THE 2015 SUMMER MEETING
of
THE HIP SOCIETY

October 15-17, 2015
The Fairmont Sonoma Mission Inn and Spa
Sonoma, California
Welcome to the 2015 Summer Meeting of The Hip Society

MISSION

The Mission of The Hip Society is to advance knowledge of hip disorders, promote evidence-based treatment, and refine surgery of the hip in order to improve the lives of patients.

VISION

The Vision of The Hip Society is to be the premier independent professional association dedicated to the pursuit of new knowledge, and dissemination of advancements in clinical practice related to disorders of the hip.

VALUES

- **Knowledge** – The Hip Society’s principal function is the pursuit of knowledge about disorders of the hip and promoting its dissemination in an unbiased and transparent manner.
- **Research** – The Hip Society promotes discovery and innovation through support of research that seeks to further our understanding and treatment of disorders of the hip.
- **Integrity** – The integrity of The Hip Society is based on candid and honest discourse in an environment predicated on mutual respect and full disclosure of conflicts of interest.
- **Collaboration** – Through active collaboration with other organizations that embrace its mission, The Hip Society will expand its sphere of influence while preserving its strategic focus.
- **Membership** – The Hip Society supports its members as thought leaders in the field of hip disorders who have demonstrated excellence in the domains of diagnosis, treatment, and research.
- **Patient Care** – The Hip Society will pursue advances in the field that improve the quality of life for patients with disorders of the hip.
THE 2015-2016 BOARD OF DIRECTORS

- President: Daniel J. Berry, MD
- 1st Vice President: Harry E. Rubash, MD
- 2nd Vice President: Kevin L. Garvin, MD
- Secretary: Craig J. Della Valle, MD
- Treasurer: Joshua J. Jacobs, MD
- Immediate Past President: Paul F. Lachiewicz, MD
- Chair, Education Committee: Mark W. Pagnano, MD
- Chair, Membership Committee: Michael D. Ries, MD
- Chair, Research Committee: Richard D. Iorio, MD
- Member-at-Large: Christopher L. Peters, MD
- Chair, Fellowship & Mentorship Committee (Ex-Officio): Adolph V. Lombardi, Jr., MD

PAST PRESIDENTS

<table>
<thead>
<tr>
<th>Years</th>
<th>President</th>
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<tbody>
<tr>
<td>1968-1969</td>
<td>William H. Harris, MD, DSc</td>
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<tr>
<td>1969-1970</td>
<td>Frank E. Stinchfield, MD †</td>
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<td>1970-1971</td>
<td>Walter P. Blount, MD †</td>
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<td>1971-1972</td>
<td>Albert B. Ferguson, Jr., MD †</td>
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<td>1972-1973</td>
<td>J. Vernon Luck, Sr., MD †</td>
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<td>1973-1974</td>
<td>Mark B. Coventry, MD †</td>
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<tr>
<td>1974-1975</td>
<td>Emmett M. Lunceford, Jr., MD †</td>
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<td>1976-1978</td>
<td>Augusto Sarmiento, MD</td>
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<tr>
<td>1978-1979</td>
<td>Marshall R. Urist, MD †</td>
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<td>1979-1980</td>
<td>Harlan C. Amstutz, MD</td>
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<tr>
<td>1980-1981</td>
<td>Philip D. Wilson, Jr., MD</td>
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<td>1981-1982</td>
<td>Richard C. Johnston, MD, MS</td>
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<td>1982-1983</td>
<td>Clement B. Sledge, MD</td>
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<td>1983-1984</td>
<td>Floyd H. Jergesen, MD †</td>
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<td>1984-1985</td>
<td>C. McCollister Evarts, MD</td>
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<td>1985-1986</td>
<td>Jorge O. Galante, MD, DMSc</td>
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<tr>
<td>1986-1987</td>
<td>Lee H. Riley, Jr., MD †</td>
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<td>1987-1988</td>
<td>William R. Murray, MD †</td>
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<td>1988-1989</td>
<td>Joseph E. Miller, MD †</td>
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<td>1989-1990</td>
<td>Donald E. McCollum, MD †</td>
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<td>1990-1991</td>
<td>J. Phillip Nelson, MD</td>
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<td>1991-1992</td>
<td>Nas S. Eftekhar, MD</td>
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<td>1992-1993</td>
<td>William N. Capello, MD</td>
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<td>1993-1994</td>
<td>Robert H. Fitzgerald, Jr., MD</td>
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<td>1994-1995</td>
<td>Mark G. Lazansky, MD</td>
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<td>1996-1997</td>
<td>Dennis K. Collis, MD</td>
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<td>Eduardo A. Salvati, MD</td>
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<td>1998-1999</td>
<td>Robert B. Bourne, MD, FRCSC</td>
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<td>1999-2000</td>
<td>Richard D. Coutts, MD</td>
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<td>2000-2001</td>
<td>Leo A. Whiteside, MD</td>
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<td>2001-2002</td>
<td>Benjamin E. Bierbaum, MD</td>
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<td>2002-2003</td>
<td>Miguel E. Cabanela, MD</td>
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<td>2003-2004</td>
<td>Charles A. Engh, Sr., MD</td>
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<td>2004-2005</td>
<td>Richard E. White, MD</td>
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<td>James A. D'Anthony, MD</td>
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<td>2006-2007</td>
<td>John J. Callaghan, MD</td>
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<td>2007-2008</td>
<td>Lawrence D. Dorr, MD</td>
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<td>2008-2009</td>
<td>Wayne G. Paprosky, MD</td>
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<td>2009-2010</td>
<td>William J. Maloney, III, MD</td>
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<td>2010-2011</td>
<td>Chitranjan S. Ranawat, MD</td>
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<td>2011-2012</td>
<td>Adolph V. Lombardi, Jr., MD, FACS</td>
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<td>2012-2013</td>
<td>David G. Lewallen, MD</td>
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<td>2013-2014</td>
<td>Vincent D. Pellegrini, Jr, MD</td>
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<tr>
<td>2014-2015</td>
<td>Paul F. Lachiewicz, MD</td>
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Online program evaluation is available at: https://www.surveymonkey.com/r/HSSummerMtg2015

Although The Hip Society’s Summer Meeting is NOT a CME accredited program, your opinion and input is solicited for future planning.

Photography, video, audio recording or reproduction of any kind is not allowed during any portion of the program, unless authorized by The Hip Society.

Consent to Use of Photographic Images
Registration and attendance at, or participation in, The Hip Society's activities constitutes an agreement by the registrant to allow The Hip Society to use and distribute (both now and in the future) the registrant's or attendee's image or voice in photographs, video, electronic reproductions, and audio of such events and activities.

Please silence all your electronic communication devices while inside the session room.

Thank you for your cooperation!
SAVE THE DATE!

The 2016 Summer Meeting
October 27-29
The Liberty Hotel
Boston, MA

Future Summer Meetings of
The Hip Society

- 2017: October 5-7
  Omaha, Nebraska

Future Winter Meetings at the
AAOS Annual Meetings

- 2016: March 5
  Orlando County Convention Center
  Orlando, Florida
- 2017: March 18
  Venue TBD
  San Diego, California

The New Membership Cycle Begins After This Meeting

**JANUARY 15, 2016** – new member nominations are due. Please contact The Hip Society office to receive comprehensive updated membership guidelines ([hip@aaos.org](mailto:hip@aaos.org) or 847-698-1638), or go to the Members Only section of The Hip Society’s website at [www.hipsoc.org](http://www.hipsoc.org). The incoming Membership Committee Chair is Michael Tanzer, MD, FRCSC.
Mark Your Calendars!

DECEMBER 1, 2015 – The deadline to submit papers in consideration for The Hip Society’s Scientific Awards. Papers are to be submitted through Clinical Orthopaedic and Related Research (CORR). More information and specific instructions are posted on www.hipsoc.org, under Awards.

Encourage Your Younger Colleagues to Apply!

DECEMBER 1, 2015 – The deadline to submit abstracts for the 2016 Young Investigator Symposium. Young Investigators have a chance to present a paper at the Hip Society/AAHKS 2016 Open (Winter) Meeting (at the AAOS 2016 Annual Meeting / Specialty Day), March 5, 2016, in Orlando, FL. The three best papers will be selected for podium presentation by The Hip Society’s Education Committee. More information can be found on www.hipsoc.org.

DECEMBER 1, 2015 – The deadline to submit an application for The Hip Society / British Hip Traveling Fellowship. Successful candidates will travel throughout the United Kingdom for a period of three to four weeks and will be hosted by world-renowned experts in adult hip reconstruction. More information and an application can be found on www.hipsoc.org under Education.

FROM OUR PARTNERS

AJRR Hospital Participation, Submission, and Subscription Progress

Our new Annual Report will be Available in early November - Check it Out!
We Have Over 300,000 procedures in our Registry!
Join Today!
Visit www.AJRR.net to Learn More
**SCIENTIFIC PROGRAM**

**Friday | October 16, 2015**

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<tr>
<th>Time</th>
<th>Session I: Cross-Linked Polyethylene</th>
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<tbody>
<tr>
<td>7:05 – 8:00 AM</td>
<td><strong>WELCOME</strong></td>
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<tr>
<td></td>
<td>Daniel J. Berry, MD</td>
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<td></td>
<td>President of The Hip Society</td>
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<tr>
<td>7:05 – 8:00 AM</td>
<td><strong>Session I: Cross-Linked Polyethylene</strong></td>
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<td><strong>Moderator: Mark W. Pagnano, MD</strong></td>
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<th>Time</th>
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<tr>
<td>7:05 – 7:10 AM</td>
<td>Highly Cross-Linked Polyethylene Provides Decreased Osteolysis And Reoperation At Minimum 10 Years Follow-Up</td>
<td>Paul F. Lachiewicz, MD</td>
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<td>7:11 – 7:16 AM</td>
<td>A Multi-Center Long-Term Clinical And Radiographic Evaluation Of THR With Highly Cross-Linked Polyethylene</td>
<td>Charles R. Bragdon, PhD</td>
</tr>
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<td>7:17 – 7:22 AM</td>
<td>Mid-Term Wear Of Larger Diameter XLPE: Does Liner Thickness Or Component Position Matter?</td>
<td>Thomas P. Schmalzried, MD</td>
</tr>
<tr>
<td>7:23 – 7:28 AM</td>
<td>Highly Cross-Linked Polyethylene Decreases The Revision Rate Of Total Hip Arthroplasty Compared To Conventional Polyethylene At 13 Years Follow-Up</td>
<td>Richard W. McCalden, MD</td>
</tr>
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<td>7:29 – 7:34 AM</td>
<td>In Vivo Oxidative Changes In Highly Cross-Linked UHMWPE</td>
<td>Orhun K. Muratoglu, PhD</td>
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<tr>
<td>7:35 – 7:40 AM</td>
<td>Zirconia Vs. Cobalt Chromium Femoral Heads In Total Hip Arthroplasty: Average 10 Year Wear Assessment</td>
<td>Matthew J. Kraay, MS, MD</td>
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<th>Time</th>
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<td>7:40 – 8:00 AM</td>
<td><strong>DISCUSSION</strong></td>
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**Session II: Infection**

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<th>Title</th>
<th>Authors</th>
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<tr>
<td>8:01 – 8:06 AM</td>
<td>Is A Second Two-Stage The Answer? The Results Of Second Two-Stage Reimplantations For Periprosthetic Hip Infection</td>
<td>Arlen D. Hanssen, MD</td>
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<tr>
<td>8:07 – 8:12 AM</td>
<td>The Accuracy Of Joint Aspiration Lavage For The Diagnosis Of Infections In Total Hip Arthroplasty</td>
<td>Steven J. MacDonald, MD, FRCSC</td>
</tr>
<tr>
<td>8:13 – 8:18 AM</td>
<td>Optimizing Operating Room Air Quality: A Prospective Observational And Simulated Study</td>
<td>Javad Parvizi MD, FRCS</td>
</tr>
<tr>
<td>8:19 – 8:24 AM</td>
<td>A Multi-Center Randomized Clinical Trial Of Articulating And Static Spacers For Periprosthetic Hip Infection</td>
<td>Craig J. Della Valle, MD</td>
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<td>Time</td>
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<td>8:25 – 8:30 AM</td>
<td>Paper 11</td>
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<td>8:30 – 8:50 AM</td>
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<td>8:51 – 9:46 AM</td>
<td>Session III: Revision THA</td>
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<td>9:46 – 10:01 AM</td>
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<td>10:02 – 10:57 AM</td>
<td>Session IV: Data from Administrative Sources</td>
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<td>Time</td>
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<td>10:37 – 10:57 AM</td>
<td>DISCUSSION</td>
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<tr>
<td>10:58 – 11:54 AM</td>
<td>Session V: Adjunctive Interventions to Minimize Complications</td>
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<tr>
<td>10:58 – 11:03 AM</td>
<td>Paper 24</td>
<td>What Is The Benefit Of Staphylococcal Screening And Treatment Prior To Elective Hip/Knee Arthroplasty?</td>
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<tr>
<td>11:10 – 11:15 AM</td>
<td>Paper 26</td>
<td>Preoperative Celecoxib And Postoperative Aspirin Reduce The Incidence Of Heterotopic Ossification After Total Hip Arthroplasty</td>
</tr>
<tr>
<td>11:22 – 11:27 AM</td>
<td>Paper 28</td>
<td>Oral And Intravenous Tranexamic Acid Are Equivalent At Reducing Blood Loss Following Total Hip Arthroplasty</td>
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<td>11:27 – 11:54 AM</td>
<td>DISCUSSION</td>
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<td>11:54 – 1:00 PM</td>
<td>LUNCH</td>
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<tr>
<td>1:01 – 1:51 PM</td>
<td>Session VI: Metal-on-Metal I</td>
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<td>1:01 – 1:06 PM</td>
<td>Paper 29</td>
<td>Magnetic Resonance Imaging As Biomarker Of Adverse Local Tissue Reactions In Total Hip Arthroplasty</td>
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<td>1:07 – 1:12 PM</td>
<td>Paper 30</td>
<td>Pseudotumors Associated With Metal-On-Metal And Metal-On-Polyethylene Hip Implants May Not Correspond To Type IV Hypersensitivity Reactions</td>
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<td>1:13 – 1:18 PM</td>
<td>Paper 31</td>
<td>Metal-On-Metal: Making Sense Of Blood Cobalt And Chromium Ion Concentrations</td>
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<td>1:19 – 1:24 PM</td>
<td>Paper 32</td>
<td>Myocardial Cobalt Levels Are Elevated After Joint Arthroplasty And Associated With Cardiac Pathology</td>
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<td>1:25 – 1:30 PM</td>
<td>Paper 33</td>
<td>Incidence And Magnitude Of Metal Ion Levels In Blood With Large Ceramic And Metal Femoral Heads: A Prospective Study With Five-Year Follow-Up</td>
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New Algorithm Precisely Depicts Margin-Of-Safety In Cup Wear Patterns With Respect To CPR Clinical Data
Ian C. Clarke, PhD

1:36 – 1:51 PM

DISCUSSION

1:52 – 2:47 PM

Session VII: Metal-on-Metal II
Moderator: Steven J. MacDonald, MD, FRCSC

The Natural History Of Metal-On-Metal Articulation For Primary Hip Arthroplasty: A Mid- To Long-Term Follow-Up Study
Donald S. Garbuz, MD, MHSc, FRCSC

Simplifying The Current Risk Stratification For Metal-On-Metal Patients
Henrik Malchau, MD, PhD

Revision Of Monoblock MOM Total Hip Arthroplasty: Is There A Place For Dual Mobility Without Cup Extraction?
Thomas K. Fehring, MD

How Do Material, Geometry, And Vertical Load Influence Trunnion Torsional Strength
Michael A. Mont, MD

Soft-Tissue Impingement In Dual Mobility Components: A Proposed Mechanism Of Intraprosthetic Dislocation Using Cadaver Models And Retrievals
Harry E. Rubash, MD

Biomechanical Analysis Of Deformation In Mobile Bearing THA Acetabular Components
John B. Meding, MD

2:27 – 2:47 PM

DISCUSSION

2:47 – 3:02 PM

BREAK

3:03 – 3:30 PM

Session VIII: Patient and Design Factors that Impact THA Results
Moderator: Douglas E. Padgett, MD

Unfulfilled Functional Expectations Following Joint Arthroplasty Procedures
Philip C. Noble, PhD

Prior Lumbar Spinal Arthrodesis Increases Prosthetic-Related Complications And Revision Surgery After Primary Total Hip Arthroplasty
Thomas P. Vail, MD

The Effects Of Elastic Moduli On Primary THA: A Clinical And Radiographic Follow-Up
Carlos J. Lavernia, MD

3:20 – 3:30 PM

DISCUSSION
### Session IX: Primary THA Results
**Moderator: Harry E. Rubash, MD**

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<tr>
<th>Time</th>
<th>Title</th>
<th>Author</th>
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<tbody>
<tr>
<td>3:31 – 3:36 PM</td>
<td>Formal Physical Therapy After Primary Total Hip Arthroplasty May Not Be Necessary</td>
<td>Richard H. Rothman, MD, PhD</td>
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<tr>
<td>3:37 – 3:42 PM</td>
<td>Short Stem Cementless Components In THR: Excellent Fixation, Thigh Pain A Concern!</td>
<td>John J. Callaghan, MD</td>
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<tr>
<td>3:43 – 3:48 PM</td>
<td>Total Hip Arthroplasty For Post-Traumatic Arthritis Following An Acetabular Fracture</td>
<td>Kevin L. Garvin, MD</td>
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<td>3:49 – 3:54 PM</td>
<td>Characterization Of Femoral Component Initial Stability And Cortical Strain In A Reduced Stem Length Design</td>
<td>Michael E. Berend, MD</td>
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</table>

#### DISCUSSION

#### BUSINESS MEETING

*6:00 pm – Buses will leave promptly from the main entrance of the Fairmont to The Hip Society Members’ Dinner at Chateau St. Jean Winery (6:30 pm cocktails, 7:30 pm dinner). Please be on time.*

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### Saturday | October 17, 2015

*No break is scheduled on Saturday. However, coffee and other refreshments will be available throughout the morning.*

**WELCOME BACK**

**Daniel J. Berry, MD**  
President of The Hip Society

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<thead>
<tr>
<th>Time</th>
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<tbody>
<tr>
<td>7:33 – 8:28 AM</td>
<td>The Direct Anterior Approach Is A Risk Factor For Early Failure In Cementless Total Hip Arthroplasty: A Multi-Center Study</td>
<td>R. Michael Meneghini, MD</td>
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<td>7:39 – 7:44 AM</td>
<td>Acetabular Component Positioning With Direct Anterior Versus Direct Lateral Approach In Primary Total Hip Arthroplasty</td>
<td>Adolph V. Lombardi, Jr., MD, FACS</td>
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<td>7:45 – 7:50 AM</td>
<td>Deep Infection Is Less Frequent With The Direct Anterior Than The Direct Lateral Approach In Primary Total Hip Arthroplasty</td>
<td>Keith R. Berend, MD</td>
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<tr>
<td>7:51 – 7:56 AM</td>
<td>Muscle Biomarkers Are Not An Objective Surrogate Measure Of Surgical Invasiveness After Contemporary THA</td>
<td>Mark W. Pagnano, MD</td>
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</table>
Accelerated Physical Therapy Rehabilitation Following Elective Primary Total Hip Arthroplasty Facilitates Early Discharge

Stephen J. Incavo, MD

A Multi-Center Prospective Randomized Study Of Outpatient Versus Inpatient Total Hip Arthroplasty

William J. Hozack, MD

DISCUSSION

The Global Position Of The Acetabular Component

Lawrence D. Dorr, MD

Standing And Sitting Lumbosacral Alignment In Patients Undergoing Hip Arthroplasty: What Is Normal?

