect Effects on Pelvic Floor Structure and Function

Natalie Clark, Cynthia Brincat, MD, PhD, Aisha Yousuf, MD, John DeLancey, MD

Objectives: Prolapse is known to be associated with lower perineal position and also with defects in the levator ani muscles. Whether perineal sagging is due to levator damage or to the presence of the prolapse is not known. This project quantifies perineal position in women matched for prolapse status and size to evaluate the independent effect of levator defects in perineal location.

Methods: Forty women were selected from an ongoing study of pelvic floor function to constitute two groups. The women in group one (n=20), had major levator ani defects (>50% of muscle missing as identified on supine magnetic resonance scan) and group two (n=20), had no major levator defects. The groups were selected to have equal numbers of women with and without prolapse (50%) so that the effect of defects could be assessed independent of their known association with prolapse. Measurements were taken of perineal structure location relative to the sacro-coccygeal inferior pubic point (SCIPP) axes at: rest, during maximal voluntary contraction (Cmax) and maximum Valsalva (Vmax) on mid-sagittal MR scans by evaluators blinded to levator defect status and prolapse status. Measurements were then compared at rest, Cmax and Vmax, calculating for displacement and for distance between perineal positions.

Results: At rest, Cmax and Vmax, the perineal body and external anal sphincter are more caudal in women with levator ani defects than those without (p<.01 at all points of measure). At Vmax the bladder of women with major levator ani defects is more caudal than the bladder of women without defects (p=.02). The bladder is more posterior in women with major levator ani defects at

rest (p=.02) and Cmax (p<.01). The bladder of women with major levator ani defects displaces further caudally with Vmax compared to women without defects (p=.03). At rest, Cmax and Vmax, the levator hiatus and urogenital hiatus are larger in women with major levator ani defects than those without defects (p<.05 at all points of measure). All measures were significant independent of prolapse status.

Conclusions: Women with major levator ani defects have a more caudal location of their perineal structures and larger hiatuses at rest, Cmax and Vmax than women without defects in subjects with similar prolapse status.

Mapping of Obstetrical Factors with Levator Ani Injury on MRI in the Early Weeks Post Complex Vaginal Birth in Primiparous Women: The EMRLD Pilot Study

Lisa Kane Low, PhD, CNM, FACNM, Ruth Zielinski, MS, CNM, Janis M. Miller, PhD, ANP-BC

Retrospective studies have found that vaginal birth complicated by obstetrical (OB) risk factors such as anal sphincter tear, instrumental delivery, and long second stage have been associated with levator ani muscle (LA) injury as demonstrated on MR imaging in primiparous women at nine months post partum. This finding is significant in that LA injury is associated with vaginal prolapse later in a women's life span. The objective of this pilot study was to demonstrate successful case-finding of women with LA injury by previously known OB risk factors and explore additional potential OB risk factors that may aide in case finding in primiparous women following a complex vaginal birth.

We used the previously known OB risk factors described above as inclusion criteria to recruit an enriched sample of primiparous women (n=19) with high potential for LA injury and studied these women immediately after birth (within a few weeks postpartum) by MRI. All received multiplanar intermediate-weighted sequences. MR images were evaluated for LA tears and were graded as none, minor or major. Classification of major injury required >50% loss of muscle fibers on at least one side.

Of the 19 women in the pilot study, 10 women demonstrated no injury while nine demonstrated from minor to major evidence of LA injury (53% vs. 46%).
Tally of LA injury by potential OB risk factors are shown in Table 1.

Case finding for LA injury was enhanced using the OB risk factors noted in prior studies. Findings also suggest consideration of additional OB factors or potentially a matrix of OB risk factors may improve sensitivity in case-finding primiparous women with LA injury as documented on MRI.

An Investigation of Pubovisceral Muscle Enthesial Loading at the End of the Second Stage of Labor

Jinyong Kim, MS, James A. Ashton-Miller, PhD, John O. L. DeLancey, MD

The most vulnerable part of the pelvic floor muscle to injury during the second stage of labor is the pubovisceral muscle (PVM). Some 10-15% of parous women demonstrate a PVM muscle defect 1-year postpartum. The most common form of injury appears to be avulsion of the origin of the PVM, suggesting a failure at or near its enthesis on the posterior aspect of the os pubis. To explore the biomechanics of this injury, a simplified finite element (FE) model of the PVM was developed based on an isotropic material model. Enthesial geometries (quadrilateral / angled / angled and flared) were placed under tension in the caudoposterior direction in order to compare PVM stress and strain distributions. The results show larger stress concentration on the inferior

aspect and midsection of the enthesis than on its superior aspect. There appears to be an optimal enthesial stiffness to minimize enthesial stress concentrations.

We gratefully acknowledge the financial support of Project 1 of the PHS SCOR P50 HD044406-06 grant.

Anatomy of the perineal body as seen in MR images

Kindra Larson, MD, Aisha Yousuf, MD, Christina Lewicky-Gaupp, MD, Dee Fenner, MD, John DeLancey, MD

The perineal body (PB) is a connecting point for important perineal structures. This study evaluates MR imaging's ability to visualize PB structures and better delineate their inter-relationships.

MR images of 10 women were examined. All subjects had normal pelvic organ support on POP-Q examinations (most dependent portion of vagina $\geq$ 1cm above the hymen) and had no incontinence or prolapse symptoms. To maximize visibility of small perineal body structures, 2 mm thick multi-planar proton density MR images were acquired with a 3 Tesla scanner. Anatomic structures were analyzed in axial, sagittal and coronal slices. Slicer® was utilized to generate 3-D models from these images to better define their inter-relationships.

On MRI, the PB's structures are best visualized in the axial plane and can be divided into three regions: the distal, mid and proximal portion. In the *axial* plane at the most distal portion at the level of the vestibular bulb (VB) (Figure 1a), the bulbospongiosus (BS) inserts into the PB, while the superficial transverse perineal muscle (STP) and external anal sphincter (EAS) traverse the space. In the PB's mid-region at the proximal end of the STP (Figure 1b), one component of the pubovisceral muscle, the puboperineal muscle inserts into the PB and may cross the midline. The puboanal muscle is also visible in this area as it inserts in the intersphincteric groove between internal and external anal sphincters. In the PB's most proximal region at the level of the midurethra (Figure 1c), the pubovaginal muscle becomes visible as it fuses with the vaginal sidewall, sending fibers posteriorly to the PB. In this location, the longitudinal fibers of the rectum are also visible in the midline. The puborectal muscle forms a loop behind the rectum at this level, but does not contribute fibers to the PB. In the *mid-sagittal* plane, the PB's recognizable pyramidal structure is visible between the vagina and the rectum (Figure 2a). Parasagittally (Figure 2b), cranio-caudal relationships can be appreciated, although individual structures aren't as well visualized as in axial scans. The perineal membrane is visible above the BS and VB in the region of the PB. The fibers of the pubovisceral muscle extend across the PB, while the dorsal portion of the EAS extends caudal to the PB. Figure 3 illustrates a 3-D model of the PB generated from MR images, further clarifying structural inter-relationships.

Axial MR images are best at revealing the PB's anatomy and can be organized into three regions: the distal, mid and proximal portions. Sagittal images show the pyramidal shape and delineate cranio-caudal relationships. 3-D models can then be generated which enhance our ability to understand the PB's complex inter-relationships.

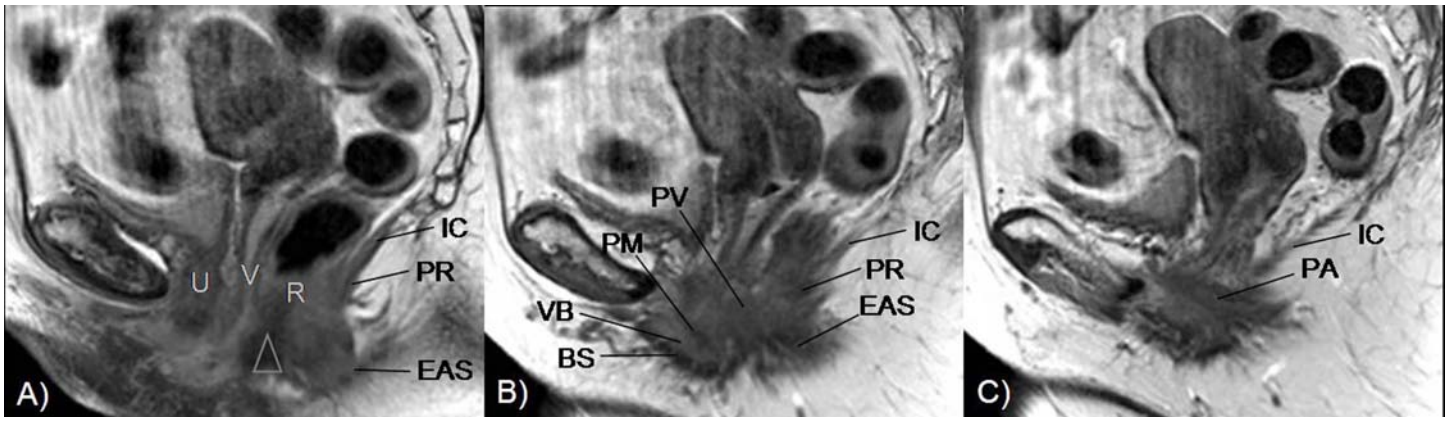


Figure 1.