Douglas E. Padgett, MD

Restoration Of Normal Anatomy Improves Outcomes Eight To Fourteen Years After Total Hip Arthroplasty

John M. Martell, MD

Validation Of A Simple, Laser-Guided System For Prescribing Acetabular Cup Inclination Angle In Total Hip Arthroplasty

William A. McGann, MD

The Cross-Table Lateral Radiograph Remains A Useful Surrogate For CT Scan To Assess Cup Version After Total Hip Arthroplasty

William B. Macaulay, MD

Long Term Follow-Up Of A Randomized Controlled Trial Using An Active Robotic System For Total Hip Replacement

William L. Bargar, MD

Effect Of Acetabular Component Positioning On Total Hip Arthroplasty Revisions For Instability

Robert L. Barrack, MD

DISCUSSION

Intermittent PTH Stimulates Bone Formation Rapidly In The Human Femoral Neck

Mathias P. G. Boström, MD

Adult Reconstructive Surgery – A High Risk Profession For Work-Related Injuries

Michael Tanzer, MD, FRCSC

Initial Stability Of A Standard Porous Coated Acetabular Component Compared To Highly Porous Component

William A. Jiranek, MD
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<thead>
<tr>
<th>Time</th>
<th>Session</th>
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<tr>
<td>9:49 – 9:54 AM</td>
<td>Paper 64</td>
<td><strong>Sustaining A Teamwork Culture In An Orthopaedic Surgical Unit Through TeamSTEPPS</strong></td>
<td>Lynne C. Jones, PhD</td>
<td>102</td>
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<tr>
<td>9:55 – 10:00 AM</td>
<td>Paper 65</td>
<td><strong>Pulmonary Embolism Rates Following Total Hip Arthroplasty With Prophylactic Anticoagulation: Some Pulmonary Embolisms Cannot Be Avoided</strong></td>
<td>Jay R. Lieberman, MD</td>
<td>103</td>
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<tr>
<td>10:01 – 10:15 AM</td>
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<td><strong>DISCUSSION</strong></td>
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<tr>
<td>10:16 – 11:17 AM</td>
<td>Session XIII: Impingement and Dysplasia</td>
<td><strong>NEW MEMBER PRESENTATION</strong> Natural History Of Hip Impingement And Dysplasia Over 10-35 Years In Patients Without Initial Degenerative Changes**</td>
<td>Rafael J. Sierra, MD</td>
<td>104</td>
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<tr>
<td>10:22 – 10:27 AM</td>
<td>Paper 67</td>
<td><strong>NEW MEMBER PRESENTATION</strong> T1 rho Advanced Cartilage Mapping Correlates With Surgical Outcome Of Patients Treated For Cam Type Femoro-Acetabular Impingement**</td>
<td>Paul E. Beaulé, MD, FRCSC</td>
<td>106</td>
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<tr>
<td>10:28 – 10:33 AM</td>
<td>Paper 68</td>
<td><strong>NEW MEMBER PRESENTATION</strong> Complications After Hip Arthroscopy: A Prospective Multicenter Study Using A Validated Grading Classification**</td>
<td>Christopher M. Larson, MD</td>
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<td>10:34 – 10:39 AM</td>
<td>Paper 69</td>
<td><strong>Risks For Conversion To THA After Primary Hip Arthroscopy In A Healthcare System</strong></td>
<td>Christopher L. Peters, MD</td>
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<td>Paper 70</td>
<td><strong>Does Articular Cartilage Damage Progress In Patients Requiring Revision Hip Arthroscopy?</strong></td>
<td>Joseph C. McCarthy, MD</td>
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<td><strong>Average Ten Year Clinical Outcomes Of The Bernese PAO For The Treatment Of Classic Acetabular Dysplasia</strong></td>
<td>John C. Clohisy, MD</td>
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<td><strong>Long-Term Results Following Bernese Periacetabular Osteotomy</strong></td>
<td>Michael B. Millis, MD</td>
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<td>10:57 – 11:17 AM</td>
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<td><strong>DISCUSSION</strong></td>
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<td>11:18 – 11:45 AM</td>
<td>Session XIV: Revision THA</td>
<td><strong>Flat Tapered Stem Revision For End Of Stem Pain Below A Well-Fixed Long Cementless Femoral Stem</strong></td>
<td>Vincent D. Pellegrini, Jr., MD</td>
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<td>11:18 – 11:23 AM</td>
<td>Paper 73</td>
<td><strong>Fixation Of Allografted Titanium And Hydroxyapatite Implants In Revision Settings With And Without Cracking Of Sclerotic Cavity</strong></td>
<td>Joan E. Bechtold, PhD</td>
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Prior Operative Notes Are Inadequate For The Planning Of Revision Total Hip Replacement
Stuart B. Goodman, MD, PhD

11:30 – 11:35 AM
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DISCUSSION

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CLOSING REMARKS
MEETING ADJOURNED
Abstracts (Friday, October 16, 2015)

SESSION I: Cross-Linked Polyethylene

Highly Cross-linked Polyethylene Provides Decreased Osteolysis and Reoperation at Minimum 10 years Follow-up

Paul F. Lachiewicz, MD and Elizabeth S. Soileau, BSN
Chapel Hill Orthopedic Surgery & Sports Medicine, Chapel Hill, NC

Background: Highly cross-linked polyethylene was introduced to decrease periprosthetic osteolysis and reoperation compared to compression molded polyethylene, but this has not been conclusively proven.

Questions/Purposes: We asked the following questions: (1) What is the long-term survival of a modern, cementless titanium acetabular component with screw fixation? (2) What are the differences in the frequency of reoperation and radiographic osteolysis between hips with standard and highly cross-linked polyethylene (XLPE) at minimum 10 years follow-up time?

Methods: One surgeon performed 513 consecutive primary total hip arthroplasties (450 patients) using one modern, cementless, titanium-mesh acetabular component with screw fixation. Standard polyethylene was used in 304 hips and electron-beam, remelted XLPE in 209 hips. Survivorship analysis to 17 years was performed using the entire cohort. We analyzed the rate of reoperation and radiographic osteolysis in two matched cohorts of hips, 133 with standard polyethylene and 112 with XLPE, at a minimum follow-up time of 10 years.

Results: Of the entire cohort of 513 hips, one acetabular component was revised for early aseptic loosening and one was removed for infection. The cup survival at 17 years was 99%. The two cohorts were well-matched, except that the XLPE cohort had a greater weight, BMI, more uncemented femoral components, and higher activity level. There were significantly more reoperations in the cohort with standard polyethylene (11 of 133, 8%) than XLPE (1 of 112, 1%, p=0.03). Osteolysis was seen in 26% (35 of 133 hips) with standard polyethylene, compared to 13% (15 of 112 hips) with XLPE (p=0.02).

Conclusions: This acetabular component provided excellent long-term fixation and we continue its use. Longer follow-up is required to determine the progression of osteolysis in hips with XLPE.
A Multi-Center Long-term Clinical and Radiographic Evaluation of THR with Highly Cross-linked Polyethylene

Charles R. Bragdon, PhD1,2; Christopher Barr, BS1; Christian Nielsen, MD1; Daniel Berry, MD4; Craig Della Valle, MD5; Kevin Garvin, MD6; Per-Erik Johansson, MD, PhD3; John Clohisy, MD7; Henrik Malchau, MD; PhD1,2

1Harris Orthopaedic Laboratory, Massachusetts General Hospital, Boston, MA, USA; 2Harvard Medical School, Department of Orthopaedic Surgery, Boston, MA, USA; 3Department of Orthopaedics, Institute of Clinical Sciences, Sahlgrenska Academy, University of Gothenburg, Sweden; 4Mayo Clinic, Rochester, MN, USA; 5Rush University Medical Center Chicago, IL, USA; 6Nebraska Orthopedic Hospital, Omaha, NE, USA; 7Washington University Orthopedics, Saint Louis, MO, USA

Purpose: The first highly crosslinked and melted polyethylene acetabular component for use in total hip arthroplasty was implanted in 1998. Since then, numerous publications on this and other forms of highly crosslinked polyethylenes have reported reduced wear rates and a dramatic reduction in particle induced peri-prosthetic osteolysis at short and mid-term follow-up. The purpose of this study was to re-assemble a previous multi-center patient cohort in order to evaluate the longest possible clinical, radiographic, and wear analysis of patients receiving this form of highly crosslinked polyethylene, both in the standard head diameter configuration as well as head diameters greater than 32mm.

Methods: Six centers contributed patients to this ongoing clinical study. Inclusion criteria for patients with femoral head diameters up to and including 32mm, (standard head) was a minimum 13 year follow-up while that for the group with femoral heads greater than 32mm, (large head) was a minimum 10 year follow-up. Currently 140 hips have been enrolled, 71 in the standard head group and 69 in the large head group. For the standard head group, with an average follow-up of 13.7 years (range 13-16) there were 25 females (33%). For the large head group with an average follow-up of 11.2 years (range 10-15) there were 32 females (50%). Wear analysis was performed using the Martell Hip Analysis software. Detailed radiographic grading was performed on the longest follow-up AP hip films. The extent of radiolucency in each zone greater than 0.5mm in thickness was recorded along with the presence of sclerotic lines and/or osteolysis.

Results: Wear analysis: Using the average of the slopes of the individual regression lines, there was no significant difference between the wear rates of the two groups: standard head group 0.006±0.033mm/yr; large head 0.004±0.094mm/yr group, (p=0.9). There was a significant difference in the wear rates using the early to latest film method: standard head group 0.004±0.056mm/yr; large head 0.035±0.076mm/yr group, (p=0.008).

Radiographic analysis, combined: Acetabular side: the greatest incidence of radiolucency occurred in zone 1 at 20%; sclerotic lines had a 1% incidence in each of the 3 zones; there was no osteolysis identified. Femoral side: the highest incidence of radiolucencies was in zones 1 and 6, 9% and 5%; sclerotic lines were rare in any zone, maximum in zone 3, 4%; there was no osteolysis identified.
Conclusion: The wear rates of this form of irradiated and melted highly crosslinked polyethylene remained at levels lower than the detection limit of the soft wear at minimum 10 year follow-up for the large head group and minimum 13 year follow-up for the standard head group. Radiographic analysis revealed no identified osteolysis.

Significance: The mid to long-term wear performance of this form of HXLPE is excellent and no osteolysis was identified at follow-up as long as 16 years.
Mid-term Wear of Larger Diameter XLPE: Does Liner Thickness or Component Position Matter?

Jonathan Haw, MD; Andrew K. Battenberg, MD; Der-Chen Tim Huang, MD; Thomas P. Schmalzried, MD
Joint Replacement Institute, Los Angeles, CA; Harbor-UCLA Medical Center, Torrance, CA

Introduction: Highly cross-linked polyethylene (XLPE) has demonstrated significantly reduced wear and osteolysis into the second decade. However, there is a relative paucity of data with ≥36mm bearings. Issues include the potential effects of reduced liner thickness and component position on wear, osteolysis, and mechanical failure of the bearing.

Materials and Methods: Forty-seven hips with modular XLPE bearings, in 40 patients, were retrospectively analyzed. Twenty-three hips were in females; 24 were in males. The mean age at surgery was 61.8 years (range 35.8-85.6). Follow-up averaged 6.7 years (range 5.0-12.8). Wear was measured on serial radiographs using a validated, edge-detection based algorithm. An average of 4.3 (range 2-8) films per patient were measured. Wear rates were calculated using linear regression analysis. Radiographs in 3 planes were assessed for the presence of osteolysis by 3 independent observers and were graded: none, possible, probable, or definite.

Results: This cohort had a mean linear wear rate of 0.053mm/yr and mean volumetric wear rate of 38.5 mm³/yr. Sub-groups were examined (Table 1): 1) femoral head size 36mm vs 40 and 44mm; 2) XLPE liner thickness <6.5mm vs ≥6.5mm (range 3.8-11.2mm), 3) acetabular component inclination <45 vs. ≥ 45 degrees (range 22.2-55.5 degrees), 4) acetabular component anteverision <20 vs. ≥20 degrees (range 5.2-39.6 degrees), 5) Gender, 6) Age <65 vs. ≥65 years. For these 6 variables, there were no statistically significant differences in linear or volumetric wear rates, although there was a trend toward higher volumetric wear with ≥36mm bearings. There was one case of possible osteolysis, no liner fractures, no liner dissociations, and no dislocations.

Discussion: A reduced rate of dislocation has increased the utilization of larger diameter XLPE bearings. In the current study, the wear of ≥36mm XLPE is higher than that reported with 28 and 32mm bearings1,2. Wear simulator studies have conflicting results on the effect of XLPE liner thickness on wear3,4. In this 5-13 year clinical assessment, liner thickness had no significant effect on XLPE wear, and there were no mechanical failures. Further, wear of these larger XLPE bearings was not influenced by a wide range of component positions. Although there was just one case of possible osteolysis, continued close observation is indicated because of the higher volumetric wear of these larger bearings.
Table 1. Mean Linear (mm/yr) and Volumetric (mm^3) Wear Rates

<table>
<thead>
<tr>
<th>Bearing Size</th>
<th>36 mm</th>
<th>&gt;40 mm</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear Wear</td>
<td>0.051</td>
<td>0.064</td>
<td>0.78</td>
</tr>
<tr>
<td>Volumetric Wear</td>
<td>34.1</td>
<td>59.9</td>
<td>0.3</td>
</tr>
<tr>
<td>Liner Thickness</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>&lt;6.5 mm</td>
<td>0.05</td>
<td>0.056</td>
<td>0.87</td>
</tr>
<tr>
<td>&gt;6.5 mm</td>
<td>44.1</td>
<td>31.6</td>
<td>0.51</td>
</tr>
<tr>
<td>Acetabular Inclination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;45 deg</td>
<td>0.055</td>
<td>0.049</td>
<td>0.89</td>
</tr>
<tr>
<td>&gt;45 deg</td>
<td>39.5</td>
<td>36.1</td>
<td>0.87</td>
</tr>
<tr>
<td>Acetabular Anteversion</td>
<td></td>
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<tr>
<td>&lt;20 deg</td>
<td>0.075</td>
<td>0.035</td>
<td>0.27</td>
</tr>
<tr>
<td>&gt;20 deg</td>
<td>53.9</td>
<td>26.1</td>
<td>0.14</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Female</td>
<td>0.045</td>
<td>0.06</td>
<td>0.69</td>
</tr>
<tr>
<td>Male</td>
<td>42.8</td>
<td>34.4</td>
<td>0.66</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;65 years</td>
<td>0.042</td>
<td>0.068</td>
<td>0.51</td>
</tr>
<tr>
<td>≥65 years</td>
<td>38.3</td>
<td>38.8</td>
<td>0.98</td>
</tr>
</tbody>
</table>

References:

1) Lachiewicz PF, Soileau ES, Martell JM. Wear and Osteolysis of Highly Crosslinked Polyethylene at 10 to 14 Years: The Effect of Femoral Head Size. CORR. 2015.


Highly Cross-Linked Polyethylene Decreases the Revision Rate of Total Hip Arthroplasty Compared to Conventional Polyethylene at 13 Years Follow-Up

Richard W. McCalden, MD; Sammy Hanna, MD; Lyndsay Somerville, PhD;
Steven J. MacDonald, MD, FRCSC; and Douglas Naudie, MD, FRSCSC
London Health Sciences Centre, London, Ontario, Canada

Purpose: Although highly cross-linked polyethylene (XLPE) has been shown to have decreased wear in-vivo compared to conventional polyethylene (CPE), it remains unclear whether this is associated with a decrease in wear-related THA revision rates. The aim of this study was to compare the clinical outcomes, incidence of osteolysis and rate of wear-related revision for young patients with long-term follow-up after a primary THA with either a CPE or XLPE liner. We sought to answer the question: did the transition from CPE to XLPE liners during the early 2000s in our institution lead to clinical benefit for our patients?

Methods: We reviewed all THA patients followed prospectively in our institutional database who received either a CPE or XLPE liner. The inclusion criteria in this study included: primary THA performed between January 2000 and December 2001 for osteoarthritis, age between 45-65, THA with one of two cementless modular porous-coated acetabular shells designs and a 28mm cobalt-chrome femoral head, no previous surgery to the hip and no coexisting musculoskeletal or neurological problems affecting mobility. 158 patients (177 hips) were available for review (89 – CPE, 88 – XLPE). Mean age, BMI and follow-up in each group were: (CPE: 56.8 years, 30.7 kg/m², 13.2 years) – (XLPE: 55.6 years, BMI: 30 kg/m², 13.1 years). Patient records were reviewed to identify wear-related failures/revisions. Pelvic/hip radiographs were assessed for osteolysis defined as punched out lesions with sclerotic margins and/or calcar resorption. Functional outcome was assessed using the Harris Hip Score (HHS). Linear wear was assessed using the Livermore technique and measured the total head penetration in-vivo (ie including the bedding-in period).

Results: There were 17 revision THAs in total in the CPE group, of which 13 (14%) were related directly to polyethylene wear and/or osteolysis at a mean of 11.6 years (10 – 13.8). All 13 cases had a liner exchange and 12 required bone grafting. Cumulative implant survival, with revision for polyethylene wear as an end point, was 86% in the CPE group (78% to 94%, 95% CI), and 100% in the XLPE group at 13 years (p<0.05). Osteolysis was present in 17% (acetabular) and 18% (femoral) of the CPE hips compared to 0% (acetabular) and 0% (femoral) of the XLPE hips. The mean annual radiographic linear wear of the CPE liners was 0.11 mm/year compared to 0.035 mm/year for the XPLE liners – (p=0.006).

Conclusion & Significance: This study demonstrates that XLPE liners are associated with significantly less osteolysis and wear related revision rates than CPE liners following primary THA in young and active patients at mid to long-term follow-up. In other words, during the time frame of our transition from CPE to XLPE liners (circa 2000-2002), those patients who received an XLPE liner rather than a CPE liner (where all other aspects of their treatment were identical) have demonstrated a clear benefit at long-term follow-up.
In Vivo Oxidative Changes in Highly Cross-Linked UHMWPE

Shannon L. Rowell, Orhun K. Muratoglu, PhD
Harris Orthopaedics Laboratory, Massachusetts General Hospital, Boston, MA

Purpose: Oxidation of UHMWPE compromises mechanical properties and wear resistance. We investigated the oxidative changes in retrieved highly cross-linked UHMWPE components.

Methods: We collected 93 first generation (irradiated and melted, 0.3-155.9 mos. in vivo) and 56 second generation (39 sequentially irradiated and annealed, 0.5-97.4 mos. in vivo; 17 vitamin E stabilized, 0.1-26.5 mos. in vivo) highly cross-linked retrievals under IRB-approval (total of 149 acetabular retrievals). We analyzed the retrievals either immediately or stored them at -20°C until analysis to prevent any post-explantation changes. We used (i) infrared spectroscopy to quantify oxidation and oxidation potential; (ii) gravimetric swelling in xylene to quantify cross-link density. All characterization was carried out in articular and non-articular surfaces to assess the effect of load on in vivo changes. We reacted the hydroperoxides with nitric oxide to increase their detection with infrared spectroscopy and, thus, quantified oxidation potential.

Results: No retrievals were revised for oxidation-derived failure of the polyethylene. Irradiated and melted retrievals showed subsurface oxidation and increased oxidation potential, predominantly in the articular surfaces. Sequentially annealed retrievals showed white banding (indicating loss of strength), decrease in cross-link density (indicating loss of wear resistance) in both articular and non-articular surfaces, and an increase in oxidation with in vivo duration. Antioxidant-stabilized retrievals with up to 2.2 years in vivo remained oxidatively stable.

Conclusion: Polyethylenes containing unstabilized free radicals are oxidizing more rapidly than irradiated and melted PEs with evidence of material property loss. No clinical failures as a result of this oxidation have been reported to date at current in vivo oxidation levels. Increased oxidation levels observed in loaded areas raises an important question in terms of polyethylene thickness. With thinner acetabular liners the contact stresses increase; therefore, the rate of oxidation in these regions is expected to be higher. More detailed analysis of polyethylene thickness effect on long-term in vivo oxidative changes is warranted. Continued analysis of retrieved components is crucial to better document the rate of oxidative changes.

Significance: All polyethylenes appear vulnerable to in vivo oxidation mechanisms; antioxidant-stabilization is showing the greatest retardation of the oxidation.
**Zirconia Versus Cobalt Chromium Femoral Heads in Total Hip Arthroplasty: Average 10 Year Wear Assessment**

*Todd Morrison, MD; Jia Meng, BS; Rebecca Moore, MS; Clare M. Rimnac, PhD; Matthew J. Kraay, MS, MD*

**Introduction:** Polyethylene (PE) wear and associated osteolysis continues to be a major concern in total hip arthroplasty (THA). In vitro laboratory studies demonstrate reduced PE wear with ceramic femoral heads. Prior to the introduction of cross-linked PE, Yttria-stabilized zirconia ceramic femoral heads and conventional PE were used as an alternative bearing surface until problems related to the potential for this material to undergo in vivo tetraclinic to monoclinic phase transformation occurred clinically. This transformation can result in increased surface roughness and the potential for increased PE wear. After increased reports of femoral head fractures, yttria-stabilized zirconia femoral heads were withdrawn from the market. Although previous studies have demonstrated low PE wear rates with yttria-stabilized zirconia femoral heads, long term wear analysis of this bearing material in comparison to Co-Cr femoral heads is lacking.

**Methods:** We performed a long term evaluation of a previously reported cohort of patients who participated in a prospective randomized clinical trial comparing Co-Cr and yttria-stabilized zirconia femoral heads and conventional ultra-high molecular weight PE liners. The study enrollment ceased at the time of component recall with 30 THAs with zirconia and 29 THAs with Co-Cr enrolled between 1998 and 2002. Eight study subjects received bilateral THAs with a zirconia femoral head on one side and a Co-Cr head on the contralateral side. Patients were evaluated with standardized clinical outcomes instruments and radiographs were obtained at routine follow-up intervals. Two independent observers assessed radiographs for evidence of loosening or osteolysis and femoral head penetration was determined using a widely used computerized wear measurement software program (Hip Analysis Suite).

**Results:** Late term follow-up was obtained on 64% of the original cohort (20 THAs with zirconia and 18 THAs with Co-Cr). 12% of the study subjects were confirmed as decreased and 24% lost to follow-up. Mean follow-up was similar between groups (Co-Cr = 124±46 months (range 4.9-15.8 years), zirconia = 127±41 months (range 4.2-16.6 years), p = 0.87). There was no difference in
Harris Hip Scores between Co-Cr and zirconia THAs. The mean linear PE wear rate remained low and similar between groups (Co-Cr = 0.074±0.041 mm/year, zirconia= 0.066±0.031 mm/year, p = 0.49). Interobserver correlation for measuring linear PE wear was 0.882. Observed PE wear secondary to creep or liner settling during the “bedding in” period for Co-Cr and zirconia THA’s was 0.121 mm and 0.139 mm respectively with a steady state wear of 0.053 mm/year and 0.050 mm/year for Co-Cr-Mo and zirconia THAs, respectively. Analysis of subjects with bilateral THA’s revealed no difference in average PE wear rates, “bedding in” or steady state wear between zirconia and Co-Cr-Mo THAs. No significant osteolysis was observed in either group. There were no instances of femoral head fracture in the zirconia THA group.

**Discussion:** Despite concerns regarding phase transformation that can potentially lead to degradation of wear properties, yttria-stabilized zirconia ceramic femoral heads maintain a low wear rate at an average of 10 years. Wear performance of these zirconia femoral heads is similar to conventional Co-Cr bearings with both bearings demonstrating comparable “bedding in” and nearly identical steady state wear rates. The steady state wear rate with both zirconia and Co-Cr heads and the conventional PE used in this study were below the threshold at which osteolysis typically occurs. This suggests that previously described in vivo phase transformation of this material does not affect its clinical performance or longevity.
Is a Second Two-stage the Answer?
The Results of Second 2-stage Reimplantations for Periprosthetic Hip Infection
Keith A. Fehring, MD; Matthew P. Abdel, MD; Tad M. Mabry, MD; Arlen D. Hanness, MD
Department of Orthopedic Surgery
Mayo Clinic

**Purpose:** Failed 2-stage reimplantation with subsequent infection is a devastating outcome following 2-stage exchange arthroplasty for periprosthetic hip infection. Attempts at further 2-stage reimplantation procedures are fraught with difficulties without clear guidelines for treatment or prognosis. A staging system has been previously described in an attempt to stratify patients according to infection type, host status, and local soft tissue status. This system may prove useful when developing treatment algorithms for this difficult patient population. The purpose of this study was to report the results of subsequent 2-stage reimplantation following a failed 2-stage protocol for periprosthetic hip infection, as well as identify risk factors for failure, and complications associated with these procedures.

**Methods:** We retrospectively identified 22 patients who underwent a second 2-stage exchange arthroplasty for periprosthetic hip infection from 2000 to 2013. These patient’s records were examined for outcomes following these procedures, risk factors for failure, and complications. Minimum follow-up was 2 years (mean 3.5 years).

**Results:** 8 patients (38%) underwent re-revision for infection with 17 patients (81%) undergoing revision for any reason. The most common reasons for revision were infection (8 patients) and instability (5 patients). 7 of 8 patients revised for infection were classified as an immunocompromised host (B or C) and had a compromised local extremity grade (2 or 3). Recurrence of infection was diagnosed in 40% of immunocompromised hosts. A constrained or dual mobility construct was used in 33% patients at the time of reimplantation. A total femur or proximal femoral replacement was utilized 30% of cases at the time of reimplantation. A causative microorganism was identified in 19 patients with 9 (43%) of these patients becoming infected with a different microorganism than the initial periprosthetic hip infection. 8 of the patients free of revision for infection were placed on lifelong antibiotic suppression. No patients were free of gait aids at final follow-up.

**Conclusions/Significance:** This data suggests that expectations following a second two-stage exchange arthroplasty for periprosthetic hip infection should be tempered as the failure rate of this procedure is high with considerable patient morbidity and complications associated with these procedures.
The Accuracy of Joint Aspiration Lavage for the Diagnosis of Infections in Total Hip Arthroplasty

S MacDonald, Valente G, B Lanting, J McAuley, R McCalden, D Naudie, E Vasarhelyi, J Howard

Introduction: The diagnosis of infection regarding hip arthroplasty is based on clinical suspicion, joint aspiration and laboratory investigations. A positive joint aspirate implies a periprosthetic infection and may direct subsequent surgical intervention. Therefore, it is imperative that joint aspirates provide accurate results. If no fluid can be aspirated from an arthroplasty hip with the suspicion of infection, current practice is to inject sterile fluid into the hip joint and attempt to reaspirate the fluid for analysis. There is currently no strong evidence to date that this practice yields accurate results in determining whether an arthroplasty hip is infected or not. The goal of this study was to determine whether aspiration lavage laboratory results can accurately identify infected hip arthroplasties by: 1) comparing aspiration lavage culture results to the operative culture results (utilized as the gold standard in diagnosing infection) and 2) determining the usefulness of cell count and differentiation in aspirated lavaged hip arthroplasties.

Methods: Review of our institutional arthroplasty database was completed to identify all revision total hip arthroplasties performed from 2005 – 2013. Retrospective chart review was completed to identify all patients who had joint aspiration lavage to exclude infection. Patients whose aspirate was greater than 6 months before surgery and those that did not have intraoperative cultures at the time of revision were excluded. Charts were retrospectively reviewed to record gender, fluid used for lavage, volume of substance injected into the hip joint (ml), volume of fluid aspirated after lavage (ml), CRP, ESR, synovial fluid cell count, synovial fluid percentage neutrophils, synovial fluid culture, operative culture, antibiotic use, and time to revision surgery after aspiration lavage.

Results: Fifty nine cases received aspiration lavage to diagnose infection during the study period. There were 47 hip arthroplasties (total hip arthroplasty, bipolar, or hip resurfacing) and 12 antibiotic spacers. Of the 47 arthroplasties, 17 (36.1%) had positive bacterial operative cultures, while only 5 (10.6%) had positive bacterial aspiration lavage cultures. The lavage aspiration correctly identified the presence of periprosthetic infection in only 2 of the 17 cases which were positively intra-operatively (11.8%). Of the 12 antibiotic spacers, 0 had positive operative cultures, while 1 (8.3%) had a positive bacterial aspiration lavage culture. Of the 59 cases that underwent lavage aspiration, synovial fluid cell count could only be determined in 10 aspirates (16.9%) and synovial fluid percentage neutrophils in 1 aspirate (1.7%).

Discussion/Conclusions: The method of attempting to reaspirate an arthroplasty hip with nonbacteriostatic saline when a dry aspirate occurs is not an accurate or effective means of diagnosing infection in hip arthroplasty.
Optimizing Operating Room Air Quality:
A Prospective Observational and Simulated Study
Maryam Rezapoor, MS; Antonia F. Chen, MD, MBA; Jorge Manrique, MD; Taylor Paziuk, BA;
Mitchell G. Maltenfort, PhD; Javad Parvizi, MD, FRCS

Introduction: Periprosthetic joint infection (PJI) is a devastating complication and all efforts should be made to minimize this untoward complication of arthroplasty. The importance of ultraclean operating room (OR) with a reduced number of aerosolized particles, which is considered an indirect measure of airborne bacteria, has been deemed to be extremely important for prevention of contamination of the wound and a reduction in the incidence of subsequent infection. This prospective study, using a recently developed accurate particle counter, was designed to evaluate the influence of various parameters on the number of aerosolized particles in the operating room.

Methods: A prospective study was performed to assess air quality of an OR during femoroacetabular osteoplasty (FAO) in fifteen patients. Two particle count machines were placed on the opposite sides of the operating table that sampled the air every 2-3 minutes. Laminar airflow (LAF) was turned off for 7 cases, while LAF was on for 8 cases. The number of door openings, length of time the door was kept open, number of people in the OR, and transportation of instrumentations were recorded. Effect of personnel activity on air quality was assessed by dividing each surgery into five 10-minute intervals with different levels of personnel activity: after patient entrance, before incision, after incision, middle of surgery, and after wound closure. In different simulated experiments, 10 volunteers were assembled in the same OR (without a patient), with each person entering every 15 minutes, and the changes in number of particles were detected with and without LAF.

Results: When controlling for confounding factors, the density of particles (0.5-1 µm) decreased by 85% when LAF was on (p<0.0001) and increased by 131% when the door remained open (p=0.0003). The 10-minute interval between incision and closure, which was the lowest personnel activity phase, resulted in the lowest particle density compared to the other four phases of surgery (p<0.0001). During the simulation studies, particle count linearly correlated with the number of people in the OR (r²=0.88) and number of door openings when LAF was off, but not when LAF was on.

Conclusion: The use of LAF, limiting activity of people in OR, and minimizing OR door opening reduce the number of particles in the OR, which may correlate to a decrease in subsequent infection. If implemented, these simple measures may provide an ultraclean OR that is considered desirable for arthroplasty surgery.
A Multi-Center Randomized Clinical Trial of Articulating and Static Spacers for Periprosthetic Hip Infection

Erdan Kayupov MSE¹, Peter N. Chalmers MD¹, Mario Moric MA¹, Timothy Tan MD², Scott M. Sporer MD¹, Greg Deirmengian MD², Javad Parvizi MD², Matt Austin MD², Craig J. Della Valle MD¹

¹Rush University Medical Center, Chicago, IL, USA
²Rothman Institute, Philadelphia, PA, USA

Introduction: Although the use of an interim antibiotic spacer is considered standard for a two-stage exchange for periprosthetic joint infection (PJI), the use of an articulating versus a static spacer is controversial. The purpose of this multicenter, randomized trial is to compare articulating and static spacers for the treatment of PJI after total hip arthroplasty (THA).

Methods: 36 Patients who met MSIS criteria for PJI following a primary THA at 3 centers were randomized; 17 into the articulating and 19 in the static group. Power analysis determined that 44 total patients were needed to identify a difference in operative time during the second stage (β=0.80 and α=0.05). Demographics between the two groups were not significantly different, suggesting appropriate randomization. Statistical analysis was performed using t-tests for normally distributed variables and Wilcoxon tests for non-normally distributed variables.

Results: For the stage 1 procedure there were no differences in operative time (201 articulating vs. 195 minutes static, p=0.702), blood loss (762 vs. 579 ml, p=0.163), units of blood transfused (0.35 vs. 0.74, p=0.176) or likelihood of discharge to home with the number of patients available for study. Similarly, at reimplantation there were no differences in operative time (194 articulating vs. 187 minutes static, p=0.840), blood loss (642 vs. 469 ml, p=0.235), units of blood transfused (0.64 vs. 1.06, p=0.309), or discharge disposition. Length of stay was significantly longer in the static group following stage 1 (5.2 vs. 8.7 days, p=0.011) and stage 2 (3.9 vs. 6 days, p=0.009). Three patients in the static group and 2 in the articulating group required a second debridement and spacer prior to reimplantation.

Conclusions: Preliminary results of this multicenter randomized trial demonstrate few differences between the two techniques at the time of the 1st or 2nd stage reconstruction.

Significance: While the results of the two techniques appear similar, the longer length of stay in the static group, could have important economic consequences for the hospital.
Intraarticular Antibiotic Infusion Effective in One-Stage Revision for Infected Total Hip Arthroplasty

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Purpose: Antibiotic-loaded cement has been considered standard for antibiotic delivery after revision for infected total hip arthroplasty (THA), but antibiotic levels rapidly diminish after the first three days, leaving the cement vulnerable to colonization by resistant organisms. This report describes a protocol for intraarticular delivery of antibiotics and presents results of prospective studies of 1) single-stage revision and 2) single-stage debridement with retention of implants followed with daily intraarticular infusion of antibiotics for 6 weeks.

Methods: 21 hips (21 patients) with infected THA had single-stage revision with cementless total hip implants. At closure, two Hickman catheters were placed to begin intraarticular delivery of antibiotics in the early postoperative period. Antibiotics were infused daily into the hip for six weeks. Nine hips (9 patients) with infected THA had bone-ingrown implants and were treated with debridement and daily intraarticular antibiotic infusion. Eleven of the single-stage revision cases and 4 of the debridement cases had methicillin-resistant Staphylococcus aureus.

Results: Twenty single-stage with infusion cases resolved and remain free of infection. One case grew candida in the operative cultures and resolved the infection after re-revision followed by infusion of fluconazole. Infection resolved in all nine debridement with infusion cases, and all remain free of infection.

Discussion/Conclusion: Antibiotic infusion into the operative site achieves concentrations that are hundreds of times higher than can be achieved with any other technique. The results of these two studies suggest that the failure rate of revision THA with resistant organisms is lower with intraarticular delivery than with other currently available methods. Results of this treatment with resistant Staphylococcus were especially encouraging. If an expected failure rate of 20% is assumed, the probability of fifteen sequential cases without an infection is 0.035 (p=0.035), which is statistically compelling evidence that this is not a chance occurrence.

Significance: Although antibiotic infusion is somewhat tedious and labor-intensive for the surgeon and supportive staff, it is highly effective for treatment of infected THA. When combined with thorough debridement and effective soft-tissue management, resolution of infection occurs in a high percentage of cases.
Modular Fluted Tapered Stems in Aseptic Revision Total Hip Arthroplasty
Matthew P. Abdel, MD, Umberto Cottino, MD, David G. Lewallen, MD; Daniel J. Berry, MD

Introduction: Titanium modular fluted tapered (TMFT) stems have become the mostly commonly used method in North America. Results have been limited. The goal of the current study was to determine the results of TMFT stems utilized in aseptic revision total hip arthroplasties (THAs) in largest series to date.

Methods: We identified 519 femoral revisions performed for aseptic loosening treated with a TMFT stem. Paprosky classification was used to classify bone loss: 0.5% had a type 1, 16% type 2, 42% type 3A, 19.5% type 3B, and 22% type 4. Median stem diameter was 18-mm. Harris hip score (HHS), radiographic stability, and Kaplan-Meier survivorship were assessed. Mean age was 70 years, mean BMI was 29 kg/m², and mean follow-up was 4 years.

Results: The mean HHS improved significantly from a preoperative of 51 to 76 at 2 years (p < 0.001) and was maintained at 10 years (HHS = 75). At most recent follow-up, there were 16 femoral revisions (7 for aseptic loosening, 3 for instability, 4 for infection, and 2 for periprosthetic fracture). In addition, another 12 reoperations occurred. There was no difference in failure rate between the different preoperative bone loss categories. The 10-year survivorship free of femoral revision for aseptic loosening was 98%, free of femoral revision for any reason was 96% and free of any reoperation was 87%. Implant survivorship free of aseptic femoral loosening was not correlated with gender (p= 0.39). In living and unrevised patients, early stem subsidence occurred in 17 patients (mean=15-mm). However, all subsequently stabilized and none had loosening.

Conclusions: In this large series, TFMTs provided a high rate of survivorship free of aseptic femoral loosening and free of femoral revision for any reason at 10 years. The high rate of long-term femoral fixation occurred across all categories of preoperative bone loss.

Summary: Titanium modular fluted tapered stems demonstrated a high rate of survival free of aseptic loosening at 10 years and a low rate of implant loosening across all categories of preoperative bone loss.
Femoral Revision with Non-Modular Tapered Fluted Titanium Stems: A North American Experience
Nemandra A. Sandiford, Donald Garbuz, Bassam Masri, Clive Duncan

Purpose: Modular tapered fluted titanium stems (TFTS) are popular as a revision stem of preference in North America. Our experience has been encouraging (1,2,3,4). Fracture at the stem-body junction emerged as an issue however. Attempts to address this include improved junction manufacture and design among other strategies. We have used a non-modular design at our centre since 2011, initially in selected cases. We present the results of our first 104 cases, with a minimum follow up of two years. We believe it may represent the first substantial report of the non-modular design concept from North America. The study included validated quality of life outcome and patient satisfaction measurement and careful radiological analysis. Only one patient was lost to follow up.