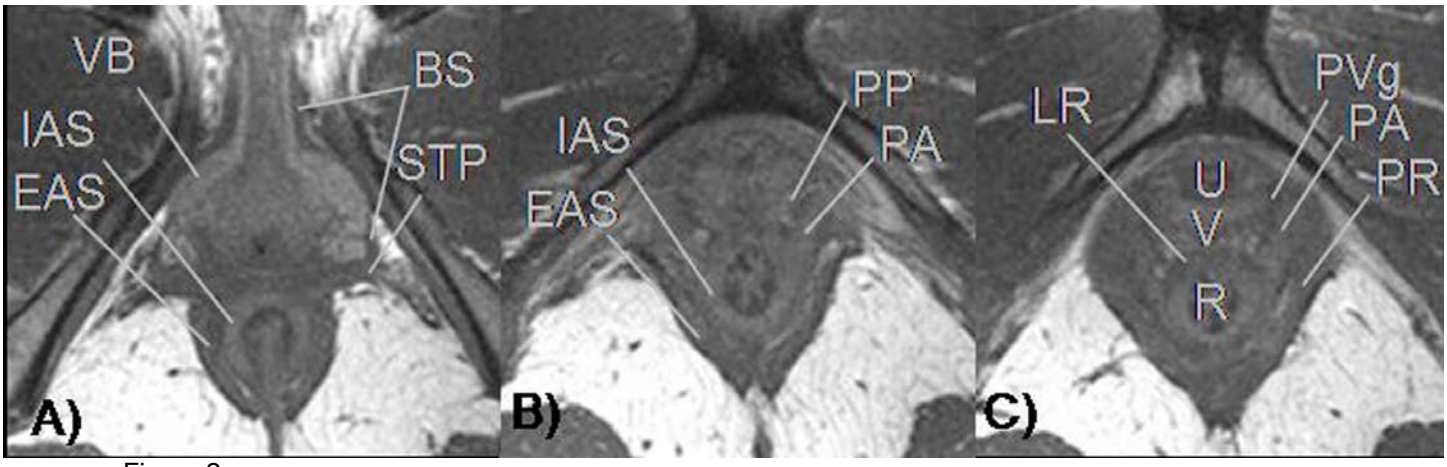


Figure 2.

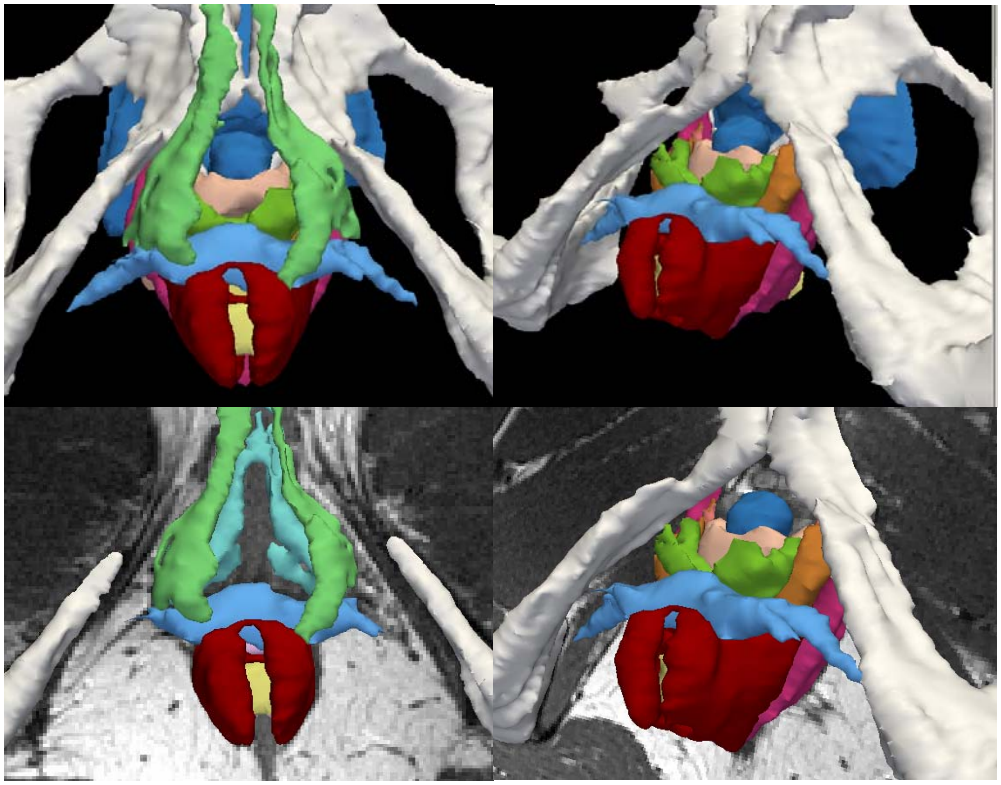


Figure 3.

Locations of paravaginal anatomy in women with unilateral levator ani muscle defects

Kindra Larson, MD, Jiajia Luo, MS, Aisha Yousuf, MD, James Ashton-Miller, PhD, John DeLancey, MD

Several structures are found in the paravaginal area including the arcus tendineus levator ani (ATLA), arcus tendineus fascia pelvis (ATFP), conjoined arch, and levator ani muscle (Fig 1). While these are individual structures, it is likely they interact to provide anterior vaginal support. This study presents a method to define the locations of the ATLA and ATFP in women with unilateral levator defects and to compare normal and abnormal anatomy.

Five subjects with unilateral levator defects were recruited from an ongoing, IRB approved case-control study. Supine multi-planar MR imaging of the pelvis was completed for each subject. From the axial images, 3-D models of the ATFP, ATLA and pelvic bone were generated using Slicer® (Fig 2). These models were then imported into Imageware® for measurement. A reference line was established on each side of the pelvis, from the ATFP's insertion on the pubis to the ischial spine (P-IS line). The perpendicular distances from the P-IS line to selected points along the ATFP and ATLA were then calculated. Points superior to the line were assigned a positive value, while those below were given a negative value (Fig 3).

The mean age of subjects was 50.4 $\pm$ 12.8 yrs, median vaginal parity 3, mean BMI 23.7 $\pm$ 2.7, and all were Caucasian. The most pronounced anatomical changes occurred in the ATLA and conjoined arch. The pubic portion of the ATLA forms an arch <u>above</u> the P-IS line on the non-defect side of the pelvis (mean distance: 16.3 $\pm$ 5mm). In contrast, on the defect side, it drops <u>below</u> this line (mean distance: 16.2 $\pm$ 5.8mm, $p < 0.0001$). Similarly, there was a trend towards significance in the conjoined arch position. Although this remains above the P-IS line on both the

sides with and without defects, the distance from the line was greater on the normal side (mean distance: 13.2 ± 4.8mm vs. 7.6 ± 3.2mm, p=0.06). When analyzing position along the length of the P-IS line, the pubic portion of the ATLA begins more caudally on the defect side (mean position as percent of reference line length: 31 ± 4% vs. 18 ± 9%, p=0.02). With this sample size, we found no difference in the ATFP's position along or distance to the P-IS line when comparing normal and defect anatomy.

Using 3-D models from MR images, we quantified the differences in relationships of paravaginal structures in women with normal and abnormal (defect) anatomy. Even with this small sample, the pubic end of the ATLA lies significantly below (3 cm) its normal location and has a more caudal origin on the defect side. These findings help us understand why these women are at higher risk of prolapse and allow objective documentation of geometrical changes so that biomechanical consequences of abnormal anatomy can be further studied.

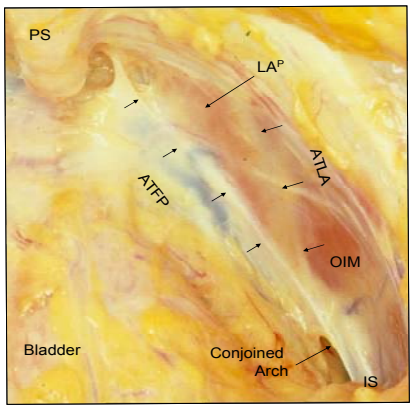
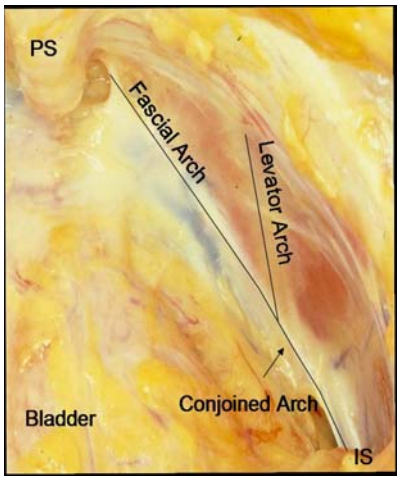


Fig 1. View into the Space of Retzius showing the right pelvic sidewall. ATFP, ATLA and conjoined arch visible. PS - pubic symphysis, IS – ischial



View into the Space of Retzius at the right pelvic sidewall. All three arches are visible: the fascial arch (ATFP), levator arch (ATLA), and conjoined arch. PS - pubic sympysis, IS – ischial spine, LA – levator ani.

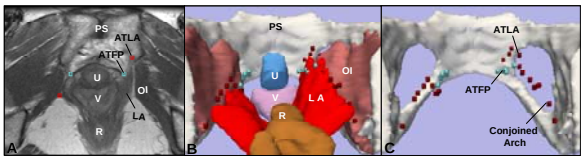


Fig 2. Panel A, axial image showing location of ATFP and ATLA. B, 3D model made of from MRI showing ATFP and ATLA with adjacent structures. C, same showing only ATFP, ATLA and conjoined arch. LA, levator ani; OI, obturator internus; PS, pubic symphysis; R, rectum; U, urethra; V, vagina.

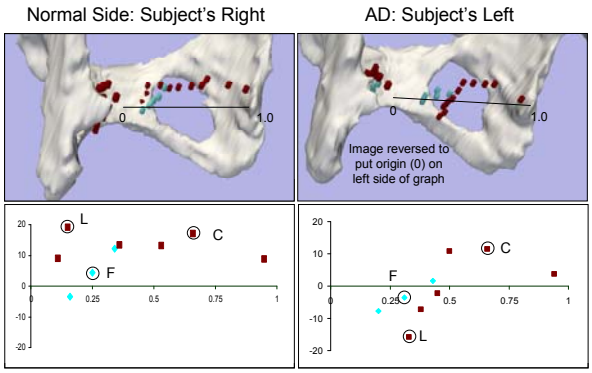


Fig 3. Technique for plotting distance to reference line. ATFP is in blue and the ATLA and its conjoined extension beyond the separate fascial arch are in red. Below is the plot of distances measured from selected points to the reference line. With the points sampled for the ATLA (L), ATFP (F) and conjoined (C). AD – defect side.

Technique for plotting distance to reference line. ATFP is in blue and the ATLA and its conjoined extension beyond the separate fascial arch are in red. Below is the plot of distances measured from selected points to the reference line (P-IS). With the points sampled for the ATLA (L), ATFP (F) and conjoined (C).

MRI-based 3-D model of anterior vaginal wall position at rest and maximal strain in women with and without prolapse: a pilot study investigating "what really occurs."

Kindra Larson, MD, Yvonne Hsu, MD, Luyun Chen, PhD, James A. Ashton-Miller, PhD, John DeLancey, MD

Data from 2-D mid-sagittal MR imaging during Valsalva demonstrates that both apical support and vaginal length contribute to anterior vaginal wall prolapse. Objective information is still lacking on the role played by paravaginal defects between the vagina and arcus tendineus fascia pelvis (ATFP) and the degree of transverse vaginal stretching. The aim of this study was to develop a 3-D technique to study the vagina and its relationship to the pelvic sidewall at rest and maximal Valsalva and to report preliminary findings.

Five symptomatic women with anterior vaginal wall prolapse and five asymptomatic women with normal support were recruited from an ongoing study. Supine, multi-planar MR imaging of the

pelvis was performed at rest and maximal Valsalva with gel in the vagina to delineate the lateral sulci. 3-D reconstructions of the pelvic bones and anterior vagina at rest and during Valsalva were created using 3-D Slicer (Slicer2). The pelvic bones of resting and Valsalva scans for each subject were aligned to allow direct comparison of vaginal position. A line representing the normal ATFP location was constructed from the inferior pubic bone to the ischial spine to allow assessment of vaginal position relative to this landmark.

With Valsalva the vaginal apex descended in women both with and without prolapse. In women with prolapse several other phenomena were also visible: (a) the vagina moved downward along its length, increasing the vertical distance between the lateral sulcus and normal ATFP; (b) the degree of apical descent allowed the lower vagina to slide below the introitus where it was no longer in contact with the perineal body; (c) the distal portion of the vagina not supported by the levator ani exhibited evidence of "cupping" (Fig. 1) with a modest increase in transverse diameter; (d) the vagina above this portion where it was in contact with the posterior wall did not reveal any transverse stretching; and (e) the distal end of the vagina appears to rotate downward along an arc centered on the inferior pubis (Fig. 2).

This novel technique allows objective analysis of vaginal position during Valsalva in women both with and without prolapse. This demonstrates additional processes which could contribute to cystocele size and severity – not only the change in relationship between the vagina and pelvic sidewall with increased vertical distance from the normal ATFP, but also the distension and "cupping" of the unsupported distal wall, and the mobility inferior to the pubic bone.

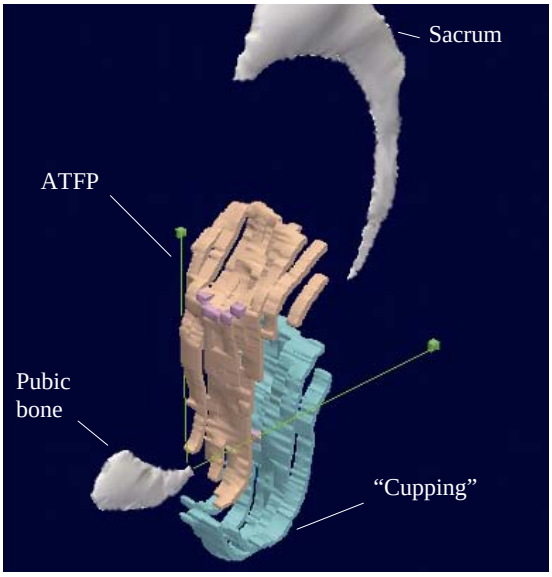


Fig 1. Oblique 3-D model illustrating distal vaginal "cupping". Vaginal wall is modeled with sagittal strips for accuracy. Vagina is shown at rest (pink) and during Valsalva (blue). Also shown are cervicovaginal junction (purple), ATFP (green, with the ischial spines as cubes); and mid-sagittal pubic bone and sacrum (white).

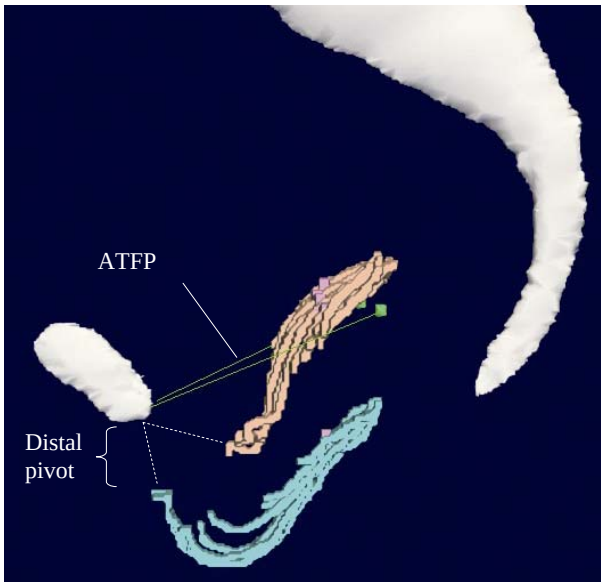


Fig 2. Sagittal 3-D model illustrating relationship of vagina to ATFP and distal vaginal "pivot" around inferior pubis.

Fecal Incontinence: Are Levator Ani Defects a Factor?

Christina Lewicky-Gaupp, MD, Aisha Yousuf, MD, Cynthia Brincat, MD, PhD, Divya Patel, MD, MPH, John DeLancey, MD, Dee Fenner, MD

To examine pelvic floor structure and function related to aging and fecal incontinence (FI) on dynamic MRI.

We compared young, continent women aged 20-41 years (YC; n=9) to older women aged 60-88 years with FI (OI; n=8) and without FI (OC; n=9). Continence was defined as a Wexner score of < 4; incontinence was defined as a score > 8. Patients underwent a POP-Q, measurement of levator ani force at rest and with maximum contraction, and static and dynamic MRI in the supine position. Mobility of the pelvic structures was measured on dynamic MRI with location changes relative to the SCIPP (sacrococcygeal-inferior pubic point) line (x-axis) and perpendicular y-axis (Figure 1). Levator ani (LA) defects were determined on static images.

LA defects were more common in OI women compared to OC and YC women (Table); overall, women with FI were much more likely to have LA defects than women without FI (OR 14.0, p=0.01). On MRI, levator and urogenital hiatuses were significantly larger in both groups of older women. Similarly, the OI and OC groups had less vertically-oriented levator plate angles with Kegel (Table). On instrumented speculum exam, the OI group generated 27.0% less LA force during contraction (F_{LAC}) compared to the OC group (p=0.13) and 30.1% less than the YC group (p=0.04) (Table). Regardless of continence, women with LA defects had 25.9% less F_{LAC} (6.0 ± 2.3 N vs. 8.1 ± 2.7 N) compared to those without a defect (p=0.05). During Kegel, PB and EAS displacements were smaller in the OI group compared to the OC group (p=0.01) (Figure 2).