Methods: One hundred and four patients (55 males, 49 females) underwent revision THA using a non-modular TFTS stem between May 2011 and December 2012. Hip function and quality of life were assessed using the Oxford Hip Score (OHS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Short Form 12 (SF12), a satisfaction score and the University of California Los Angeles (UCLA) activity score. Radiographs were assessed by 2 separate reviewers for signs of loosening and subsidence.

Results: The mean age of our cohort was 69.4 years (Range 40-94 years). Mean body mass index (BMI) was 29.1 (Range 17.7 -39.9). Indications for revision included aseptic loosening (48%), infection (24%) and periprosthetic fracture (15%). Mean duration of follow up was 31 months (Range 24-46 months). Seven patients died (their status known before death) and one was lost to follow up. Patients had a mean of 3 procedures prior to their latest revision. Mean OHS and WOMAC scores were 86.6 (Range 79-100) and 87 (Range 75-100) respectively. Mean satisfaction and UCLA scores were 87 (Range 66-100) and 5.4 (Range 1-9) respectively. Median subsidence was 2.8mm (Range 2-15). Six (5.8%) patients had subsidence of 10mm or more. Five dislocations (4.8%) and 3 cases of infection (2.9%) occurred.

Conclusion: This non-modular design provides encouraging levels of patient satisfaction and functional improvement based on validated patient reported outcome measures. No cases of progressive or clinically symptomatic subsidence occurred.

Significance: These outcomes compare favourably with our previous experience using a modular design (1,2,3,4). These results from North America also concur with published results from Europe (5). This stem type remains our revision implant of choice except in cases of uncommon complexity.
The Use of Structural Distal Femoral Allografts for Acetabular Reconstruction at an Average 21 Years Follow-Up

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Background: Total hip arthroplasty acetabular component revision in the setting of a Type IIIA Paprosky class bone defect requires augmentation, as a porous component alone will not reliably osseointegrate. The purpose of this study is to report the long-term results of utilizing porous coated hemispherical acetabular components supported with distal femoral structural allograft.

Methods: Twenty-nine (29) consecutive hips in twenty-nine (29) patients with Paprosky Type IIIA defects treated with structural distal femoral allograft at one institution between November 1987 and March 1996 were retrospectively reviewed for clinical outcomes. Twelve (12) patients died with inadequate follow-up and two (2) were lost to follow-up, leaving fifteen (15) patients for evaluation. The patients who were deceased did not require revision prior to death. The average age at time of surgery was 61 years, and the average post-operative follow-up was 21 years (range 17-26 years). Patients were considered failures if the acetabular component was revised or if revision was recommended. Long-term survivorship was calculated using the Kaplan Meier method.

Results: Kaplan Meier analysis revealed 73.5% survivorship (95% confidence interval, 53.7%-87.4%) at 25 years of follow-up. Overall, six (6) patients were revised and one (1) patient was recommended for revision. These failed at an average of 6.0 years post-operatively (range 2.5 to 12.9 years). The average Merle d’Aubigne and Postel hip score increased from 5 points pre-operatively to 9 points at the time of latest follow-up in patients who had their allograft in place (p<0.0001). Complications within the first 3 months included one (1) post-operative foot drop and one (1) dislocation treated with closed reduction. Late complications included one greater trochanter fracture treated non-operatively and one patient requiring femoral component revision.

Conclusion: While there was a subset of patients with early failure, the remaining patients who were still living had clinically well-functioning hips at an average follow-up of 21 years. Acetabular revision with the use of a porous-coated acetabular component along with a structural distal femoral allograft for the treatment of a Type IIIA defect demonstrated a high rate of clinical success in patients not requiring early revision.
Outcome of Total Femoral Replacement for Revision Arthroplasty in the Setting of Severe Femoral Bone Loss

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**Purpose:** Total femoral replacement (TFR) has been used for limb salvage in cases with massive bone loss that is often associated with multiple failed hip arthroplasties and ipsilateral knee arthritis or total knee arthroplasty\(^1\). Much of the experience and reported outcomes with total femoral arthroplasty are in the treatment of bone or soft tissue sarcomas\(^2,3\). We questioned whether the outcome of TFR for the treatment of multiple failed arthroplasties would be equivalent to TFR for treatment of neoplastic conditions.

**Materials and Methods:** A retrospective chart review of patient’s undergoing TFR for a diagnosis other than primary or metastatic neoplastic disease was performed. Cases performed between 1995-2013 were reviewed for patient characteristics and outcome variables including number of prior surgeries, surgical diagnosis, reoperations, infections, implant survival, and ambulatory status.

**Results:** Seventeen patients who underwent 18 TFR procedures between 1995 and 2013 were identified. The clinical diagnoses included infection (9/18), aseptic loosening (4/18), and periprosthetic fracture (6/18). All patients had severe bone loss and an average of 11.8 prior surgeries. One patient died in the perioperative period and three were lost to follow up. Thirteen patients with 14 TFR implantations were followed to explantation or a minimum of 2-years, (average 4.5 years, max 10.5 years). Of these patients, 66.7% were ambulatory with an assistive device. Reoperation was required in 64.3% of cases and infection occurred in 57.1%. Two of the 14 limbs ultimately went on to amputation, the other 12 implants (85.7%) were in place at their most recent follow up. Five year survivorship was 72% and five year survivorship free of infection was 25.0%.

**Conclusion:** Total femoral replacement in the non-tumor setting is a reasonable limb-salvage procedure in cases of severe femoral bone loss, however it is associated with a high reoperation and infection rates. There is a reported lower incidence of infection (3 - 17.6%) and better five year survival (97 - 100%) for TFR performed as a limb salvage procedure for neoplastic conditions\(^2,3\).
**Significance:** Total femoral replacement for revision arthroplasty is associated with a higher rate of infection, and lower implant survivorship compared to TFR for neoplastic conditions. We now recommend post-operative long-term suppressive antibiotic therapy in all patients treated with TFR for multiply failed arthroplasty.

**References**


Management of Massive Acetabular Bone Defects in Revision Hip Arthroplasty Using a Reconstruction Cage and Trabecular Metal Augment

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Purpose: The majority of acetabular revisions with bone loss can be managed by an uncremented hemispherical cup alone or combined with metal augments. However, there are situations in which the bone loss is more severe and there is not enough bleeding host bone to support the osseointegration of a hemispherical cup. The purpose of this study is to describe the early clinical results of the combination of a reconstruction cage and metal augment in the treatment of massive acetabular bone deficiency in revision total hip arthroplasty (THA) with a minimum follow-up of 2 years. The augments are used in place of structural allografts.

Methods: We performed 17 acetabular revisions in 16 patients using a reconstruction cage and metal augment. The mean age of the patients at surgery was 70 years (range 27-85) and 10 patients were women. One patient died of causes not related to the surgery. One patient was lost to follow-up although the data on intraoperative complications was included. The mean number of previous THAs was 1.9 (range 1-3). Based on the Gross classification, there were 11 Type IV defects and 6 Type V defects [1]. The radiographic evaluation included the comparison of the hip center of rotation (HCOR) using the method described by Pagnano [2]. Stability of the cage and osseointegration of the augment was also evaluated. Clinical assessment included the Oxford Hip Score (OHS). Failure was defined as a revision or radiographic loosening of the acetabular cage.

Results: With a mean follow-up of 36 months (range 24-55), we had two failures. Both of these had a previous oncological resection of the acetabulum. One of these failures was treated with resection arthroplasty and the other one elected not to undergo further surgery. Other complications included a sciatic nerve injury, a dislocation, a deep infection treated with irrigation and debridement, and a greater trochanter fracture. OHS improved from a mean of 13.9 (range 2-23) to 28.7 (range 13-38) at the end of the follow-up (P<0.001). The vertical HCOR decreased from a mean of 2.97 cm to 0.99 cm (P=0.002).

Conclusion: Acceptable early survivorship can be achieved using reconstruction cage and metal augment for patients presenting with the most severe forms of acetabular bone deficiencies. Patients with previous oncological resections have a poor outcome. Long-term follow-up is needed.

Significance: This is a novel surgical technique for patients with global acetabular deficiency precluding the use of hemispherical component.

Cup-Cages in the Treatment of Massive Acetabular Defects
Sculco PK, Abdel MP, Hanssen AD, Lewallen DG

Introduction: Massive acetabular defects and pelvic discontinuity encountered during revision total hip arthroplasty (THA) can be treated with a host of techniques. The cup-cage construct with a highly porous acetabular component against host bone, and an overlying cage for stability, has shown satisfactory results in small series. We have recently adapted this method to include both full ilioischial cup-cages when maximal fixation is needed and half cup-cages with a flange fixed only to the ilium or ischium when intermediate or localized support is required, with the choice made depending on the added cup support needed. The goal of the current study was to compare the clinical and radiographic outcomes of both the cup-cage and half cup-cage constructs in the largest series of such patients with extended follow-up.

Methods: We identified 66 patients treated with highly porous cup-cage constructs from 2002 - 2013. Acetabular defects included Paprosky type 2 (10), type 3A (7), and type 3B (49) defects. 35 patients received a full cage and 31 patients had a half-cage construct with only the iliac (29) or only the ischial flange (2) used. Pelvic discontinuity was confirmed intraoperatively in 39 patients. Mean age was 67 years, with a mean follow-up of 4 years. Clinical results (Harris hip score), radiographic analysis, survivorship (Kaplan-Meier), and complications of cup-cage and half cup-cage constructs were analyzed and compared.

Results: Mean Harris hip score increased from 32 pre-operatively to 66. At most recent follow-up, 60 constructs were radiographically well-fixed, 3 were fibrous stable, and 3 were radiographically loose. All radiographically loose constructs were in patients with pelvic discontinuity. At 4 years, 1 patient had undergone revision for aseptic loosening, and 1 patient had had revision of their construct for recurrent instability. There were 5 additional reoperations where the cup-cage was left intact: 2 for instability, 1 for sciatic nerve exploration, 1 for hematoma evacuation, and 1 for ORIF of a periprosthetic femur fracture. The 10-year survivorship free from revision for any cause including aseptic loosening was 82%. There were 19 complications (28%), with the most common being instability in (6%), wound complications (5%), and neurovascular injury (4%). Both peroneal nerve palsies occurred in the full cage group, one of which required reoperation. There were no remaining differences in outcomes between the two techniques.

Discussion: At mid-term follow-up, both the full cup-cage and half cup cage reconstructions proved to be reliable and durable techniques in the treatment of severe acetabular deficiency. There was no difference in the radiographic or clinical outcomes between the full cage and half cup --cage reconstructions, demonstrating the potential efficacy of selective use of the half cup-cage technique. The step wise approach to increasing implant support provided by the selective use of both half and full cup–cage options proved useful in this series. The half cup-cage technique can allow avoidance
of the added exposure, greater technical challenge, risk of fracture of the deficient acetabulum (when intact) and greater neurologic risks inherent to insertion of a full cage.

**Summary:** Use of a full cup-cage and selective use of a half cup-cage reconstruction technique demonstrated excellent survivorship at mid-term follow-up in the treatment of massive acetabular defects and pelvic discontinuity.

**Keywords:** Acetabular revision, cup-cage construct, pelvic discontinuity, clinical outcomes
SESSION IV: Data from Administrative Sources

10:02 – 10:07 AM
Paper #: 18 - ★New Member Presentation★

Pain and Function Profiles in Patients Undergoing THR; Are Readmissions Associated With Poorer Functional Gain?

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**Background:** THR effectively relieves pain and restores function in patients with advanced arthritis. Optimal timing is of concern, as greater pain and disability at the time of THR is associated with poorer post-THR gains. Furthermore, CMS is now publically reporting 30 day readmission rates following TJR by hospital and the relationship between readmission and functional gain after TJR has not been evaluated.

**Methods:** Data on 5298 patients undergoing THR from a comparative effectiveness consortium that includes 155 surgeons in 25 states was analyzed including pre-operative demographics, BMI, medical and musculoskeletal comorbidities, pain and function (HOOS; SF-36) and 6 month post-THR pain and function. Data were merged with CMS claims to verify 30 day readmissions. Descriptive statistics and multivariate models adjusted for covariates and clustering within site were performed.

**Results:** Patients were grouped pre-operatively by pain and function. 81% of patients had high pain and low function pre-op, 13% of patients had high pain and high function, 3% of patients low pain and low function, and 4% of patients had low pain and high function pre-operatively. Overall 4.7% of patients were readmitted. Readmitted patients had significantly more medical comorbidities, poorer pre-THR function, and more severe OA in knees and other hip (all p<0.05). After TJR, a greater proportion of readmitted patients had poor global function (PCS<30=14% VS. 8%; P<0.008) but similar hip function in both groups. Hip pain improvement did not differ by readmit status.

**Conclusion:** The overwhelming majority of THR were performed to relieve pain and/or restore physical function. Quality of life issues (pain frequency and awareness of hip problems), and limitations of vigorous activities are reasons for THR utilization in patients with low pain pre-op. Patients with readmission within 30 days after THR have significantly poorer global function at 6 months than patients without readmissions. No clinically meaningful difference in pain relief or hip function was observed whether patients were readmitted or not.

**Significance:** This data support the importance of hip-specific PRO measures to assess THR outcome in quality of care programs and CMS public reporting programs.
Which Hospital and Clinical Factors Drive 30-Day Readmission after THA?

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Introduction: Medicare has introduced 30-day readmission (30d RA) as a quality measure. We studied the hospital as the unit of analysis and asked what hospital and clinical factors, in the context of patient factors, influence 30d RA after primary total hip arthroplasty (THA).

Methods: Medicare 100% national hospital claims were used to identify 442,333 elderly patients (65+) with a primary THA in 3,730 hospitals between 2010-2013 based on ICD-9-CM codes. We used a 1-year look back period before the index THA to compute patient factors, including comorbidities; hospital volume; and surgeon volume. We developed multi-level logistic regression models using clustered data structures to investigate the risk of 30d RA, incorporating hospital, clinical, and patient factors. We studied the hospital geographic location (rural/urban); bed size; and hospital type (e.g., profit/nonprofit, teaching/nonteaching) as hospital factors; and length of stay (LOS), discharge status (home vs. SNF), and perioperative transfusion as clinical factors.

Results: We observed wide geographic variation in 30d RA among hospitals (range: 0-33%, ave±SD: 7.5±9.6%, Median: 5.8%). Patients in the west had 9-14% lower RA risk (p < 0.0001). Besides geography, hospital procedure volume (p = 0.0002) and nonprofit ownership (odds ratio: 1.10, p = 0.0007) were the only significant hospital factors among those we studied. Overall, clinical factors explained more of the variation in RA rates than general hospital factors. Use of a perioperative transfusion was associated with 14% greater risk (p<0.0001); patients discharged to home had 28% lower risk (p < 0.001); surgeon volume and LOS were also significant (p<0.0001). These effect sizes were at least comparable to patient factors, such as age, gender, comorbidities, and socioeconomic status. The top five most frequently reported primary reasons for 30d RA in THA were procedure related: dislocation (5.9%), deep infection (5.1%), wound infection (4.8%), periprosthetic fracture (4.4%), or hematoma (3.4%).

Conclusions: In light of the impressive variability we observed among hospitals across the US, the results of this study suggest several different potential strategies for reducing 30d RA after THA by optimizing clinical pathways. Although previous studies have focused on patient factors and readmission due to medical-related reasons that were unrelated to surgery, we were surprised to observe the opposite tendency among THA for the Medicare population, in which the top five reasons were procedure-related at 30 days.

Significance: These findings support further optimization of the delivery of care—both intra-op and post-op—to reduce the broad variation in hospital readmissions.
The Feasibility and Impact of Using Large Administrative Databases to Evaluate the Significance of Obesity as a Risk Factor in Total Hip Replacement

Menachem M. Meller, MD; Mark H. Gonzalez, MD; Nader Toossi, MD; Edmund Lau, MS; Min-Sun Son, PhD; Norman A. Johanson, MD

Introduction: In orthopedic patients undergoing total joint arthroplasty (TJA), medical co-morbidities contribute to prolonged hospitalizations, hospital re-admissions and re-operations. Morbid obesity represents 6% of the US population and is overly represented in individuals presenting for THA.

Methods: A pilot study was done to evaluate the validity of BMI (Body mass Index) data in total joint arthroplasty. Retrospective administrative claims data was reviewed from 3 institutions for a 3-year period involving total hip replacements. The CMS LDS (Medicare) 100% inpatient data was then accessed to establish any correlation between patient outcomes and BMI obesity codes.

Results: In the pilot study the sensitivity of the 278.x code for capturing obesity status was 67.7%. The sensitivity of the V85.xx code for capturing obesity status (as non-obese, obese, or morbidly obese) is 100%. There were no cases where an obesity code was attached to a non-obese patient. The CMS LDS 100% inpatient data 2011-2013 was then accessed regarding the effects of BMI on clinical outcomes. Dependent variables were DVT, death, pulmonary embolism, readmission, implant failure, periprosthetic infection, revision, pneumonia, renal failure and wound dehiscence. A significant dose-response relationship was demonstrated with regards to wound dehiscence, (HR 11.0), revision (HR3.2), periprosthetic infection (HR 5.3) and renal failure. Hospital cost analysis revealed a charge difference of $9,754 between obese and non-obese patients and a reimbursement difference of $2,047.

Discussion and Conclusion: As we transition from volume to value based orthopedics it will be important to have an objective basis to define quality. We have identified specific complications and risk factors which correlate with increasing degree of obesity. This data may be of benefit in patient counseling and risk stratification considerations.
Effect of Surgical Technique on Reducing Total Cost in Primary Hip Arthroplasty: A Study of Medicare Payment Data

Karim Ahmed Elsharkawy, MD; William Murphy; Daniel Le, MD; Robert W. Eberle; Carl T. Talmo, MD; Stephen B. Murphy, MD

Purpose: Evolving payment models create new opportunities for assessment of patient care based on total cost over a defined period of time. The new Federal program entitled The Bundled Payment for Care Initiative created new opportunities for the assessment of surgical interventions. The purpose of the reported study was to assess the total reimbursement for care as a function of surgical technique in primary total hip arthroplasty (THA).

Methods: The total reimbursement for services performed following primary THA for patients insured by Medicare was analyzed for a group of patients at a single institution (FY 2013 and 2014). The population included data on 356 patients who had surgery performed by seven surgeons who used the same pre-operative education, OR, PACU, PT, nursing, and case management. A total of 38 patients underwent THA by an anterior exposure, 219 had surgery performed by a posterior exposure, and 99 had surgery performed by the superior exposure utilizing patient-specific mechanical surgical navigation. Patients were unselected with the exception of the anterior hips which represented 38% of the surgeons THA practice. Reimbursement for all in-patient and out-patient services performed over the initial 90-day period from surgical admission was compared across surgical techniques. Reimbursement includes the sum of all payments including the hospital, physicians, skilled nursing facilities, home care, out-patient care, and readmission.

Results: Total average 90 day cost was $24,848 for THA performed using posterior exposure, $21,446 for the selected anterior exposure, and $20,268 for the superior exposure with navigation. The cost of care for treatment by the superior exposure with navigation was statistically significantly less than the posterior exposure (p<0.001) but not significantly less than the selected anterior exposure patients (p=0.287). Medicare in-patient reimbursements for patients treated by the superior exposure with mechanical surgical navigation was significantly less than the selected anterior exposure group (p<0.002) and the posterior exposure group (p<0.001). Overall, 84% of patients with the superior exposure were discharged directly to home versus 69% in the selected anterior group and 60% in the posterior group.

Conclusion and Significance: The current study demonstrates the potential influence of surgical technique on the direct cost during the first 90-days following THA. While preoperative education, multimodal analgesia, and early mobilization have been emphasized as variables critical to better outcomes, the current data demonstrate that refined surgical techniques create the opportunity for further cost reduction.
Early Failure in Total Hip Arthroplasty: An Institutional Analysis of 20.374 Primary Hips
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Introduction Understanding the prevalence and causes of early revision Total Hip Arthroplasty (THA) is essential for guiding research, implant design, clinical decision-making, and health-care policy.

Objectives We aimed to evaluate the overall survival rate, the mechanisms and trends of early failure, and predictors of THA revision within a 5-year follow-up period.

Materials Utilizing a prospective THA registry all THA patients who have undergone both a primary (5/2007 to 12/2012) and subsequent revision THA on the same hip within 5 years were identified. The analyzed variables included baseline demographics, medical co-morbidities, primary diagnosis, cause of failure, average length of stay (LOS), type and timing of revision THA procedure, and intraoperative and postoperative complications during the primary procedure. The time to failure was stratified in two groups to further investigate trends throughout the study period: < 2 years and 2 to 5 years. Univariate analyses using Wilcoxon ranksum for continuous variables and Fisher's Exact Test or the chi-square test for categorical variables were performed. Multivariable Cox proportional hazards and logistic regression models were developed to identify risk factors for early THA revision. Kaplan-Meier survival rates were estimated.

Results From May 2007 to December 2012, 20374 consecutive primary THAs were performed and 549 (2.7%) underwent subsequent revision within 5 years. The Kaplan-Meier survival estimates were at 1 year: 98.7%; 2 years: 98.2%; 3 years: 97.7%; 4 years: 97.2%; and 5 years: 96.9%. Within the first 2 years, 372 (1.8%) hips underwent revision. The leading cause of failure and associated time (in months) to revision were dislocation (47.6%, 6.2±6.5), followed by periprosthetic fracture (15.2%, 3.4±5.2), mechanical failure (13.9%, 14.6±7.5), mechanical loosening (10.4%, 9.7±7.2), infection (9.4%, 5.4±5.5), and other (2.9%, 7.5±7.5), p=.0001. The “mechanical failure” group encompassed the development of adverse local tissue reaction due to metal on metal arthroplasty, and implant breakage (ceramic liner and hip stem). Between 2 to 5 years, 177 (0.9%) hips were revised. The leading cause of failure and associated time (in months) to revision was mechanical failure (64.7%, 38.4±9.0), followed by dislocation (17.9%, 38.1±7.5), mechanical loosening (9.8%, 40.0±12.3), infection (5.8%, 41.1±12.3), periprosthetic fracture (2.3%, 35.8±2.5), and other (0.7%, 30.5±0), p=.0001. Longer LOS (HR 1.08, p<.001), and accidental vessel or nerve laceration (HR 12, p=.0005) during primary surgery were risk factors leading to early revision. Compared to the 2 to 5
years revision group, patients were more likely to have had their revision within 2 years if they were older (OR 1.03, CI 1.02 1.05), had a primary diagnosis of fracture, posttraumatic arthritis, and congenital disorder (OR 4.8, CI 2.1 11.3), suffered from depression (OR 2.1, CI 1.2 3.6), were obese (OR 2.5, CI 1.2 5.5), and received more blood transfusions (OR 1.7, CI 1.1 2.7) during primary surgery.

**Conclusions** Although the trends of early failure mechanisms change throughout the 5-year period, instability and mechanical failure remain the leading causes. Our results suggest that potentially modifiable surgery- and patient-related factors, including effective intraoperative blood management, anemia, obesity, depression and other neurological disorders increase the risk of undergoing early revision THA.
An International, Cross-Sectional Survey of the Management of Periprosthetic Femur Fractures around Total Hip Arthroplasties

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Background: Primary and revision total hip arthroplasty (THA) volumes are increasing, leading to a concomitant increase in periprosthetic femur fractures (PPFF’s). These occur at an incidence of 1% and 4% after primary and revision THA, respectively. There is a growing need for a consensus on the management of these injuries. This survey was designed to assess the treatment preferences, management, and evaluation of PPFF’s by orthopaedic surgeons.

Methods: Orthopaedic surgeon members of the Orthopaedic Trauma Association (OTA), the Hip Society, and the Canadian Orthopaedic Association (COA) were invited to participate in an online survey regarding the management of PPFF’s. The survey had five sections: management strategies; technical considerations; outcome measures; complications; and perceived need for future research. Responses were stratified by practice type, case volume, surgeon age, and fellowship training. Statistical analysis was performed.

Results: The survey was completed by 96 orthopaedic surgeons internationally. Conservative treatment was favoured for isolated greater and lesser trochanter fractures. Open reduction and internal fixation (ORIF) with locked plating was favoured over cable plating for fractures around a stable stem. Revision arthroplasty with plating was favoured over revision arthroplasty with allograft strut for fractures around a loose stem. Revision arthroplasty with allograft strut was the preferred treatment for proximal femur fractures with significant bone. Surgeons preferred locked plating for fractures below the femoral stem.

Responders believed the choice between locked plating and cable plating does not influence infection, malunion, and non-union rates. The rate of reoperation was perceived to be higher for the locked plate. Subgroup analysis revealed that surgeon age, fellowship training, case volume, and practice type influenced surgeons’ management of PPFF’s and beliefs regarding complications. Conclusion: There is a lack of consensus among orthopaedic surgeons about the best management of particular subtypes of PPFF’s and a need for robust studies to address this.
What Is the Benefit of Staphylococcal Screening and Treatment Prior to Elective Hip/Knee Arthroplasty?
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Introduction: Deep infection following elective total joint arthroplasty is a devastating complication. Preoperative nasal screening for Staphylococcus aureus colonization and subsequent treatment of colonized patients is one proposed method to identify at-risk patients and decrease surgical site infections (SSI). The purpose of this study was to determine 1) if a preoperative Staphylococcal screening and treatment program would decrease the incidence of SSI in elective joint replacement patients and 2) if non-Staphylococcal infections would become more prominent among those patients who developed a SSI.

Methods: Beginning in January 2009, all patients having an elective joint replacement were screened prior to surgery for methicillin resistant Staphylococcus aureus (MRSA) and methicillin sensitive Staphylococcus aureus (MSSA) with nares swabbing. All patients with positive nares colonization for MSSA or MRSA were treated with mupirocin and chlorhexidine gluconate (CHG) showers for five days prior to surgery. All patients scheduled for elective joint replacement used CHG antiseptic cloths the evening prior to and the day of surgery. Perioperative infection rates were compared one year prior to five years post-implementation.

Results: 13,717 patients (4962 hips, 8755 knees) underwent primary joint replacement between January 2008 and December 2014. The SSI rates have decreased from 0.89% (pre-screening) to 0.27% (nasal screening) (p<0.05) following initiation of the decolonization protocol. Staphylococcal species represented 91.7% of the infecting organisms prior to the routine screening, whereas, Staphylococcal species only characterized 42.7% of the infecting organisms following screening and decolonization (p<0.05).

Discussion/Conclusions: The addition of MRSA/MSSA nares screening pre-operatively and bathing with CHG antiseptic cloths evening before and day of surgery has resulted in a decreased SSI rate by 70% following primary total hip and knee arthroplasty. Conversely, routine Staphylococcal screening and decolonization may result in a greater propensity to develop a non-Staphylococcal infection among those who develop a postoperative SSI.

Summary: Staphylococcus aureus surveillance and treatment prior to elective hip/knee arthroplasty can reduce SSI rates, however, may lead to the increased prevalence of other causative organisms.
Nasal Decolonization of S. Aureus Reduces Surgical Site Infections in TJA Patients: A Meta-Analysis
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Purpose: Surgical site infection (SSI) after total joint arthroplasty (TJA) remains a serious complication. The most commonly isolated organism in SSIs in TJA patients is Staphylococcus aureus, including methicillin-resistant S. aureus. Although a number of studies have examined the effect of pre-operative S. aureus decolonization on rates of SSI, the results have varied. Additionally, many of these studies have been underpowered. To the best of our knowledge, there have been no meta-analyses that have assessed the pooled effect of these studies, in order to better clarify the effect S. aureus decolonization has on the rate of SSI after TJA.

Methods: We performed a meta-analysis of studies published between April 1999 and April 2015 that report the comparative rates of SSI after TJA between decolonized patients and historical or concurrent controls.

Results: Seventeen studies were eligible for inclusion, representing a total of 39,145 patients undergoing TJA. Decolonization protocols reduced the risk of SSI by 40.5% (Pooled OR: 0.595 [0.438-0.810]). Moderator (sub-group) analysis demonstrated that chlorhexidine treatment (OR: 0.757 [0.559-1.025]) was less effective than mupirocin and/or vancomycin (OR: 0.403 [0.236-0.690], p=0.045). No significant differences were found for empiric decolonization versus active surveillance protocols (p=0.435), or for standard culture versus polymerase chain reaction (PCR) testing (p=0.739).

Conclusions: SSI following TJA is significantly reduced in patients who are decolonized of S. aureus. The most effective protocols may consist of mupirocin nasal ointment and perioperative vancomycin, although the risk of SSI is not entirely eliminated.

Significance: A meta-analysis of 17 studies demonstrated that prophylactic nasal decolonization of S.aureus reduces the odds of surgical site infections in total joint arthroplasty patients by 40.5%.
Preoperative Celecoxib and Postoperative Aspirin Reduce the Incidence of Heterotopic Ossification after Total Hip Arthroplasty

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Introduction: Heterotopic Ossification (HO) is a common occurrence after total hip arthroplasty, affecting up to 90%. Studies have shown that NSAIDs can serve as prophylactic agent following THA, but there exists no definite prophylactic strategy. The purpose of this study is to examine the incidence and severity of HO following a multimodal pain protocol with local steroid infiltration.

Materials and Methods: Between October 2014 and November 2015, a retrospective study was performed on 678 consecutive primary THAs with minimum one-year follow-up, performed between January 2009 and December 2013. All patients underwent THA and received a multimodal pain protocol consisting of preoperative celecoxib, local cocktail infiltration intraoperatively which contained 40 mg of methylprednisolone, postoperative celebrex and ketorolac, Tylenol for breakthrough pain and aspirin or warfarin thromboprophylaxis. All patients had pre- and post-operative radiographs examined and classified for HO using the Brooker Classification. Inter-observer reliability was calculated for both incidence of HO and Brooker Classification.

Results: 98 (14.1%) patients presented with HO following THA. The incidence of mild HO was 12.3% (38 - Brooker 1; 46 - Brooker 2) and severe HO was 1.7% (11 - Brooker 3). No patients had Brooker 4 or required surgical excision. The most effective components of this pain protocol appeared to be the use of preoperative celecoxib (400mg; OR: 0.35; 95% CI: 0.18 to 0.68; p < 0.01) for pain control and postoperative aspirin (325 BID; OR:0.34 ; 95% CI: 0.20 to 0.51 ; p < 0.01) for DVT prophylaxis. Risk factors for HO included being male and hypertrophic OA. Three patients (0.43%) required reoperation for infection.

Conclusion: To our knowledge, this is one of the lowest reported incidences of HO using multimodal pain control. Celecoxib and aspirin which were used for pain control and DVT prophylaxis respectively, appear to have the most prophylactic effect at reducing the incidence of HO.
References:


Risk Stratified VTE Prophylaxis Following TJA: Aspirin and SPCD’s Versus Aggressive Chemoprophylaxis

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A risk-stratified VTE prophylaxis protocol that avoids aggressive anticoagulation in TJA patients with standard risk reduces post-operative complications and cost, maintaining low incidence of DVT/PE.

Background: Venous thromboembolism (VTE) is a major concern following total joint arthroplasty (TJA). Traditionally, aggressive anticoagulation agents such as enoxaparin, warfarin, and rivaroxaban have been the standard of care in the prevention of VTE disease. Unfortunately, these aggressive VTE chemoprophylaxis agents may be associated with increased post-operative complications, including: bleeding, infection, wound problems and need for readmission and/or reoperation. Current recommendations from the American Academy of Orthopaedic Surgeons (AAOS) and CHEST state that for patients in which a lower risk for VTE is present, aspirin combined with the use of sequential pneumatic compression devices is considered adequate VTE prophylaxis.

Methods: A total of 2664 total hip and knee arthroplasty procedures performed at one institution over a 12 month period were retrospectively reviewed comparing VTE events and bleeding-related complications between two cohorts. Cohort 1 consisted of 6 consecutive months of patients treated based on a prior VTE protocol in which all patients received aggressive chemoprophylaxis agents. Cohort 2 consisted of 6 consecutive months of patients being treated based on a new risk-stratification protocol. A screening questionnaire consisting of four VTE risk factors: 1. history of VTE; 2. cancer is active issue; 3. current smoker; 4. morbid obesity [BMI ≥ 40] was utilized to determine VTE chemoprophylaxis. Patients with zero of the four VTE risk factors received aspirin 325 mg twice daily in combination with sequential pneumatic compression devices to be worn 18 hours per day for 28 days, while patients with one or more risk factors received aggressive anticoagulation agents. All other clinical pathways were identical. VTE events, infections, hematomas, wound complications and readmissions/reoperations related to these events were recorded.
Results: 1256 TJA procedures in Cohort 1 were compared to 1408 procedures in Cohort 2. The Risk-stratified protocol cohort (Cohort 2) had a lower incidence of VTE, readmission rate, and overall adverse events than the group treated with aggressive anticoagulation (Cohort 1). In addition, subgroup analysis within Cohort 2 showed that patients receiving aspirin with no risk factors for VTE had fewer VTEs and adverse events and was much more cost effective than treating all patients with aggressive chemoprophylaxis.

Conclusions: A risk-stratified, post-operative VTE chemoprophylaxis protocol that avoids aggressive anticoagulation in TJA patients with standard VTE risk reduces post-operative bleeding, infections, readmissions, and reoperations, while maintaining low rates of DVTs and PEs. By improving outcomes and reducing cost, we increased the value of care provided to our TJA patients.

Level of Evidence: Therapeutic, Level III (retrospective cohort study)
Oral and Intravenous Tranexamic Acid are Equivalent at Reducing Blood Loss Following Total Hip Arthroplasty

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Introduction: Tranexamic acid (TXA) is an antifibrinolytic that has been shown to reduce blood loss and the need for transfusions when administered intravenously (IV) in total hip arthroplasty (THA). An oral formulation of the medication is available, at a fraction of the cost of the IV preparation. The purpose of this randomized controlled trial was to determine if oral administration is equivalent in terms of minimizing blood loss in primary THA.

Methods: In this double-blinded, placebo-controlled trial, 89 patients undergoing primary THA were randomized to receive 1.95g TXA orally two hours preoperatively, or a 1g TXA IV bolus in the OR prior to incision. The primary outcome was reduction of hemoglobin. Power analysis determined 28 patients were required in each group with a ± 1.0g/dL hemoglobin equivalence margin between groups with an alpha of 0.05 and a power 80%. Equivalence analysis was performed with two-one sided t-tests (TOST) where a p-value of <0.05 indicates equivalence between treatments.

Results: 43 Patients received IV TXA, 40 received oral and 6 were excluded for protocol deviations. Patient demographics were similar between groups suggesting successful randomization. The mean reduction of hemoglobin between oral and IV groups were similar (3.67g/dL vs 3.53g/dL; p=0.0008, equivalence). Similarly, mean total blood loss was equivalent between oral and IV administration (1339ml vs 1301ml; p=0.034, equivalence). Three patients in the oral group and one in the IV group were transfused (p=0.35), and none experienced a thromboembolic event.

Conclusion: Oral TXA provides equivalent reductions in blood loss in the setting of primary THA, at a cost of $14 compared to $47 to $108 depending on the IV formulation selected. With over 300,000 primary THA performed in the United States annually, a switch to oral TXA would yield total cost savings of $10 to $28 million per year for our health care system.
Magnetic Resonance Imaging as Biomarker of Adverse Local Tissue Reactions in Total Hip Arthroplasty

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Purpose: Radiography (1), MRI (2), and serum metal ion levels (3) are available to assess patients with THA but which test is optimal for predicting the presence of adverse local tissue reactions (ALTRs) remains unclear. We performed MRI of individuals with different THA bearing materials to determine which factors are predictive of abnormal synovial reactions.

Methods: Following IRB approval and informed consent, THA subjects undergoing revision surgery were enrolled. A total of 78 THAs have been evaluated to date: metal-on-metal (MOM, n=14), hip resurfacing (HRA, n=9), modular metal-on-poly (mMOP, n=22), metal-on-poly (MOP, n=21), ceramic-on-poly (COP, n=9), and ceramic-on-ceramic (COC, n=3). Morphologic (4) and susceptibility reduced images (5) were acquired. Images were evaluated for the presence and type of synovitis, synovial thickness and volume, and additional factors as previously described (6). Targeted tissue samples based on MRI acquired during revision surgery were scored using Campbell (7), Natu (8), and Fujishiro (9) grading methods. Statistical Analysis: Continuous and categorical variables were compared between bearing surfaces using Kruskal-Wallis and Fisher exact tests, respectively. Post-hoc pairwise comparisons between MOM and MOP and the other bearing surfaces were performed when p < 0.05. P-values were adjusted for multiple comparisons.

Results: MOP patients tended to be older, p=0.016, but gender distribution was similar across bearing types. The proportion of individuals with synovitis varied by bearing, p=0.004, but median
synovial volume and thicknesses were similar. Assignment of synovium category varied by bearing, p<0.001. MOMs had similar prevalence of ALTR to mMOP, p=0.6. HRAs had a greater prevalence of ALTRs than MOPs, p=0.03, but not MOM, p=1.0. MOPs had a greater prevalence of polymeric appearance than all other implants, including mMOPs, p<0.004. MRI-derived ALTR severity correlated strongly to Fujishiro lymphocyte layers, p<0.001, and MRI diagnosis of polymeric reactions correlated to nonmetallic particles on Fujishiro grading, p=0.002.

**Conclusion:** MRI detected different synovial reactions to THAs with different bearing materials. Histologic evaluation correlated to MRI findings. Grading on MRI may permit detection of an implant specific synovial response. The similar synovial thicknesses indicate a host-specific variable response to implants at risk.

**Significance:** THAs of different bearing materials produce detectable MRI differences in the local synovial tissue. Pre-revision MRI allows for accurate definition of the magnitude and quality of the synovial response and permits targeted biopsy.

**References:**


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**Pseudotumors Associated with Metal-on-Metal and Metal-on-Polyethylene Hip Implants May Not Correspond to Type IV Hypersensitivity Reactions**

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**Introduction:** Pseudotumors are aseptic inflammatory lesions that arise in soft tissues surrounding Metal on Metal (MoM) and Metal on Polyethylene (MoP) implants in response to ionic metallic particles. Their etiology is unknown, but the presence of mononuclear infiltration suggests an important role of the immune response in their pathogenesis. Cytokines are proteins responsible for the intercellular communication of the immune system, and have been related to the pathogenesis of most immune system modulated human diseases; however, there is no description of their role in the development of pseudotumors. The present study aims to evaluate the presence of specific cytokines in pseudotumor tissues, in order to begin to understand the etiology and pathogenesis of these adverse reactions at a molecular level.