Older women with FI are more likely to have defects in their LA muscles, and have an inability to augment their pelvic floor strength compared to continent women. Aging is associated with larger levator and genital hiatuses, as well as less vertical LP angles. Defects in levator ani muscles play a role in the development of FI in older women.

Table. Structure and function among women with and without fecal incontinence

	OI (n=8)	OC (n=9)	OI v. OC p-value	YC (n=9)	YC v. OC p-value	YC vs. OI p-value
Any Levator Ani Defect, % (n)	75.0 (6)	22.2 (2)	0.14	11.0 (1)	1.0	*0.01*
MRI Levator Hiatus (cm)						
Rest	6.7 ± 1.0	6.5 ± 1.0	0.80	5.5 ± 1.0	*0.05*	*0.03*
Kegel	6.3 ± 1.0	5.6 ± 0.7	0.14	4.5± 0.8	*0.01*	*0.002*
Valsalva	7.0 ± 1.2	6.9 ± 1.4	0.83	5.6 ±1.0	*0.05*	*0.03*
MRI Urogenital Hiatus (cm)						
Rest	5.7 ± 1.2	5.8 ± 1.0	0.87	4.4 ± 1.3	*0.02*	*0.05*
Kegel	5.5 ± 1.2	4.7 ± 0.8	0.15	3.6 ± 1.0	*0.02*	*0.004*
Valsalva	6.1 ± 1.3	6.0 ± 1.2	0.82	5.0 ±1.3	0.11	*0.002*
Levator Plate Angle (degrees)						
Rest	10.9 ± 12.2	11.0 ± 9.2	1.00	-3.2 ± 20.2	0.10	0.12
Kegel	3.4 ± 16.4	-6.1 ± 6.6	0.16	-16.1 ±10.6	*0.04*	*0.02*
Valsalva	17.1 ± 14.6	18.5 ± 14.5	0.85	12.1 ± 22.2	0.50	*0.02*
Levator Ani Force						
Rest (F_{LAR})	4.2 ± 1.0	4.1 ± 0.6	0.86	4.7 ± 0.9	0.17	0.38
Maximum Contraction (F_{LAC})	5.8 ± 2.4	8.0 ± 3.2	0.13	8.3 ± 1.8	0.83	*0.04*
MRI Perineal Body Displacement Kegel (cm)	0.6 ± 0.3	1.5 ± 0.8	*0.01*	1.0 ± 0.9	0.29	0.20
MRI External Anal Sphincter Displacement Kegel (cm)	0.8 ± 0.6	1.6 ± 0.8	*0.03*	1.2 ± 0.8	0.33	0.20

Racial differences in bother for women with urinary incontinence in the Establishing Prevalence of Incontinence (EPI) Study

Christina Lewicky-Gaupp, MD, Cynthia Brincat, MD, PhD, Elisa Trowbridge, MD, John OL DeLancey, MD, Kenneth Guire, PhD, Divya A. Patel, MD, MPH, Dee E Fenner, MD

The purpose of this study was to compare differences in degree of bother in women with urinary incontinence (UI) in a population-based sample of black and white women. Specifically, we were interested in how frequency of UI episodes, quantity of urine loss and type of UI would affect bother among black and white women.

A population-based, epidemiologic research study was conducted investigating the prevalence, impact, and structural mechanisms of UI in women of southeastern Michigan. Women aged 35-64, who self-identified as black or white race, completed a telephone interview to assess their UI, as well as the Incontinence Impact Questionnaire short form (IIQ-7) to assess their bother. Women were queried about how often they lost urine and how much urine was lost during their UI episodes. Type of incontinence (mixed, stress, urge, below threshold) was determined based on a factor analysis of a 10-item questionnaire. Incontinence “below threshold” denoted women who did not reach a threshold of “often” on any of the 10 questions. Statistical analysis included 2-

way analysis of variance (ANOVA) for post-hoc comparisons of IIQ-7 scores between the two races at different levels of frequency, amount and type of UI.

Black women tended to have higher IIQ-7 scores at each level of incontinence frequency, with the exception of women leaking <1 time in the last 12 months. This trend was statistically significant at frequencies ranging from 1-24 times in the last 12 months (Table). Black women had higher IIQ-7 scores than white women at various quantities of urine loss as well, however, most of these differences were not statistically significant (Table). Black women with mixed and urge incontinence were significantly more bothered than white women with mixed and urge incontinence. Conversely, black and white women with below threshold and stress incontinence reported equal bother. Women with mixed incontinence had the highest bother scores regardless of race (Figure).

When controlling for frequency of incontinence and quantity of urine loss, black women with mixed and urge incontinence are significantly more bothered than white women. Overall, increases in frequency and amount of urine leakage bother black women more than white women.

Table. Comparison of bother scores (IIQ-7) between black and white women based on urinary incontinence frequency and amount of urine loss in the last 12 months

	IIQ-7 score		P value
	Black Women	White Women	
Incontinence Frequency Level[1]			
<1	1.47 ± 0.34 (n=9)	1.87 ± 0.26 (n=5)	0.36
1-4	1.70 ± 0.11 (n=93)	1.42 ± 0.55 (n=96)	*0.01*
5-24	1.95 ± 0.11 (n=91)	1.71 ± 0.54 (n=99)	*0.05*
25-90	2.15 ± 0.13 (n=73)	1.96 ± 0.60 (n=81)	0.18
Amount of incontinence [2]			
Few drops	1.67 ± 0.10 (n=104)	1.50 ± 0.04 (n=149)	0.12
Wet underwear/pad	1.97 ± 0.09 (n=140)	1.76 ± 0.05 (n=111)	*0.04*
Soak outer clothes	2.48 ± 0.21 (n=27)	2.30 ± 0.10 (n=25)	0.43
Drip onto floor	3.00 ± 0.33 (n=9)	1.81 ± 0.20 (n=9)	0.46

Mean and standard deviations reported
[1]Information on frequency was provided by 547 women
[2]Information on quantity was provided by 574 total women

Structural position of the posterior vagina and pelvic floor in women with and without posterior vaginal prolapse

Christina Lewicky-Gaupp, MD, Aisha Yousuf, MD, Kindra Larson, MD, Dee Fenner, MD, John DeLancey, MD

We sought to compare pelvic floor structural location on dynamic MRI during maximal Valsalva in women with normal support with those with posterior prolapse in order to quantify perineal descent, posterior vaginal wall contour length, and apical descent, as these factors may not be adequately captured on physical exam and may contribute to prolapse.
All cases (n=37) had POP-Q point Bp $\geq$ +1cm; of these, 9 had predominant enteroceles on MRI. The mean point Bp in cases was +1.8 ± 0.3cm vs. -1.8 ± 0.1cm in controls (n=35). All had mid-

sagittal, supine, dynamic MRI at maximal Valsalva. A sacrococcygeal-inferior pubic point (SCIPP) line (x-axis) and perpendicular y-axis were drawn on the image. Structure locations (distal vagina, apex, perineal body, external anal sphincter) were determined relative to these axes; posterior vaginal wall length and levator and urogenital hiatus diameters were measured (Figure 1). MRI 'prolapse' diameter was estimated as the distance between the anterior puborectalis and most ventral point of the posterior wall. Apical descent and 'prolapse' diameter were compared using Student's t-tests and effect sizes (Cohen's d) calculated.
In cases, all structures had more caudal locations than controls ($p<0.001$, Figure 2A); the largest differences were in the distal vagina (2.3 cm, Cohen's d: -1.5) and perineal body (2.0 cm, Cohen's d: -1.4). The vaginal apex was also more ventrally displaced ($p=0.001$, Cohen's d: 0.8). Cases had larger levator and urogenital hiatuses and 'prolapse' diameters, with enteroceles being the largest (Table). The posterior wall was longer in cases (2.1cm, Cohen's d: -0.8). The straight-line distance between the apex and distal vagina was shorter in cases. In women with predominant enteroceles, the apex was more ventrally displaced ($p=0.003$, Cohen's d: 1.0) compared rectocele-predominant prolapses (Figure 2B). Unlike apical descent ($r=-0.3$, $p=0.1$), the length of the posterior wall was highly correlated with MRI prolapse size ($r=0.5$, $p=0.002$). Point Bp was also correlated with MR prolapse size ($r=0.7$, $p=<0.001$).
At maximal Valsalva on MRI, apical and perineal structures are more caudal in women with posterior prolapse. The posterior vaginal wall is 22% longer. Posterior vaginal wall length correlates with prolapse size but apical descent does not. Differences between rectocele and enterocele were seen at the apex only.

Table 1. Mean MRI measurement of anatomic differences among groups (SD)

	Controls (n=35)	**All Cases (n=37)**	**Rectocele Predominant (n=28)**	**Enterocele Predominant (n=9)**	**P-Value Controls v. All Cases**	**P-Value Rectoceles v. Enteroceles**
Posterior Wall Length (cm)	9.3 (1.8)	11.4 (3.0)	11.2 (2.6)	12.1 (4.8)	*<0.001*	0.6
Levator Hiatus (cm)	6.5 (1.2)	7.4 (1.2)	7.2 (1.6)	7.9 (1.2)	*0.003*	0.2
Urogenital Hiatus (cm)	4.9 (1.2)	7.2 (1.2)	7.0 (1.6)	8.0 (1.2)	*<0.001*	*0.05*
Prolapse A-P Diameter (cm)	3.3 (1.2)	5.4 (1.8)	4.9 (1.1)	6.9 (2.1)	*<0.001*	*0.001*
Apex to Distal Vagina (cm)	8.0 (0.6)	7.2 (2.4)	7.4 (2.1)	6.6 (2.1)	*0.04*	0.3

Figure 1. Maximum Valsalva mid-sagittal MRI. SCIPP line and pubic symphysis (PS) shown. Vaginal apex (diamond) and distal vagina (square) with intervening posterior vaginal wall (PW), perineal body (circle) and external anal sphincter (triangle) seen. The levator plate (LP) and hiatus (LH), as well as the urogenital hiatus (UH) are visible.

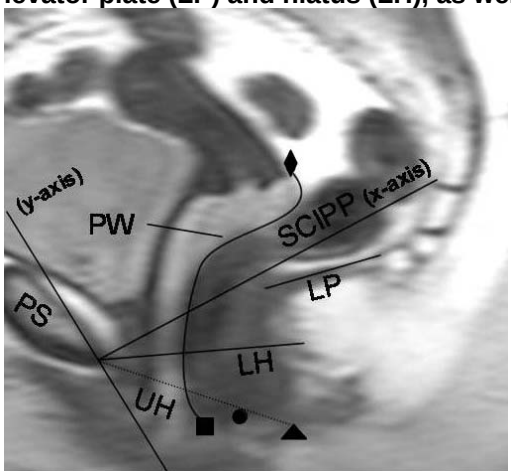
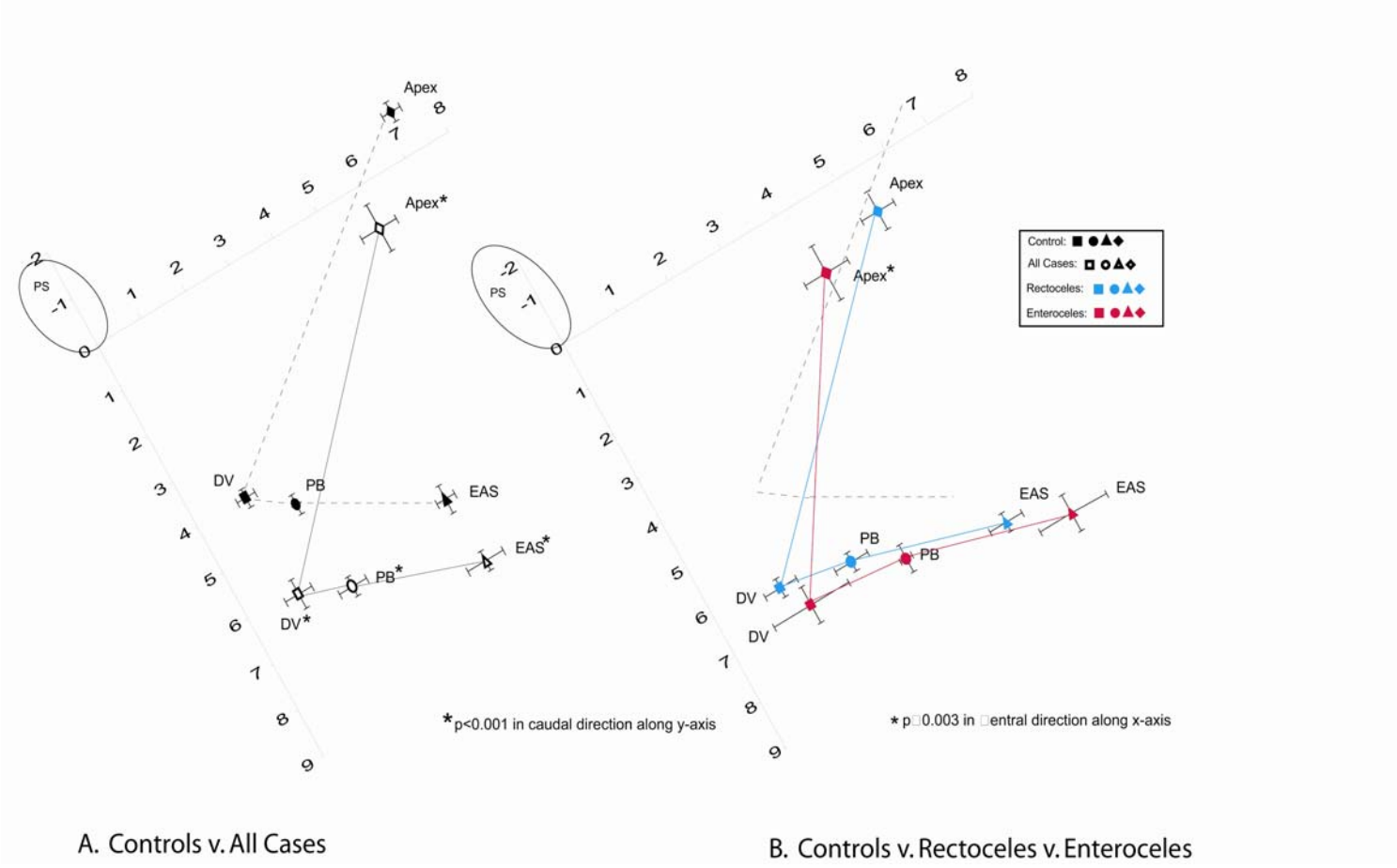


Figure 2. Perineal structure locations at maximum Valsalva in controls and (A) all cases including rectoceles and enteroceles and (B) in rectoceles compared to enteroceles. Coordinates marking the vaginal apex (apex), distal vagina (DV), perineal body (PB) and external anal sphincter (EAS) are marked. The pubic symphysis (PS) is also demarcated. The dashed line represents controls.



In Vitro Material Properties of Apical Supports

Jiajia Luo, MS, Luyun Chen, PhD, Jinyong Kim, MS, Rajeev Ramanah, MD, Vikky Morris, MD, James A. Ashton-Miller, PhD, John O.L. DeLancey, MD

Abstract: A pelvic organ prolapse (POP) can develop as a result of impairment of the muscular and apical supports of the anterior vaginal wall. Impairment of the apical supports, including Cardinal Ligament and Uterosacral Ligament, are believed to underlie anterior vaginal wall prolapse although the underlying pathomechanics is poorly understood. Finite element models provide a powerful tool to investigate the pathomechanics of POP. However, such finite element models require constitutive equations for each type of soft tissue. We could find no data published on those two ligaments that can be used to derive the parameters of the constitutive equations. The purpose of this study was to measure the material properties of the apical supports using a tensile test and then derive the constitutive equations. We then will validate the results using in situ testing in cadavers and later in vivo.

Apical support: a preliminary anatomical, histological and MR study

Rajeev Ramanah, MD, Jiajia Luo, MS, Luyun Chen, PhD, Jinyong Kim, MS, James Ashton-Miller, PhD, John DeLancey, MD

Aim: To identify characteristic anatomical and histological features of the Cardinal Ligaments(CL) and UteroSacral Ligaments(USL) and define their appearances, relationships and geometry with the pelvic organs and muscles using MRI cross-sectional anatomy and 3D modeling.
Methods: This study consisted of 3 phases. In phase I, anatomical dissections of unembalmed female adult pelves were carried out. Biopsy specimens of the CL and USL were analyzed histologically using H & E stains and PS100 specific nerve-cell antibody.
Phase II was a Magnetic Resonance (MR) study of 20 3T proton-density scans of living women to identify the ligaments and their relationships with other pelvic structures. Detailed slice-by-slice examinations of axial, sagittal, and coronal images were conducted using the original source DICOM (Digital Imaging and Communications in Medicine) through the Image J software interface. USL were measured on the axial plane on the slice where the proximal and distal insertion points were most visible. CL were measured from the insertion point on the cervix to the origin of the internal iliac artery. In phase III, Slicer 3.4 ® software was used to trace and make 3-D models of the CL, USL and the Levator Ani in the plane in which each structure was best visualized so as to have a visual 3D appreciation of the orientation and relationships of the apical support elements.
Results: Anatomical dissections identified the CL and USL. Biopsy specimens revealed that the ligaments contained connective tissue, nervous fibers, sympathetic nodes, vessels and adipose tissue, with no structured ligamentous organization.
The study of the MR axial scans found the origins of the USL to be respectively 2 (10.5%) from the cervix only, 8 (42%) from the upper part of the vagina only, and 9 (47%) from the cervix and vagina. The endpoints of the USL were 14 (73%) at the coccygeus muscle/sacrospinous ligament, 4(21%) at the sacrum, and 1(5%) at the ischial spine. From the coronal MR scans, the CL had its proximal origin in 80% (16/20) from the cervix and 20% (4/20) from the vagina. The distal endpoint was at the origin of the internal iliac artery. The lengths of the right and left CL and USL measured on the 20 MR scans in different directions were different.
Conclusion: The CL(made up of a vascular and neural part) and the USL(made up of a superficial and deep part) are mesenteries for the pelvic viscera. They have different shapes and ran in distinctly different directions. They are asymmetric in length between their left end right counterparts.