**Methods:** Biopsied periprosthetic tissues from ten pseudotumors (5 MoM and 5 MoP), and five controls (MoM without pseudotumors) were ground under liquid nitrogen, and the obtained pellets resuspended in buffer. An experienced musculoskeletal pathologist confirmed the histology. Aliquots of 100g total protein were used to semi-quantitatively assess the concentration of 120 human cytokines by incubation in a sandwich-ELISA antibody array (G1000 Human Cytokine Array, Raybiotech). The detection was performed with streptavidin-conjugated fluorescent dye and read in a laser scanner with a wavelength of 532nm. T-test for independent samples was applied to determine differences in cytokines concentration between groups. Significance was considered when p-value was lower than 0.05.

**Results:** A total of 27 cytokines showed a significantly higher concentration in MoM pseudotumors than in MoP pseudotumors, 18 had a higher concentration in MoM pseudotumors than in Controls, and none showed a higher concentration in MoP than in MoM pseudotumors. No difference was
observed in the concentration of cytokines related to hypersensitivity reactions (Il-4, Il-5, Il-9, Il-13, Il-16, Il-17), but higher concentration of monocyte chemotactic cytokines (MCP1, MCP2, MCP3, MSP-alpha) and fibroblast stimulating proteins (FGF-6, FGF-7 and bFGF) were found in MoM pseudotumors than in controls.

**Discussion:** The overall higher concentration of cytokines in MoM than in MoP agrees with previous observations of higher cellularity and mononuclear infiltration in MoM than in MoP pseudotumors. The pattern of cytokines observed in pseudotumors compared to controls suggests that non-specific chronic inflammation and not a type IV hypersensitivity reaction is the initiator of their development. This study should not be considered as proof that the formation of a pseudotumor is not initiated by a type IV hypersensitivity reaction as our numbers are small, but it should be a stimulus for further work in this area.
Metal-on-Metal: Making Sense of Blood Cobalt and Chromium Ion Concentrations

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Introduction: Adverse local tissue reactions (ALTR) have been associated with the use of metal-on-metal (MoM) bearings and the monitoring of Cobalt (Co) and Chromium (Cr) ion levels in blood or serum is a way to assess in vivo the wear of these bearings. However, the relationship between Co and Cr ion concentrations and the formation of ALTR remains unclear. We aimed 1) to investigate the relationship between ALTR and serum Co and Cr ion concentrations, and 2) to identify the clinical factors influencing the formation of ALTR, in patients treated with MoM hip arthroplasties.

Materials and methods: Three hundred and eighty three patients with MoM hip resurfacing or a stem type MoM total hip arthroplasty using the same acetabular component had serum metal ion studies. Metal artifact reduction sequence magnetic resonance imaging (MARS MRI) was performed on 63 subjects with a contact patch to rim (CPR) distance of less than 10mm and elevated metal ion studies, or symptoms that could not be explained by conventional imaging methods.

Results: The median Co was 12.7µg/L for the patients with ALTR and 1.5µg/L for the patients without ALTR (p = 0.0001). The median Cr was 12.8µg/L for the patients with ALTR and 1.9 µg/L for the patients without ALTR (p = 0.0001Logistic regression showed a threefold increase in chances of developing an ALTR when Co or Cr ion levels were 7 µg/L or greater (p = 0.0001). A low (< 10mm) CPR distance was the strongest predictor of ALTR formation. Stem-type MoM THA had higher median Co and Cr levels than HRA.

Discussion: Ion levels alone are insufficient predictors for an effective screening for ALTR. MoM bearings require a precise implantation of the acetabular component. And patients with HRA and MoM THA should not be treated with the same follow-up protocol.
Myocardial Cobalt Levels Are Elevated After Joint Arthroplasty and Associated with Cardiac Pathology

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Purpose: Orthopedic joint implants commonly contain elemental metal that may undergo wear-related release. Recently, cases of implant-associated myocardial injury have been reported; however, we are not aware of any study that has systematically measured myocardial metal levels or examined the relationship with arthroplasty.

Methods: Archives of our institution’s total joint registry and autopsy registry were cross-queried for autopsies of individuals that underwent hip, knee or shoulder replacement with cobalt-chrome components (1990-2011). Eighty age- and sex-matched, non-arthroplasty controls were procured. Demography, implant type, and the presence of heart disease were abstracted from the medical record. Myocardial tissue samples were acid-digested using closed vessel microwave digestion, diluted with internal standards, and analyzed for cobalt (Co) and chromium (Cr) by inductively coupled plasma mass spectroscopy. Wilcoxon rank-sum, chi-square tests, and Kruskal-Wallis tests were used to assess differences between cohorts.

Results: Ninety-four Co/Cr-on-polyethylene arthroplasty cases were included (mean age 77.4 years; 46.8% women). Baseline cardiac risk factors were statistically similar between groups. 77 (81.9%) cases had at least one hip replacement at the time of death. Significantly higher myocardial concentrations of Co were observed in individuals with arthroplasty compared to controls (median 0.105 vs. 0.077 µg/g, p=0.003) (Figs.1 and 2). Median Co was 62% higher in hip patients that had undergone revision versus no revision (p=0.008). In general, the highest Co levels were observed in those with multiple replaced joints. Cardiomegaly and fibrosis were observed more frequently in the postmortem samples of patients with implants (p=0.002 and p=0.025, respectively).

Conclusions: This is the first study to our knowledge that quantifies metal levels in cardiac tissue in patients with and without joint replacement. The elevated Co levels, in concert with cardiomegaly and increased interstitial fibrosis found during autopsy in the arthroplasty cohort, are novel findings. Additional study is needed to more fully characterize the clinical implications of this association.

Significance: This study demonstrates that Co levels are increased in the myocardium of patients with Co/Cr-containing prosthetics and that increased Co levels are correlated with pathologic cardiac changes.
Fig 1. Myocardial cobalt concentration quartiles are shown in patients with TJA (left) versus controls (right).

Fig. 2 (A) Scatter plot shows myocardial cobalt concentration (Log10 [Co(µg/g)]) in patients with TJA (left) versus controls (right). (B) Scatter plot shows myocardial chromium concentration (Log10 [Cr(µg/g)]) in patients with TJA (left) versus controls (right). Values of 0 µg/g are shown in red.
Incidence and Magnitude of Metal Ion Levels in Blood with Large Ceramic and Metal Femoral Heads: A Prospective Study with Five-Year Follow-Up

Peter B. White, BA; Allina Nocon, MPH; Sandra Fong, BS; Morteza Meftah, MD; Amar S. Ranawat, MD; and Chitrnanjan S. Ranawat, MD

Introduction: There is a recent recognition of the trunionnosis and trunion failure. The incidence and magnitude of metal ion release at the head-neck junction with large ceramic and metal heads has not been studied in a prospective manner.

Materials and Methods: Between June of 2014 and January 2015, 60 patients with non-cemented total hip arthroplasty (THA) using a titanium (TMZF alloy) femoral stem with highly cross-linked polyethylene were included and followed for minimum 5 years: 30 THA had large (32- or 36-mm) metal and 30 THA had ceramic femoral heads. Cobalt, Chromium and Nickel levels were measured in all patients.

Results: Patients with metal heads had elevated Cobalt and Chromium levels. Cobalt level was elevated in 17 (56.7%) patients with a median of 1.4 μg/L and a mean of 2.0 μg/L (range: <1.0 μg/L to 10.8 μg/L). Chromium level was elevated in 5 patients (16.7%) with a mean of 0.3 μg/L (range: <1.0 μg/L to 2.2 μg/L). All patients with ceramic heads had Cobalt and Chromium levels below 1 μg/L. Cobalt and Chromium levels were significantly higher with metal heads compared to ceramic heads (p <0.01). The incidence and magnitude of elevated Cobalt levels was significantly higher with 36-mm (77.8%) metal heads compared to 32-mm heads (25%) with a mean 2.2 μg/L and 0.0 μg/L, respectively (p < 0.01). All ceramic THA were asymptomatic. Seven patients with metal femoral heads had mild hip symptoms with four patients with positive findings of early adverse local tissue reaction on MRI. Two patients with metal heads and symptoms were revisited to ceramic heads and titanium sleeves.

Conclusions: Incidence of Cobalt and Chromium levels is higher in large metal heads compared to large ceramic heads (p <0.01). The elevated levels of Cobalt and Chromium ions can cause adverse soft-tissue reactions. Role of trunion size and metallurgy of the stem may play a role and needs to be further studied.

References:
New Algorithm Precisely Depicts Margin-of-Safety in Cup Wear Patterns with Respect to CPR Clinical Data

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Use of “CPR” distance has proven clinical utility in stratifying risks of “steep cups” in MOM failures.[1, 4] The CPR indice has been defined as distance between point of intersection of the hip reaction force (Fig. 1: vector-R in contact patch) and closest point on the inner cup rim.[4] However, the CPR indice has limitations. It assumes that, (1) the hip load-vector (R) will be angled 10°-medial in all patients, (2) the contact patch (Fig. 1: red-colored pattern) will be same size in all patients, and (3) the contact patch will be invariant with increasing MOM diameter. In contrast it is known from retrieval studies that larger MOM bearings created much larger wear patches.[3] Furthermore, the size of cup wear-patches in MOM bearings can now be estimated with some certainty using simulator wear data.[2] Our objective was to develop an algorithm that would predict (i) contact-patch size for all cup designs and diameters, (ii) determine actual margin of safety (Fig. 1: MOS) for different laterally-inclined cups, and (iii) predict critical test angles for “steep” cup studies in hip simulators.

The ‘CPR-distance’ (Fig. 1) is subtended by the CPA angle, but the true margin of safety is the distance from edge of wear patch (Fig. 1: red-colored pattern) to cup rim, indicated here by MOS angle. In this algorithm the wear-patch size (CAP angle) is a key parameter, as derived from MOM wear data (Fig. 2). The CAP angles decrease with increasing MOM diameter, as defined by strong linear trend (R=0.998). The key 2nd parameter is cup inclination angle that juxtaposes the wear-pattern to the cup rim (CCI). For hemispherical cups the critical inclination is given by CCI = 90 – CAP/2, where articulation angle ABA = 180°. The cup bearing-surface is typically reduced < 180° (sub-hemispherical profile, instrumentation groove, rim bevel, etc). These effects are grouped under ‘rim-detail’, as defined by RD = (180–ABA)/2 (Fig. 1). Thus critical inclination any cup is given by CCI = 90° – (CAP/2) – RD = (ABA – CAP)/2. The margin-of-safety (Fig. 1) is then represented by the equation MOS = 100 – (CIA + CAP/2 + RD).

Applicability of the new algorithm can be visualized with a 48mm MOM (cup ABA=160°) run in a standard simulator test (Fig. 3.1). The algorithm predicts that with cup at 40° inclination there is good margin of safety (11.8°), representing a 5mm distance. This would become much reduced at CIA=50°, while true edge-wear appears at the 60° test inclination (Fig. 3. EW = -8.2°). For clinical comparison with ‘CPR-distances’, the algorithm shows that positioning the wear patch 10°-medial (Figs. 1) has margin of safety averaging 11.5 mm (MOS) less than was predicted by the CPR indice (Fig. 3.2). While CPR has shown clinical utility, it is believed that compensating for actual size of the wear-patterns in different cup diameters provides a more realistic and more sensitive risk assessment at the different inclinations (Fig. 3.2: red-marked zones). Thus the new algorithm permits accurate depiction of cup wear-patterns for use in both clinical and simulator studies.
Fig. 1

48mm cup
ABA = 160°

Fig. 2

Wear-pattern angle (CAP°)

Dia 28mm
CAP 73.4°

Dia 38.5mm
CAP 64.4°

Dia 54.5mm
CAP 50.8°

Dia 60mm
CAP 46.1°

CAP° = 97.266 - 0.85257*Dia
R = 0.998

Cup Diameter (mm)
The Natural History of Metal-On-Metal Articulation for Primary Hip Arthroplasty: A Mid to Long-Term Follow-Up Study

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**Introduction:** The complication of pseudotumors in patients who have undergone large-head metal-on-metal (MOM) THA is well documented. It is widely known that symptomatic pseudotumours in MOM THA result in early revision. However, the outcome of asymptomatic pseudotumors or of MOM articulations without pseudotumors is less well understood. The aim of our study was to investigate the natural history of primary MOM THA at mid to long-term follow up.

**Methods:** Seventy-one patients were prospectively followed up after Institutional ethics review board approval. All these patients underwent metal on metal hip arthroplasty using a Metasul LDH implant with a Durom acetabular cup and an M/L Taper stem (Zimmer Inc, Warsaw, IN, USA) between Sep 2005 and Oct 2008. The average age at surgery was 56 years (range 34 to 68 years). There were 24 female patients. All patients had serum trace metal ions testing; ultrasound imaging; and patient reported outcome measures at mean 3.5 years (early follow up) after index surgery (range 3 to 5 years) and at mean 7 years (range 6.5 to 9 years) follow up (mid to long term).

**Results:** All patients showed elevated serum trace metal ions (Cobalt and Chromium) above the reference range. At mean of 5 years (range 3 to 6 years), eight patients with pseudotumours underwent revision THA for symptomatic MOM THA. The average time between positive ultrasound scan and revision surgery was 12.9 months (range 5 to 22 months).

Twenty-two patients (30.9%) had positive ultrasound scan for fluid, cystic or solid mass at early follow up. This included the 8 patients who underwent revision THA (11% of MOM THA or 36.4% of early positive ultrasound scans). Three patients did not present for repeat scans. Of the remaining 11 patients 9 (40.9%) had persistent positive ultrasound scans but remained asymptomatic and 2 (9%) patients showed complete resolution of any fluid or cystic lesions.

Eight patients (16.3%) with normal ultrasound scan at early follow up showed new onset fluid, cystic and or solid lesions on ultrasound at mid to long term follow up. Of these, 4 were conclusively diagnosed as pseudotumour.

**Conclusion:** Approximately 11% patients who undergo MOM THA and 36% of patients with a positive pseudotomour on ultrasound at early follow up undergo revision arthroplasty at mid to long-term follow up while majority remain asymptomatic and require regular surveillance. The incidence of new onset ultrasound findings suggestive of pseudotumors at mid to long-term follow up is approximately 16%.
Simplifying the Current Risk Stratification for Metal-on-Metal Patients
Daniel K Hussey; Rami Madanat, MD, PhD; Gabrielle S Donahue; Ola Rolfson, MD, PhD; Charles R Bragdon, PhD; Orhun K Muratoglu, PhD; Henrik Malchau, MD, PhD
1Harris Orthopaedic Laboratory, Massachusetts General Hospital, Boston, USA; 2Harvard Medical School, Department of Orthopaedic Surgery, Boston, USA; 3Department of Orthopaedics, Institute of Clinical Sciences, Sahlgrenska Academy, University of Gothenburg, Sweden

Purpose: When following patients with metal-on-metal (MoM) hip replacements, current evidence suggests that orthopaedic surgeons should avoid reliance on any single investigative tool. In 2014, guidelines for stratifying patients with MoM hip replacement into groups of low, medium, and high risk of failure based on multiple criteria were published. However, such risk stratification guidelines can be difficult to interpret due to the numerous risk factors related to MoM hip replacements. This is especially true for patients with various (high and low) risk levels for different criteria within the guidelines.

The first purpose of this study was to assess if a scoring system can be applied to the current MoM guidelines. The second purpose was to test, using this scoring system, how the contemporary guidelines would classify a cohort of patients with a recalled MoM hip replacement system.

Methods: The study population consisted of 605 patients (676 hips) enrolled from September 2012 to February 2015 in a multicenter follow-up study of a recalled MoM hip replacement system at a mean of 6.2 (range 2.4 – 10.3) years from index surgery. The scoring criteria were determined based on existing follow-up algorithm recommendations. For each criterion, a low risk grade was scored as 1 point, medium risk as 2 points, and high risk as 3 points. To calculate the MoM risk score for each patient, the assigned values for each of the criteria were summed and averaged, producing a score of 1.0 - 3.0.

Results: By April 2015, 29 patients had been revised. The median MoM risk score for unrevised hips (1.73) was lower compared to revised hips (2.00) (p < 0.0001). 96% of revised patients were considered medium-high risk (risk score ≥ 1.85), while 63% of unrevised patients were considered medium-high risk and 37% were low risk. A MoM risk score ≥ 1.85 had a 10.0-fold increased odds of revision (p < 0.0001).

Conclusion: The MoM risk score is an effective tool for applying the current risk stratification guidelines to a cohort of patients with a MoM hip replacement. Due to the nature of the recalled MoM replacement system, many of the unrevised patients in our study should be closely followed, and may require revision, according to recent guidelines.

Significance: This scoring system is one way to simplify the interpretation of current risk stratification guidelines for patients with MoM hip replacements.
Revision of Monoblock MoM Total Hip Arthroplasty
Is There a Place for Dual Mobility Without Cup Extraction?
Clint Wooten, MD; Brian Park, MD; Steve Marwin, MD; Jeffrey Mokris, MD; Bryan Springer, MD; Thomas Fehring, MD; John Masonis, MD

High complication rates have been reported when monoblock metal on metal (MoM) hips are revised. Dual mobility is a viable option for treatment of failed monoblock metal on metal THA. Early complications are significantly lower (3% vs 20%) when compared with complete acetabular revision.

Introduction: High complication rates have been reported when monoblock metal on metal (MoM) hips are revised. Such complications include aseptic loosening of the revised cup, extraction induced acetabular fracture and dissociation as well as instability and infection. One strategy to the problem of ALTR in monoblock MoM hips requiring revision is conversion to a dual mobility polyethylene bearing without cup extraction. We asked whether this strategy had a lower complication rate then formal acetabular revision.

Materials and Methods: A review of our institution’s total joint registry identified 34 patients who underwent revisions of monoblock metal on metal THAs to a dual mobility construct between January 2013 and December 2014. Mean patient age was 64 (range, 27-86), and 65% of patients were women. There were no hips lost to follow-up. All hips met initial inclusion criteria which included a cementless, non-modular metal-on-metal implant with revision to a dual mobility construct. Major complications including instability, infection, aseptic loosening, and wound complication were documented and compared to a group of patients who had formal acetabular revision of a monoblock MoM component.

Results: Of the 34 patients undergoing dual mobility revision, there was 1 early complication - instability requiring formal acetabular revision (.3%). Of the 114 patients who underwent formal acetabular revision, there were 28 early complications (20%). These complications included aseptic loosening (6%), deep infection (6%), dislocation (4%), acetabular fracture(3%), superficial infection (2%), infected hematoma (2%), hematoma (1%), and delayed wound healing (1%)

Conclusion: Dual mobility is a viable option for treatment of failed monoblock metal on metal THA. Early complications are significantly lower (3% vs 20%) when compared with complete acetabular revision. Longer follow up is needed to demonstrate the effectiveness (wear rate) of these articulations that were not designed or wear tested for use in this exact articulating environment. This technique is only appropriate in fully hemispheric monoblock cups with smooth inner surfaces in good position. This technique should not be used in cups that are less than a hemisphere with a sharp inner rim (ASR) or in cups in poor position that could lead to edge loading.
How Do Material, Geometry, and Vertical Load influence Trunnion Torsional Strength?
Jeffrey J. Cherian, DO1; Laura Scholl2; Gregg Scmidig2; Jaroslaw Karwowski2; Michael A. Mont, MD1
1Sinai Hospital, Baltimore, MD; 2Stryker Orthopaedics, Mahwah, NJ

Introduction: Using modularity in THA has provided surgeons with more options to replicate the appropriate leg length, femoral anteversion, and offset. These additional modular junctions provide an additional interface for fretting and crevice corrosion. This study evaluated the strength of commercially available head-stem taper combinations to determine the effect of taper geometry, materials, and vertical loads on taper junction torsional strength and distraction force.

Methods: CoCr femoral heads (44mm +0mm) were tested with Ti6Al4V trunnions that were machined with small and large type 5°40’ taper whereby the larger one had 8% more surface area (Table 1). Heads were assembled onto trunnions with a 2kN axial load. Each combination was then tested dynamically by applying 0 to 5Nm for 500 cycles. A 2,450N vertical load was held during testing. Upon completion, a static torque test was performed on the same head-trunnion specimen where the same axial load was maintained and the trunnion was rotated to 20° at a rate of 3°/sec. Static torque tests were performed on additional groups where the axial load was maintained at 50N or 4000N. The heads were then removed from the trunnions by axially distracting the trunnion at a rate of 5mm/min. Data from dynamic tests was used to calculate angular displacements. From static tests, torque and frictional energy at 1° was evaluated, as 1° value is correlated to a substantial amount of rotation between the head and stem trunnion.

Results: Torques applied during the dynamic test produced elastic angular displacement of the trunnion in all specimens (Table 2). When comparing trunnion material and taper geometry, the differences in torques, frictional energies, and pull-off forces were not statistically different between any two specimen groups. When considering vertical load, torque and pull-off forces both statistically increased as vertical load increased. There was no statistical difference in frictional energy between high and low vertical load groups.

Conclusion: Vertical load applied during testing had a significant effect on both torque required to rotate the trunnion and distraction force. In theory, this may suggest that higher physiological loads result in better stability of the head-taper junction. Despite the results demonstrated here, further studies are needed to analyze several factors such as head material and sizes, patient activity levels, impaction angles to make a confirmatory conclusion. This study has helped further elucidate some of the factors relevant to trunnion failure.
Table 1. Specimen Group Details (n=5 per group)

<table>
<thead>
<tr>
<th>Specimen Group #</th>
<th>Taper Geometry</th>
<th>Trunion Material</th>
<th>Vertical Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Small</td>
<td>B-Titanium alloy (Ti-12Mo-6Zr-2Fe)</td>
<td>2450N</td>
</tr>
<tr>
<td>2</td>
<td>Large</td>
<td>Ti6Al4V alloy</td>
<td>2450N</td>
</tr>
<tr>
<td>3</td>
<td>Small</td>
<td>Ti6Al4V alloy</td>
<td>2450N</td>
</tr>
<tr>
<td>4</td>
<td>Small</td>
<td>Ti6Al4V alloy</td>
<td>50N</td>
</tr>
<tr>
<td>5</td>
<td>Small</td>
<td>Ti6Al4V alloy</td>
<td>4000N</td>
</tr>
</tbody>
</table>

Table 2. Results – Static Torque to Failure and Pull-Off

<table>
<thead>
<tr>
<th>Specimen Group</th>
<th>Torque at 1⁰ rotation (Nm)</th>
<th>Frictional Energy to 1⁰ rotation (Nm*⁰)</th>
<th>Pull-Off Force (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20.59 ± 2.66</td>
<td>0.26 ± 0.20</td>
<td>10378 ± 2130</td>
</tr>
<tr>
<td>2</td>
<td>24.76 ± 1.83</td>
<td>0.35 ± 0.16</td>
<td>8877 ± 986</td>
</tr>
<tr>
<td>3</td>
<td>18.67 ± 2.84</td>
<td>0.20 ± 0.10</td>
<td>8141 ± 1923</td>
</tr>
<tr>
<td>4</td>
<td>12.60 ± 3.13</td>
<td>0.19 ± 0.10</td>
<td>378 ± 742</td>
</tr>
<tr>
<td>5</td>
<td>23.53 ± 0.83</td>
<td>0.34 ± 0.15</td>
<td>15026 ± 3693</td>
</tr>
</tbody>
</table>

Figure 1: Image of mechanical testing performed
Figure 2: Effects of geometry and material on dynamic rotation.

![Effect of Geometry and Material on Dynamic Rotation](image)

Figure 3: Effect of Taper Geometry and Material Combination

![Effect of Geometry and Material on Torque to Failure](image)

![Effect of Geometry and Material on Frictional Energy](image)
Figure 4: Effect of Vertical Load

Figure 5: Pull-off Tests
**Soft-Tissue Impingement in Dual Mobility Components: A Proposed Mechanism of Intraprosthetic Dislocation using Cadaver Models and Retrievals**

*Nebergall AK; Freiberg AA; Rubash, HR; Greene ME; Malchau H; Muratoglu O; Rowell S; Zumbrunn T; Mangudi Varadarajan K*

**Purpose:** The large diameter polyethylene liner of the dual mobility implant provides increased resistance to hip dislocation. However, intraprosthetic dislocation (IPD), secondary to loss of the retentive rim, causes the inner head to dissociate from the liner. We hypothesized that impingement of the liner with the soft-tissue inhibits liner motion, thereby facilitating load transfer from the neck to the liner, leading to loss of retentive rim over time. This mechanism of soft-tissue impingement was evaluated via cadaver experiments, and retrievals were used to assess polyethylene rim damage.

**Methods:** Total hip arthroplasty was performed on 10 cadaver hips using 3D printed dual mobility components. For fluoroscopic visualization, metal wires were embedded into outer surface of the liner, and a wire was sutured to the iliopsoas. Tension was applied to the iliopsoas to move the femur from maximum hyperextension to approximately 90° of flexion for the purpose of visualizing the iliopsoas interaction with the liner. Fifteen retrieved dual mobility liners (for reasons other than IPD) were assessed for rim edge and rim chamfer damage. Rim edge damage was defined as any evidence of contact, and rim chamfer damage was classified into six categories.

**Results:** Manipulation of the cadaver specimens through full range of motion showed liner impingement with the iliopsoas tendon and hip capsule in low flexion angles, which impeded liner motion. At high flexion angles impingement was not observed. When observing the hip during maximum hyperextension, 0°, 15°, and 30° of flexion, under fluoroscopy, there was obvious tenting of the iliopsoas complex. All retrieved components showed damage on the rim and chamfer surface. The most common damage seen was scratching. There was no association between presence of damage and time *in vivo* controlling for age and Body Mass Index (p≥0.255).

**Conclusion:** The cadaver studies showed that the mobile liner motion could be impeded by impingement with the iliopsoas tendon and hip capsule. Visual and fluoroscopic observation showed that the iliopsoas and hip capsule impinge on the distal portion of the mobile liner, particularly during low flexion angles. All retrieved liners showed damage despite their limited time *in vivo* and despite being retrieved for reasons other than IPD. This suggests that soft-tissue impingement may inhibit liner motion routinely *in vivo*, resulting in load transfer from the femoral neck on to the rim of the liner. This may be an important contributor to IPD.

**Significance:** Soft-tissue impingement may be an important mechanism for IPD in dual mobility systems.
Biomechanical Analysis of Deformation in Mobile Bearing THA Acetabular Components
John B. Meding, MD; Scott R. Small, MS; Renee D. Rogge, PhD;
Christine A. Buckley, PhD; Jordan W. Oja, BS; Merrill A. Ritter, MD
Joint Replacement Surgeons of Indiana Foundation, Inc.
and
Rose-Hulman Institute of Technology

Purpose: There is very little published data documenting component deformation and implantation characteristics in cups designed specifically for mobile bearing THA. The purpose of this study was to analyze the insertion and deformation characteristics of mobile bearing acetabular components.

Methods: Deformational response was performed for two cementless, mobile bearing THA cup designs: a CoCr anatomic monoblock shell and a hemispherical Ti6Al4V shell (Restoration® ADM™ and Tritanium®, respectively Stryker Orthopaedics, Mahwah, NJ). 46 mm, 54 mm and 64 mm monoblock and 48 mm, 54 mm, and 64 mm modular cups were impacted into solid rigid polyurethane biomechanical testing blocks. Monoblock 46 mm and 64 mm cups were reamed line-to-line and 1 mm over cup diameter, while the 54 mm cups were reamed 1 mm under, line-to-line, and 1 mm over cup diameter. Deformation along the rim of the implanted cups was measured utilizing digital image correlation. Maximum cup and liner compression and expansion were compared utilizing analysis of variance.

Results: A maximal axial load of 10 kN failed to fully seat 64 mm and 54 mm monoblock cups with line-to-line reaming as well as the 54 mm monoblock cups in 1 mm under-reamed scenarios. In the 1 mm over-reamed monoblock cohorts, mean insertion forces ranged from 5113 N in the 54 mm cups to 6153 N in the 64 mm cups. All modular cups exhibited low mean insertion forces between 5707 N and 6652 N, significantly lower than the under-reamed and line-to-line reamed one-piece cups of the same size (p<0.01). Cup deformation in the monoblock components increased with increasing cup size. In line-to-line reaming the 54 mm cups exhibited 28% (p=0.007) greater deformation than the 46 mm cups. Likewise the 64 mm cups exhibited 73% (p<0.001) increased deformation compared to the 46 mm line-to-line cups. A 1 mm increase in reamed diameter to an over-reamed setting decreased deformation by 48% (p<0.001), 41% (p<0.001), and 22% (p=0.003) in the 46 mm, 54 mm, and 64 mm cups respectively. Modular components exhibited lower deformation in both cup and liner than one-piece components following liner insertion (p=0.013).

Conclusion: Over-reaming by 1mm led to substantial reduction of insertion force and rim deformation. Increased deformation in larger cup sizes should be taken under consideration when utilizing these designs, particularly in high-density bone.

Significance: Reduced deformation and required insertion force in the tested modular cups may lessen the risk for wear and frictional torque generation.
References


Unfulfilled Functional Expectations Following Joint Arthroplasty Procedures

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Baylor College of Medicine, Houston, TX; 2Institute of Orthopedic Research and Education, Houston, TX

Purpose: Most patients undergoing joint replacement procedures have defined expectations of activities they will be able to perform without symptoms following recovery. A significant percentage of these patients report an inability to perform these activities following surgery. The purpose of this study was to examine the types of functional deficits reported after joint arthroplasty, how frequently these limitations occur, and the demographic of patients who experience/report these limitations.

Methods: Four groups of subjects were enrolled in this study: 111 hip resurfacing patients at approximately 14 months after resurfacing; 170 patients at approximately 16 months post-primary THA; 502 patients at approximately 12 months post-primary TKA, and 64 control subjects with no history of hip or knee surgery or pathology. Each participant completed a self-administered Hip Function Questionnaire, Knee Function Questionnaire, or Hip Resurfacing Questionnaire which assessed each subject’s overall satisfaction and expectations following surgery. The questionnaires included numerical scores of post-operative function as well as an open-ended question which inquired “Is there anything your knee/hip keeps you from doing?”

Results: A population of patients self-reported specific functional deficits after surgery, including 29 (26.1%) resurfacing, 5 (2.9%) THA, and 134 (26.7%) TKA. The unfulfilled functions varied based on the procedure, with most resurfacing and THA patients reporting trouble with running/jogging, while TKA patients experienced difficulty kneeling. A similar incidence of functional limitation was reported by male and female patients undergoing the same procedure. (THA: Males (0%) vs females (6%) p=0.021; TKA: Males (37.4%) vs. females (23.1%) p=.001) Patients who reported functional deficits had a higher incidence of dissatisfaction with the procedure. The mean age of those who reported deficits versus those who did not report deficits was not significant.
**Conclusions:** A significant portion of patients experience functional limitations following these procedures. The frequency and types of limitations vary with the expectations of the patient and are most common after hip resurfacing and TKA. The gender of the patient appears to play a role in whether specific functional deficits are reported or not, with female patients more likely to report after THA and male patients slightly more likely to report after either hip resurfacing or TKA.

**Significance:** A small portion of hip resurfacing, THA, and TKA patients report specific unfulfilled functions following surgery. The frequency and types of deficits, and the demographic of patients reporting them, varies based on the procedure.

<table>
<thead>
<tr>
<th>Surgery</th>
<th>Total</th>
<th>Male</th>
<th>Female</th>
<th>Avg Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resurfacing</td>
<td>111</td>
<td>84</td>
<td>21</td>
<td>54.7</td>
</tr>
<tr>
<td>THA</td>
<td>170</td>
<td>84</td>
<td>81</td>
<td>61.3</td>
</tr>
<tr>
<td>TKA</td>
<td>502</td>
<td>139</td>
<td>363</td>
<td>75.2</td>
</tr>
</tbody>
</table>

Table 1. Patient Characteristics
Prior Lumbar Spinal Arthrodesis Increases Prosthetic-Related Complications and Revision Surgery after Primary Total Hip Arthroplasty

David Sing; Erik Hansen, MD; Thomas Parker Vail, MD
Department of Orthopaedic Surgery, University of California, San Francisco

Purpose: Eighteen percent of patients who undergo total hip arthroplasty (THA) have coexisting degenerative lumbar spine diagnoses, known as the ‘hip-spine syndrome’. Limited data on this cohort suggests that they may have inferior functional improvement and pain relief. The purpose of this study is to test the hypothesis that prior lumbar spine arthrodesis (SA) increases the risk of complications within 2 years following primary THA.

Methods: We retrospectively analyzed the prevalence of prior lumbar SA among 811,601 Medicare patients undergoing THA from 2005-2012 using the Pearldiver database. Patients with history of spinal arthrodesis undergoing hip arthroplasty (SAHA) were stratified by length of fusion construct (1-2 levels [SAHA<3] vs 3 or more levels [SAHA≥3]. The main outcome measure was the relative risk of developing prosthetic-related complications and undergoing revision arthroplasty within 24 months comparing SAHA and control THA patients. Chi-squared testing was performed to compare for differences.

Results: Out of 811,601 patients undergoing primary THA, 16,574 (2.0%) SAHA patients were identified. 12,757 (1.6%) patients were identified as SAHA<3 and 3,817 (0.4%) patients were identified as SAHA≥3. The relative risk of developing any prosthetic complication within 24 months compared to control was 1.52 (95% CI [1.42,1.63]) for SAHA<3 patients and 1.93 (95% CI [1.73,2.15]) for SAHA≥3 patients. Two-year revision arthroplasty rate was 3.4% in the control group, 5.6% for SAHA<3 patients (RR 1.62, 95% CI [1.46,1.78]), and 7.8% for SAHA≥3 patients (RR 2.26, 95% CI [1.95,2.62]).

Conclusion: Spinal arthrodesis, especially longer segment fusions, significantly increases the risk of prosthetic-related complications, dislocation, and revision after primary THA.

Significance. Prior lumbar fusion constitutes an independent risk factor for a less than optimal outcome after total hip replacement. Prior lumbar fusion should be considered by patients, surgeons, and payers in risk assessment and determination of value after total hip replacement.
<table>
<thead>
<tr>
<th></th>
<th>No Prior Fusion (%)</th>
<th>Prior Fusion (&lt;3 Levels) (%)</th>
<th>Prior Fusion (≥3 Levels) (%)</th>
<th>Prior Fusion (&lt;3 Levels) RR</th>
<th>Prior Fusion (3+ Levels) RR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dislocation</td>
<td>2.36</td>
<td>4.26</td>
<td>7.51</td>
<td>1.81 (1.62, 2.02)</td>
<td>3.19 (2.74, 3.70)</td>
</tr>
<tr>
<td>Loosening</td>
<td>1.33</td>
<td>2.10</td>
<td>3.04</td>
<td>1.58 (1.35, 1.85)</td>
<td>2.29 (1.81, 2.90)</td>
</tr>
<tr>
<td>Periprosthetic Fracture</td>
<td>0.87</td>
<td>1.31</td>
<td>1.35</td>
<td>1.51 (1.23, 1.84)</td>
<td>1.55 (1.09, 2.20)</td>
</tr>
<tr>
<td>Infection</td>
<td>1.84</td>
<td>2.87</td>
<td>3.86</td>
<td>1.56 (1.36, 1.79)</td>
<td>2.10 (1.72, 2.59)</td>
</tr>
<tr>
<td>Any Complication</td>
<td>7.33</td>
<td>11.15</td>
<td>14.16</td>
<td>1.52 (1.42, 1.63)</td>
<td>1.93 (1.73, 2.15)</td>
</tr>
<tr>
<td>Revision</td>
<td>3.43</td>
<td>5.55</td>
<td>7.77</td>
<td>1.62 (1.46, 1.78)</td>
<td>2.26 (1.95, 2.62)</td>
</tr>
</tbody>
</table>
The Effects of Elastic Moduli On Primary THA: A Clinical And Radiographic Follow-Up
Carlos J. Lavernia, Michele D’Apuzzo, Jesus M. Villa, Carlos Naranjo

Introduction: Factors such as larger stem size, stem designs, and material composition have been associated with thigh pain. We wanted to assess the effects of material composition on thigh pain, patient oriented/clinical outcomes, and key radiographic signs of fixation/instability.

Methods: 222 cementless primary THAs (Trilock, DePuy) performed in 192 patients by a single surgeon were prospectively studied. All patients received identically shaped tapered cementless stems. Two types of stem alloy were utilized: CoCr-Mo (n=82) and Ti-6Al-4V (n=140). Outcomes studied included postoperative thigh pain (pain diagram, present yes or no), pain intensity/frequency visual-analogue-scale (VAS; range, 0-10), QWB-7, SF-36, hip-Harris score, and WOMAC. The presence of spot welds and pedastals on the latest radiographs were also noted. Comparisons between groups were made controlling for race (MANCOVA). Mean follow-up: 7.8 years (range, 2-17 years). Alpha was set at 0.05.

Results: Thigh pain was not different between the groups [CoCr-Mo (4%) Vs. Ti-6Al-4V (10%)] (p=0.2). The level of pain was very low in both groups. Globally both groups obtained significant pain relief, however, CoCr-Mo stems had a higher mean pain intensity when compared to Ti-6Al-4V stems (2.59 vs. 0.94, respectively; p=0.001). The QWB-7 (0.567 vs. 0.601; p=0.038), hip-Harris (75 vs. 85; p=0.001), and WOMAC-total scores (18 vs. 9; p=0.002) were also worse in the CoCr group. Spot welds were observed in 29% of CoCr-Mo stems and 45% of Ti-6Al-4V stems (p=0.2). Pedastals were evident in 14% of CoCr-Mo stems and 12% of Ti-6Al-4V stems (p=1.0).

Conclusion: The results of our study suggest that, regardless of the stem alloy composition with this tapered stem design, thigh pain was not prevalent or significant with this particular design. However, we found better patient oriented outcomes in the stems made up of titanium alloy. Radiographic parameters were also better in the titanium group.