Pelvic Floor Recovery in Primiparous Women at 1 Month Compared to 7 Months After Vaginal Delivery

Aisha Yousuf, MD, John DeLancey, MD, Catherine Brandon, PhD, Janis Miller, PhD, ANP-BC

Objectives : It is known that certain factors related to vaginal delivery (e.g. prolonged second stage, external anal sphincter tears, forceps) are associated with damage to the levator ani muscles. This injury can affect both 1) the location of pelvic structures ("sagging") and 2) pelvic floor movement during Kegel or Valsalva. We do not know whether healing after delivery affects one or both of these parameters.

We tested the null hypothesis that there were no changes in location or movement of pelvic floor structures at early (1 month) compared to late (7 months) postpartum as observed on dynamic MRI activities at rest, Kegel, and Valsalva.

Materials and Methods: We studied 17 primiparous women who had birth events associated with levator muscle damage. Women were studied by mid-sagittal MRI in the supine position with scans obtained at the early and late postpartum time-points. We made measures at rest, at maximum Kegel and at maximum Valsalva. The locations of the perineal body, external anal sphincter, bladder neck and cervix were determined as x and y coordinates with the origin set at the inferior pubic point and the x-axis aligned with the sacro-coccygeal inferior pubic point line (SCIPP) using ImageJ 1.4l (NIH) software (Fig.1). We calculated displacements from rest to maximal Kegel and Valsalva, and urogenital and levator hiatus diameters and levator plate angles relative to the SCIPP line.

Results: At rest, the perineal body and external anal sphincter were higher on late scans by a mean (SD) of 0.8±0.9 cm and 0.9±0.9 cm respectively ($p<0.001$ for both) (Fig.2). During Kegel, the bladder neck moved 0.3±0.5 cm more on the later scans ($p=0.004$). There were no differences in displacement during Kegel and Valsalva at either time-point for other structures. At rest, Kegel and Valsalva, the urogenital and the levator hiatus diameters were shorter on the late scans compared with the early scans (see table). The levator plate angle did not differ from early to late time-points.

Conclusion: The perineal body and the external anal sphincter are higher at rest at 7 months compared to 1 month after vaginal delivery in women with known risk factors for levator ani injury. Overall, the amount of pelvic visceral movement with Kegel and Valsalva is similar over time, suggesting that factors other than muscle activation must be at play in the recovery of resting position.

Urogenital and levator hiatus diameters at 1 month and 7 months postpartum (mean±SD)

Urogenital Hiatus (cm)	1 month n=17	7 months n=17	p (Wilcoxon)
Rest	7.4±1.3	6.4±1.2	<0.001
Maximum Kegel	6.8±1.2	5.9±1.0	0.001
Maximum Valsalva	7.9±1.5	7.0±1.4	0.005
Levator Hiatus (cm)	1 month n=17	7 months n=17	p (Wilcoxon)
Rest	6.1±0.8	5.6±0.8	<0.001
Maximum Kegel	5.7±0.9	5.0±0.7	0.003
Maximum Valsalva	6.6±1.2	6.1±1.3	0.015

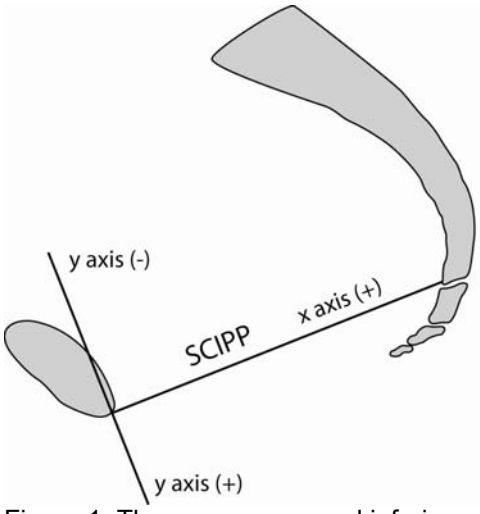


Figure 1. The sacro-coccygeal inferior pubic point line (SCIPP) and the axes

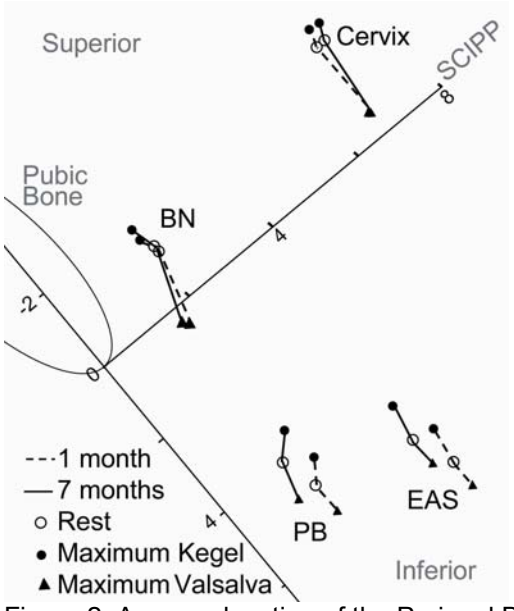


Figure 2. Average location of the Perineal Body (PB), External Anal Sphincter (EAS), Bladder Neck (BN), and Cervix at rest, maximum Kegel and maximum Valsalva at 1 month and 7 months postpartum shown in the upright posture

The Correlation Between Unsupported Anterior Vaginal Wall Length And The Most Dependent Bladder Point at Maximal Valsalva in MRI

Aisha Yousuf, MD, Patricia Pacheco, BA, Kindra Larson, MD, James Ashton-Miller, PhD, John DeLancey, MD

In cystoceles, the distal anterior vaginal wall (AVW) is not in contact with the perineal body, leaving it unsupported. The principles of physics suggest that the larger the unsupported area subjected to abdominal pressure (force/area), the greater the resulting forces on AVW and its supports. This would suggest a higher likelihood of structural failure. This study is a first step in testing this hypothesis by quantifying the relationship between the status of AVW support and the length of unsupported AVW at maximum Valsalva.

Subjects were selected from an on-going case-control study evaluating anterior vaginal wall prolapse. Fifty women were selected to represent a full spectrum of AVW support including women with normal support (all vaginal points above the hymen, n=26) and AVW prolapse with anterior points below hymen (n=24). The image at maximal Valsalva from a supine dynamic sagittal MR series was selected. Measurements were taken using a Cartesian coordinate system based on the sacro-coccygeal inferior pubic point line (SCIPP) and ImageJ software v1.4l (Fig 1). The curving length of the unsupported AVW from the distal urethra to the point of perineal body contact was measured. The status of AVW support was quantified as position of the most dependent bladder point relative to normal rest location previously established in 20 nulliparas. Similarly, the apex position relative to its normal nulliparous location was measured. Because the locations of the distal vaginal points form an arc centered on the inferior pubis, it was quantified as an angle (α) relative to the SCIPP line. Exponential and polynomial regression analyses were used to examine relationships between variables.

Unsupported vaginal length shows an exponential relationship with bladder position (R2=0.74, p<0.001, Fig 2). Bladder positions less than 3 to 4 cm below normal were not as associated with different lengths of unsupported vagina. However, with bladder positions greater than 4 cm, there were increasing lengths of unsupported vagina. In the distal vagina, the angle α ranged from 50 to 150 degrees and also increased exponentially with unsupported vaginal length (R2=0.50, p<0.001, Fig 3). A weaker association between apical position and unsupported vaginal length was present using a second-order polynomial curve (R2=0.30, p<0.001).

At maximum Valsalva, unsupported AVW length increases exponentially when the position of the most dependent bladder point is more than 3 to 4 cm below normal. *Comment:* This suggests that a threshold for AVW descent may exist which when exceeded exposes progressively larger areas of the unsupported AVW to abdominal pressure, thereby increasing the load structural supports must sustain.

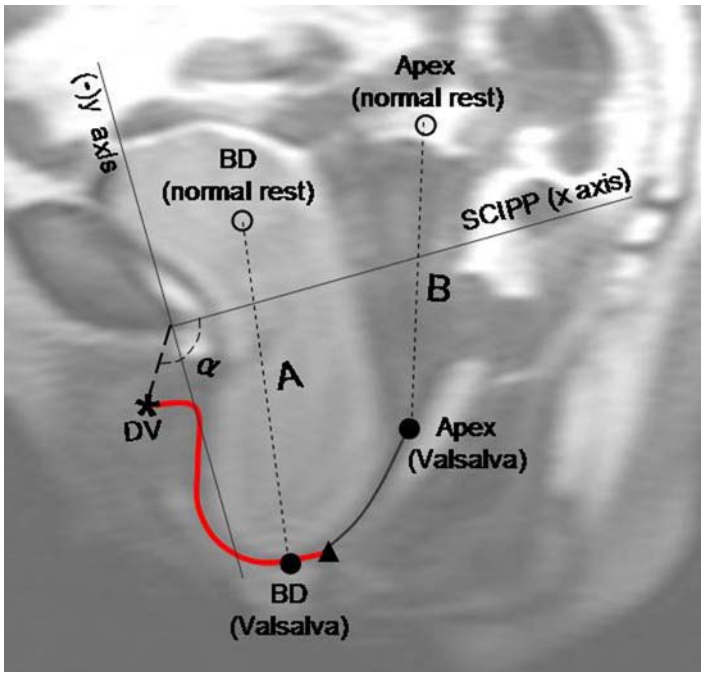


Fig 1. **Sagittal MRI at maximum Valsalva:** Red-bolded line: length of unsupported AVW, ▲: point of AVW contact with the perineal body, Dashed line A: position of the most dependent bladder point (BD) relative to normal, Dashed line B: Apex position relative to normal, ***** DV: the location of the distal vagina point, α: angle of distal vaginal point relative to SCIPP line.

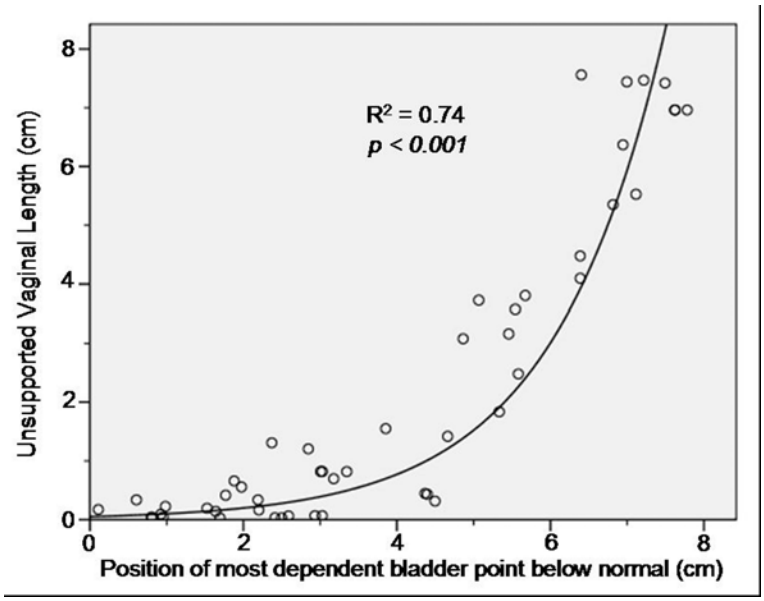


Fig 2. An exponential relationship was found between the position of the most dependent bladder point below normal and the length of unsupported vagina**.**

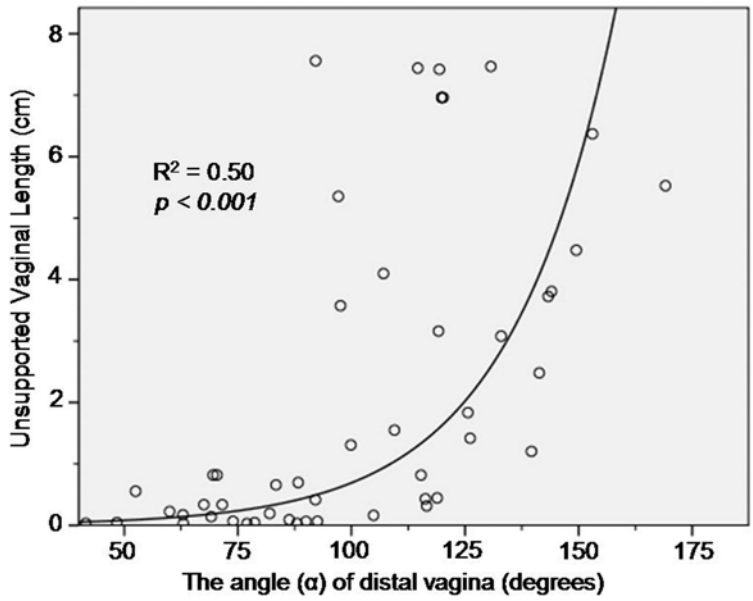


Fig 3. An exponential relationship was also found between angle α and the length of unsupported vagina.

Measurement of Female Maximum Isometric Levator Ani Muscle Strength Unconfounded by Intraabdominal Pressure

Ruth Zielinski, MS, CNM, James Ashton-Miller, PhD, John DeLancey, MD, Janis Miller, PhD, ANP-BC

Accurate measurements of maximum voluntary isometric contraction strength (MVC) of the levator ani have been a longstanding challenge. This is partly due to the rise in intra-abdominal pressure (IAP) that often accompanies a pelvic floor muscle contraction. This study tested the validity and reliability of a newly modified instrumented speculum ('Levator Ani Strength Sensor; LASS) with the following hypotheses:
H1 - Levator MVC measured with LASS will not positively correlate with the simultaneous increase in IAP. (Discriminant validity)
H2 - Women with more levator strength on palpation will have higher MVC measurements compared to those with poor strength. (Contrasting groups validity)
H3 - MVC measurements taken with the LASS at baseline and at one month will demonstrate acceptable test-retest repeatability. (Reliability)

The LASS was designed with a shortened upper bill so that upon vaginal insertion, its tip does not protrude dorsal to the pubic symphysis thus limiting exposure to IAP (Fig. 1). The LASS was instrumented with strain gages near the root of each bill to measure levator force and symphyseal reaction force. We tested the LASS in a group of 49 study participants who had incontinence and completed a clinical exam at baseline and again at 1-month. A catheter was placed in the bladder (at the baseline visit only) to simultaneously measure IAP. Participant coaching on pelvic floor contraction was limited to a verbal request to "contract your pelvic muscles". Prior to LASS testing an experienced research nurse palpated the levator contraction to categorize muscle function by the Oxford grading scale. Palpation measurements were then dichotomized as: poor/fair or good/excellent to create extreme groups for the contrasting groups analysis. Data analyses for discriminant and contrasting groups validity relied on graphical portrayal of data, correlation and t-tests.
Forty-seven women completed both visits. Mean age was 54.3 (range 20-83) years; the majority were Caucasian. H1 was supported; MVC and IAP readings were negatively correlated ($r = -.31$, $p = .043$). A sample reading with exceptionally high IAP is shown in Figure 2. H2 was supported; the mean (SD) force developed by women with good/excellent muscle strength ($n = 38$) was significantly greater at 3.8 (1.7) N compared to 1.9 (0.8) N in the group with poor/fair muscle strength ($n = 11$) ($p = .001$). H3 was supported; the between-visit coefficient of repeatability (± 2 X the SD_{diff}) was ± 3.1 N; $r = .58$ ($p = .000$).

The LASS demonstrated discriminant and contrasting groups validity. Test-retest repeatability was similar to previously reported instruments [2, 3]. To our knowledge this is the first device that minimizes the confounding affects of IAP on the accurate assessment of isometric levator MVC.
Comment: The results suggest that the LASS is a valid and reliable instrument for estimating levator ani muscle strength with minimal artifact from IAP in women with incontinence.

Figure 1. Lateral view of the Levator Ani Strength Sensor (LASS). The upward broad white arrow ("LA") shows the force developed by the levator ani, the downward broad white arrow ("SP") shows the equal and opposite reaction force developed by the symphysis pubis. The black arrows show how IAP acts on the upper and lower surfaces of the lower blade, cancelling the effect of one another so as to cause no net force on the device.

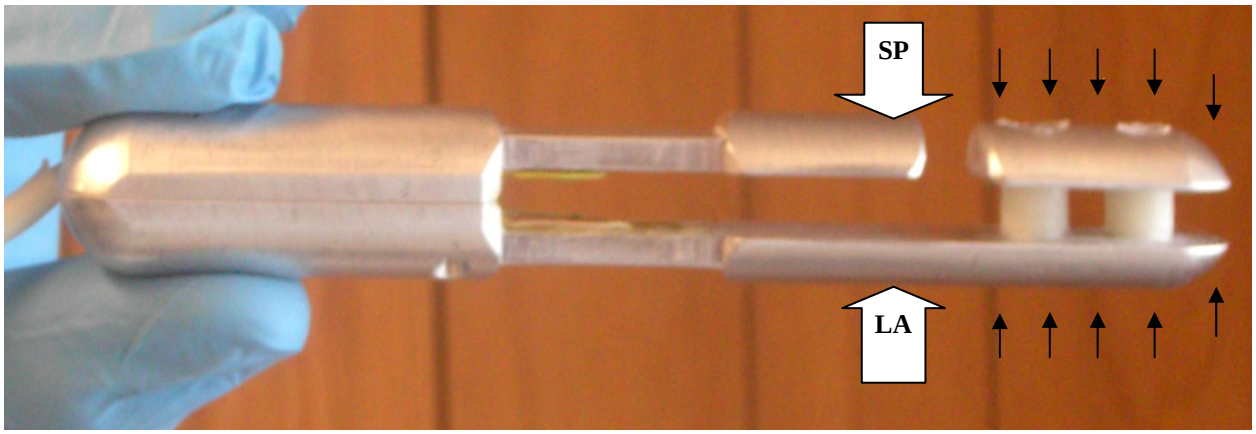
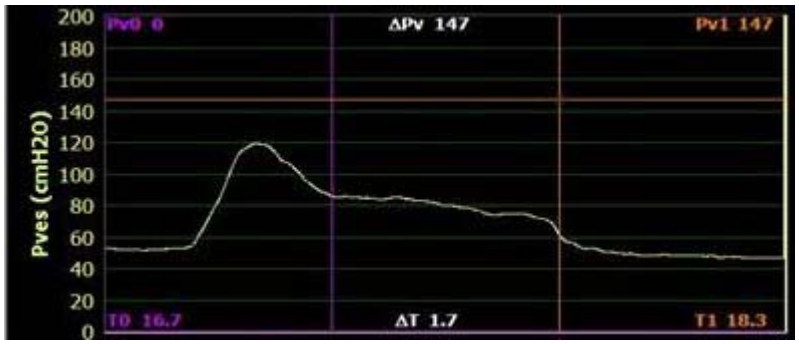
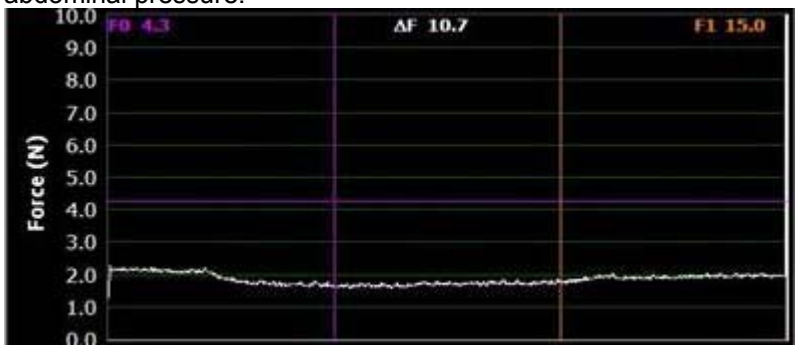


Figure 2



Panel A – A rise in intra-vesical pressure (Pves cmH_2O) is seen during this woman's attempt at pelvic floor contraction. The participant strained when asked to contract, thereby increasing intra-abdominal pressure.



Panel B – Shows force (in Newtons) measured with the Levator Ani Strength Sensor (LASS) during attempted muscle contraction simultaneous with measurement of intra-vesical pressure shown in Panel A. The levator ani muscles in this subject were not palpable and no contraction could be elicited on exam. Despite the rise in abdominal pressure, LASS correctly records no increase in vaginal closure force.

The Pelvic Floor Research Group 2010 Index

Keynote Speaker

Peggy Norton, MD
Dr. Norton completed her residency in Obstetrics and Gynecology at the University of Oregon on 1986 and went on to complete a fellowship in urogynecology at the University of Long in 1988. She is currently a Professor of Obstetrics and Gynecology at the University of Utah School of Medicine, and Chief of Urogynecology and Reconstructive Pelvic Surgery. Dr. Norton is funded by the NIH researching genetics and the pelvic floor. She has served as president of the American Urogynecologic Society and of the Society of Gynecologic Surgeons and is currently chair of the ACOG committee on urogynecology.

Presenters

James A. Ashton-Miller, PhD
Dr. Ashton-Miller received his Bachelor of Science in Mechanical Engineering in 1972 from the University of Newcastle-Upon-Tyne. He received his Master of Science in Mechanical Engineering from the Massachusetts Institute of Technology in 1974 and his PhD in Biomechanics from the University of Oslo in 1982. Currently, he is the Director of the Biomechanics Research Laboratories in the Department of Mechanical Engineering at the University of Michigan. He is also a Senior Research Scientist at the Institute of Gerontology at the University of Michigan. His research interests include: the biomechanics, functional anatomy and aging of the female pelvic floor structures including muscle, fascia, tendons, nerves, urethra, vagina, and rectum; experimental and computer simulation approaches; instrumentation design & development, and measurement systems. Dr. Ashton-Miller functions in the PFRG as a Co-Investigator on the OPALII and SCOR2 projects. He is the Project Leader of Project 1 and Core B (Imaging) of the SCOR2. jaam@umich.edu

Catherine Brandon, MD
Dr. Brandon received her Bachelor of Arts in Anthropology from University of Arizona in 1976 and a Masters in Arts in Anthropology from University of California, Berkeley in 1977. She went on to receive her Medical Degree from the University of California, Irvine in 1985. She completed her residency in Diagnostic Radiology from University of Michigan in1989 with Fellowships in Mammography and Ultrasound from Henry Ford Hospital, Detroit, MI in 1990. She then received a Masters in Science in Medical Management from the joint program at University of Texas School of Management and University of Texas Southwest Medical Center, Dallas, TX in 2000. She completed a fellowship in Musculoskeletal Imaging at Henry Ford Hospital, Detroit, MI in 2005. Currently she is an Assistant Professor in Radiology, Musculoskeletal Division with research interests in muscle imaging, musculoskeletal ultrasound and 3T MRI musculoskeletal imaging. Her role in the PFRG is Co-Investigator for the SCOR 2 project in CORE B to study 3T MRI of pelvic floor muscles to determine patterns of injury and to distinguish between muscle injuries secondary to structural disruption verse neuropathy changes. catbrand@med.umich.edu

John O.L. DeLancey, MD
Dr. DeLancey received his Bachelor of Science in Biology from Oberlin College in 1973 and received his Medical Degree from the University of Michigan in 1977. He completed his residency in 1981 at the University of Michigan in Obstetrics and Gynecology. Currently, he is a Norman F. Miller Professor for the Department of Obstetrics and Gynecology at the University of Michigan Medical Center. His research interests include: the anatomy of the pelvic floor, pelvic floor biomechanics, vaginal birth and pelvic floor injury. Dr. DeLancey functions in the PFRG as the Principal Investigator of the OPALII and SCOR2 projects. delancey@umich.edu

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Dr. Fenner received a Medical Degree from the University of Missouri-Columbia in 1985 and

completed residency in Obstetrics and Gynecology at the University of Michigan in 1989. Currently, she is an Associate Professor and Director of the Division of Gynecology in the Department of Obstetrics and Gynecology at the University of Michigan. Her research interests include: anal incontinence and defecation disorders; depression and its impact on urge incontinence. Dr. Fenner functions in the PFRG as a Co-Investigator on the SCOR2 projects. deef@med.umich.edu

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Dr. Low received a Bachelor of Science in Nursing from the University of Michigan, a Master of Science in Nurse Midwifery from the University of Illinois at Chicago and PhD in Nursing and Graduate Certificate in Women's Studies from University of Michigan in 2001. Dr. Low was a BIRCWH Scholar from 2001-2003. Currently, Dr. Low is an Assistant Professor in the School of Nursing and Women's Studies Department in the College of LS&A at University of Michigan and is a member of the midwifery service and lecturer in the Department of Obstetrics and Gynecology. Her research interests include care practices during childbirth with an emphasis on the association of processes of care and social support on health outcomes postpartum. Within the PFRG she focuses on the management of second stage and associated risks for pelvic floor damage. She has other grants focusing on the role of stress and trauma on childbearing outcomes and the role of social support in reducing risks for post partum depression. She has an ongoing project in Honduras focused on care practices during labor in low resources settings. Dr. Low functions in the PFRG as a Co-Investigator on SCOR2. kanelow@med.umich.edu

Janis M. Miller, PhD, ANP-BC
Dr. Miller received a Bachelor of Science in Nursing from Goshen College in 1981 and her Master of Science in Nursing from Loyola University of Chicago in 1987. She went on to receive Certification in Gerontology in 1999, a PhD in Nursing in 1996, and Adult Nurse Practitioner Certification in 2000. Currently, Dr. Miller serves as a faculty member in the Department of Obstetrics and Gynecology and in the School of Nursing at the University of Michigan. Her research interests focus on understanding the etiology of urinary incontinence and other pelvic floor disorders in order to provide the most effective prevention strategies and conservative treatment interventions. Dr. Miller functions in the PFRG as a Principal Investigator for Project 2 of SCOR2 and the University of Michigan branch of BRIDGES. She is also a Co-Investigator on OPAL II. janismm@umich.edu

Vikky Morris, BSc. MBBS MRCP
Dr. Morris received a British medical Degree (MBBS) from the University College London (UCL) in 1999. She has an intercalated Bachelor of Science degree in Anatomy. Dr. Morris will finish her registrar post specializing in General Medicine and Geriatrics in 2011. She has research interests in urinary incontinence in the elderly and is currently spending a year working with the PFRG project on ageing and the pelvic floor. vikkymorris@doctors.org.uk

Carolyn M. Sampselle, PhD, RNC
Dr. Sampselle received a Bachelor of Science in Nursing with honors from Ohio State University in 1965. She went on to receive a Master of Science in Nursing from Ohio State University in 1968. In 1985, she received her PhD in Clinical Nursing Research from the University of Michigan. Currently, she is the Carolyne K. Davis Collegiate Chair, Professor of Nursing at the University of Michigan. She has joint appointments in the Department of Obstetrics and Gynecology and Women's Studies. Her research interests focus on self-care strategies to treat and prevent urinary incontinence. She recently received the Pathfinder Award for distinguished service from the Friends of the National Institute for Nursing Research. Dr. Sampselle functions in the PFRG as a consultant on the SCOR2 Project. csampsll@umich.edu

Cathie Spino, DSc
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