Significance: The material composition of femoral stems affects patient oriented outcomes in primary total hip arthroplasty patients.
Formal Physical Therapy After Primary Total Hip Arthroplasty May Not Be Necessary
Brian T. Urbani, MS; James J. Purtill, MD; William J. Hozack, MD; Richard H. Rothman, MD, PhD; Javad Parvizi, MD, FRCS; Matthew S. Austin, MD

Introduction: Many surgeons and patients believe that formal outpatient physical therapy (OPT) is necessary in order to optimize the functional outcome of patients undergoing total hip arthroplasty (THA). Limited evidence currently exists to support this belief. The purpose of this prospective, randomized study was to determine the effect of formal OPT on the functional outcome of THA.

Methods: We randomized 77 patients into one of two groups. In Group I, 39 patients received 2 months of formal OPT, with 2-3 sessions per week. In Group II, 38 patients received no formal OPT, but followed a prescribed exercise program on their own for a 2 month duration. Harris Hip Score (HHS), WOMAC, and SF-36 were recorded preoperatively and postoperatively at 1 month and 6 months. The results were analyzed using a linear mixed model with patients as a random effect, and treatment time and treatment group as independent variables.

Results: Preoperative functional scores and demographics between the two groups were similar. There were no significant differences in any measured outcomes at 1 month or 6 months postoperatively. HHS for Group I were 67.67 ± 3.00 at 1 month and 80.19 ± 4.33 at 6 months. Group II had HHS scores of 71.26 ± 3.24 at 1 month and 84.68 ± 3.32 at 6 months (95% CI -12.44, 5.25 and -15.62, 6.63 respectively). Similarly, there were no significant differences in the WOMAC or SF-36 scores at either postoperative interval. Cost to the patient for OPT visits ranged from $10-$60 per session for non-Medicare patients.

Conclusion: These findings suggest that formal OPT is not superior to prescribed, patient-directed home exercises. The value of formal OPT for all patients undergoing primary THA needs to be examined. Based on the findings of this study, we have moved away from routinely prescribing formal OPT for all patients after THA.
Short Stem Cementless Components in THR: Excellent Fixation, Thigh Pain a Concern!!

John J. Callaghan, MD; Richard Amendola, MS; Devon D. Goetz MD; Steve S. Liu, MD

Purpose: Short stem cementless femoral components were developed for ease of insertion, preserve metaphyseal bone, and decrease thigh pain. The purpose of this study was to evaluate the 2 to 4 year clinical and radiographic results of a consecutive series cohort of THR’s performed by a single surgeon using a short stem femoral component. The authors hypothesized that the clinical and radiographic results would be comparable to those where the same surgeon used a standard length taper stem that was inserted with ream and broach technique.

Methods: 261 consecutive THAs were performed in 241 patients by one surgeon between November 2010 and August 2012. A short titanium taper stem was utilized in all cases. Patients rated their thigh pain on a 10-point visual-analog scale. Radiographs were evaluated for bone-implant fixation, bone remodeling, osteolysis and heterotopic ossification (HO). Results were compared to the same surgeon’s previously published consecutive series cohort of standard length ream and broach tapered cementless stems.

Results: 7 patients (8 hips) were deceased, all others were followed. The Tegner and UCLA scores were 2.6 and 5.6 respectively. 72% reported no thigh pain, 18% reported mild thigh pain, 9.7% reported moderate or severe thigh pain. 1 hip was revised for severe thigh pain. Radiographically, 99% had no or mild stress shielding. All but one component demonstrated bone ingrowth fixation (99.5%). The thigh pain rate with this stem was 5 times that of the standard stem and the moderate or severe thigh pain rate was 8 times that of the standard stem.

Conclusion: Excellent femoral fixation (99.5% bone ingrowth) was obtained with this short stem prosthesis. In addition, metaphyseal bone was preserved in 99% of cases. However, the thigh pain rate was substantial and moderate or severe in 10% of cases. The surgeon no longer uses this device.

Significance: The patient reported thigh pain rate in a single surgeon experience using a short tapered stem was 8 times the rate of the same surgeon’s experience with a standard length tapered stem.
Total Hip Arthroplasty for Post-Traumatic Arthritis Following an Acetabular Fracture
Anand Dusad, MBBS; Beau Konigsberg, MD; Justin Makovichka, BS;
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**Purpose:** Fractures of the acetabulum can lead to post-traumatic arthritis necessitating total hip arthroplasty (THA). THA for post-traumatic arthritis can be significantly more complex due to retained hardware, retroversion of the acetabulum, neumuscular damage, and bone loss. The population of patients who suffer acetabular fractures can also be challenging as they may be younger and more active. As a result, THA for post-traumatic arthritis has had a failure rate that is higher than that of THA for osteoarthritis. The results of THA using uncemented acetabular components have demonstrated an improved outcome at early follow-up (mean 5-8 years). The purpose of this study was to determine the long-term outcome in patients with THA after an acetabular fracture. We also asked if the type of fracture pattern and the ability to reconstruct the acetabulum of the anatomic site contribute to the success of THA.

**Methods:** Forty-five consecutive THA’s in patients with a previous acetabular fracture were performed at our institution between 1991-2011. Twenty-six males (27 hips) and 18 females (18 hips) with a mean age of 50 years (range 19-81) were studied. The time from fracture to THA was 3.7 years (0-22 years). A retrospective review of the 44 patients’ (45 hips) medical records was completed. Seven patients (7 hips) were deceased leaving 37 patients (38 hips) available for follow-up. HHS, SF-36, and radiographs were evaluated for evidence of loosening or implant failure. Radiographs were also reviewed to determine fracture pattern and acetabular component placement.

**Results:** At the mean follow-up of 11 years, 2 patients’ hips had been revised (1-osteolysis, 1-loose femur). The fracture pattern (posterior wall, one column or transverse) did not correlate with the outcome. All of the acetabular components were within 1 cm of the anatomic hip. The mean HHS was 82 (SD = 18). The SF 36 mean score was 42 (SD = 10) for the physical component and 50 (SD = 9.6) for the mental component. Complications included 2 intraoperative femur fractures, one post-operative dislocation treated with a closed reduction and no revision. Two revisions included one for a femoral component that had become loose 4 years post-operative and one for acetabular osteolysis 16 years post-operative. One acetabular non-union persisted but the acetabular component was well fixed to the proximal portion of the acetabulum.

**Conclusion:** Total hip arthroplasty for traumatic arthritis of the acetabulum can be successful. It is likely that reconstruction of the hip near the anatomic center of rotation played a role in the success for these patients.
Characterization of Femoral Component Initial Stability and Cortical Strain in a Reduced Stem Length Design

Michael E. Berend, MD; Scott R. Small, MS; Merrill A. Ritter, MD; John B. Meding, MD

**Purpose:** Short-stemmed femoral components are designed to restore joint function while preserving more native bone than traditional designs. As a result of reduced length, shorter stems must maximize primary stability to allow for adequate bone ingrowth for long-term clinical success. This study quantified load distribution in the femur as a result of reduced stem length, while capturing the effect on micromotion between the implanted stem and surrounding bone.

**Methods:** Short, medium, and long-stemmed variations of a currently marketed cementless femoral component were implanted into composite femurs using incremental broaching and manual impaction. For cortical strain analysis, femurs were loaded in single-legged stance with a 2.0 kN joint reaction force and paired 1.4 kN abductor force at the greater trochanter. Additional cyclic axial and torsional loads were used to quantify primary implant stability within the ingrowth surface of the implanted stems. Strain and implant micromotion were quantified using digital image correlation analysis.

**Results:** The medial aspect of the femur demonstrated greatest strain response in all specimens. Cortical strain in short stems most closely matched the strain patterns (within ±7%) of an unimplanted femur. Load shunting the stems was demonstrated, corresponding to an increase in distal strain and decrease in proximal strain with increasing stem length. Torsional loading resulted in greater micromotion response across all stems versus axial loading (p>0.081). Interface micromotion ranged from 0.047 to 0.091 mm in all stems evaluated with no significant difference in primary stability detected as a function of stem length in otherwise identical implants in either axial or torsional loading (p>0.063).

**Conclusion:** Stem length in THA femoral components significantly alters the load distribution and resulting cortical strain patterns in the femur. Long-stemmed components shunt load distally, while short stemmed components more closely mimicked the unimplanted femur model. In both axial and torsional micromotion tests, isolated change in component stem length generated no statistically significant effect on primary implant stability. In cases where adequate bone stock is present in the proximal femur, a short-stemmed design may preserve bone stock while minimally impacting strain distribution across the femur. Reduced stem length did not negatively impact axial or torsional primary stability in this model.

**Significance:** Focus on bone preservation in primary THA has driven a renewed interest in short-stemmed femoral components. This study suggests that, in the patient with high quality proximal bone, short stems may provide more physiological loading without sacrificing primary implant stability.
SESSION X: Direct Anterior and Rapid Recovery THA in 2015

7:33 – 7:38 AM
Paper #: 48

The Direct Anterior Approach is a Risk Factor for Early Failure in Cementless Total Hip Arthroplasty: A Multi-Center Study

Meneghin RM, Elston A, Chen AF, Kheir MM, Fehring TK, Springer BD

Introduction: The direct anterior approach (DAA) for total hip arthroplasty (THA) continues to be marketed heavily with claims of superiority over other approaches. Femoral exposure can be technically challenging and potentially lead to early failure. The purpose of this study was to examine whether DAA is associated with early femoral component failure and revision THA.

Methods: A retrospective review of 484 consecutive early revision THAs at three academic centers from 2011 to 2014 was performed. Surgical approach for the primary procedure was unavailable for 40 hips, leaving 444 early revision THAs for analysis. Early revision was defined as being within 5 years of the primary THA. Hemi-arthroplasties, conversion THAs and re-revisions were excluded. Primary surgical approach was documented for each revision THA, along with the time to revision and etiology of failure. Statistical analysis was performed with p<0.05 considered significant.

Results: The mean time to revision was 4.0 months (range, 0-60). 44.1% of early failures were originally via the DAA, compared to 32.0% via the direct lateral and 23.6% via the posterior approach (p<0.001). Of the 123 femoral component failures due to fracture or aseptic loosening, 47.2% of them were performed through the DAA, compared to 17.1% for the posterior approach (p=0.001). Of the 42 failures due to instability, 47.6% were performed via the posterior approach, compared to 38.1% via the DAA and 14.3% via the direct lateral approach (p=0.002).

Conclusion: Despite the claims of early recovery and improved outcomes with the DAA, this approach is associated with a larger than anticipated percentage of early failures, including femoral component loosening and fractures, within five years compared to the posterior approach. Surprisingly, a relatively high percentage of early failures due to instability were originally performed via the DAA surgical approach, despite claims of minimal dislocation risk.

Significance: This study provides evidence concerning the risks of the DAA that should be considered when contemplating adoption in practice or marketing this surgical approach and should be discussed with patients. Further study in the longer term is required to determine if improvements in instrumentation, training and implementation are able to mitigate the risks reported in this study.
Acetabular Component Positioning with Direct Anterior 
Versus Direct Lateral Approach in Primary Total Hip Arthroplasty 

Adolph V. Lombardi, Jr., MD, FACS; Keith R. Berend, MD; 
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New Albany, Ohio USA 

The direct lateral approach became popular in the 1980s with the introduction of porous, cementless stems in primary total hip arthroplasty (THA), and has been used by the senior author since the beginning of his practice. With the evolution to less invasive modifications, the direct lateral approach continues to provide good direct visualization of the acetabulum to accomplish component positioning based on anatomic landmarks. More recently, the direct anterior approach has gained popularity as studies have reported enhanced early outcomes. One would expect that in using the direct anterior approach assisted with fluoroscopy, acetabular component positioning would be improved compared to the direct lateral approach. The purpose of this study was to retrospectively review a single surgeon experience in primary THA to assess radiographically whether acetabular component positioning in terms angle of inclination and anteversion was improved with the direct anterior versus direct lateral approach, and if there were differences between right and left side hips for a right-hand dominant surgeon. 

After a gradual transition from less invasive direct lateral to direct anterior supine intermuscular approach assisted by fluoroscopy, by 2014 the senior, right hand dominant surgeon was performing a slight majority (53%; 156 versus 47%; 137) of his primary THA cases through the anterior interval. There was a selection bias to use the direct anterior approach in younger, less heavy patients. Mean patient age in the anterior group was 61 years (range 18-87 years) versus 67 years (range 30-96 years) for the lateral group, and mean BMI was 28.4 kg/m² anterior versus 33.5 kg/m² lateral. The goal in acetabular positioning in all cases was 40° of abduction and 20° of anteversion. Immediate postoperative radiographs were measured by a blinded, independent observer (XXX) on a digital picture archiving calibrated system (PACS; IntelePACS, Intelerad, Westminster, CO), using a Cobb angle tool for abduction angle and the method of Widmer (2004) to determine anteversion. 

Results:

<table>
<thead>
<tr>
<th>Measure</th>
<th>Direct Anterior</th>
<th>Direct Lateral</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abduction angle</td>
<td>41.9°</td>
<td>42.1°</td>
<td>0.8</td>
</tr>
<tr>
<td>Frequency of outliers ±5°</td>
<td>60 (38.5%)</td>
<td>59 (43.1%)</td>
<td>0.4</td>
</tr>
<tr>
<td>Anteversion</td>
<td>23.6°</td>
<td>22.8°</td>
<td>0.3</td>
</tr>
</tbody>
</table>
The two approaches yielded similar results for all measures. However, when comparing operative side via the anterior approach, abduction angle was slightly higher in right hips versus left (42.7° versus 41.1°, p=0.04) but no different in terms of outliers or anteversion. For lateral approach hips, abduction angle and frequency of outliers were similar for right versus left sides, but anteversion angle was higher (24.9° versus 21.0°, p=0.007).

In the hands of an experienced joint replacement surgeon, there was no difference in acetabular component positioning when using the direct anterior versus the direct lateral approach. However, the surgeon should be aware that operative side of the patient has an influence on component positioning depending on surgeon hand dominance.
Deep Infection is Less Frequent with the Direct Anterior than the Direct Lateral Approach in Primary Total Hip Arthroplasty

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Purpose: There continues to be debate regarding the advantages and disadvantages of the direct anterior supine intermuscular (ASI) approach to primary total hip arthroplasty (THA). Faster recovery, better implant position, and lower risk of dislocation have been described with ASI. In reviewing our practice experience with ASI it was noted that the rate of deep infection appeared to be very low. The purpose of this study is to compare the rate of deep infection between ASI and a less invasive direct lateral approach (LIDL) in a large consecutive series of primary THA.

Methods: A retrospective review of our institutional database identified 5732 primary THA performed by 3 surgeons between 2007-2014. ASI approach was used in 3550 hips and LIDL in 2168. Patient records were reviewed for reoperations and the indications for reoperation reviewed. Chi-squared analysis for risk of reoperation, infection or wound related complication, and deep infection was performed.

Results: During the 8 year follow-up period there were 98 reoperations in the ASI group (2.9%) and 77 in the LIDL group (3.6%; p=0.09 NS). Wound or infection related reoperation occurred in 32 ASI THA (0.09%) versus 36 LIDL THA (1.2%; P=0.007). Deep infection occurred in 7 ASI THA (0.2%) versus 21 LIDL THA (0.97%; p<0.0001).

Conclusions: While the overall reoperation was not significantly different, the risk of wound or infection related reoperation was significantly lower with ASI THA compared with LIDL approach. Most notably, the risk of deep infection was statistically lower in the ASI approach.

Significance: While multiple reports debate the advantages of the direct anterior approach, this study clearly demonstrates that this approach has a significantly reduced risk of deep periprosthetic infection.
Muscle Biomarkers Are Not an Objective Surrogate Measure of Surgical Invasiveness after Contemporary THA

Kirsten L. Poehling-Monaghan, MD; Michael J. Taunton, MD; Robert T. Trousdale, MD; Rafael Jose Sierra, MD; Mark W. Pagnano, MD

Purpose: Several orthopedic journals published studies comparing total hips done with different surgical approaches where biomarkers of inflammation/muscle damage were the so-called objective outcome measure. This prompted us to ask: do serum biomarkers of inflammation/muscle damage predict pain or early functional outcomes after contemporary THA done with either a mini-posterior or direct anterior approach?

Methods: 100 consecutive THA patients had CK, CKMB, CRP, IL-6, Hbg, Hct, myoglobin, and TNF-a collected preop and on days 1 & 2 and compared with therapy progress, VAS pain scores, and a functional milestone diary of ADLs out to 8 weeks. Advanced biostatistical analysis looked for correlations between biomarkers and pain/function outcomes and sought discreet cut-off values to determine if threshold effects existed.

Results: Biomarkers of inflammation and muscle damage including CK, CKMB, CRP, IL-6, Hbg, Hct, myoglobin, and TNF-a were not correlated with either VAS pain, early function in the hospital or function as measured in a milestone diary after hospital dismissal. By way of example the correlation values for serum creatine kinase (CK) and each outcome measure are included here, are quite low and suggest no useful predictive value: VAS pain (0.213); ambulation in hospital (-0.104), days with walking aids (-0.175), days with opioid pain meds (-0.018), stair climbing (-0.301), driving (-0.210) and return to work (-0.266).

Conclusion: Serum biomarkers including CK, CKMB, myoglobin, CRP, IL-6 and TNF-a did not predict pain or function after contemporary THA done with either a mini-posterior or direct anterior approach. Further reporting of serum biomarkers as a measure of physiological burden after THA should be suspended unless new, robust data establishes clear linear or threshold values.

Significance: Biomarkers of inflammation/muscle damage were not correlated with pain or functional outcome after contemporary THA and should not be used as a surrogate or as a measure of surgical invasiveness.
Accelerated Physical Therapy Rehabilitation Following Elective Primary Total Hip Arthroplasty Facilitates Early Discharge

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¹Orthopedics and Sports Medicine, Houston Methodist Hospital

Background: Accelerated physical therapy protocols are a potential mechanism to achieve early mobilization and safe discharge from the hospital following elective primary total hip arthroplasty (THA).

Questions/Purposes: Does physical therapy (PT) initiated the same day following unilateral, primary total hip arthroplasty (THA) lead to a reduction in the length of hospital stay compared to unilateral primary THA patients starting PT on postoperative day 1?

1) Are there differences in early function before discharge measured by gait distance and total number of PT sessions performed by this patient population prior to discharge?

Methods: This study compared 62 patients who received physical therapy on the same day of surgery (Day 0 PT group) following elective, unilateral THA, versus 50 patients who received physical therapy starting the day after surgery (Non-Day 0 PT group). Using previously published mean length of hospital stay following THA of 4 days and the hypothesized mean length of stay being reduced by at least 0.5 day to 3.5 days, level of significance set at 5%, power of test set at 0.95, and allocation ratio of 1, minimum sample size of 23 subjects in each group would be required to attain a statistically significant difference using non-parametric, Mann-Whitney test.

Results: The difference in the mean length of hospital stay was not statistically significant (2.26 days ± .11 vs. 2.50 days ± .15, p=0.270). Sixteen (16) percent of the patients in the Day 0 PT group were able to meet physical therapy discharge goals and be discharged by postoperative day 1 compared to six (6) percent in patients the non-Day 0 PT group (p=0.041, Fischer’s exact test). On post-operative day 1, the mean gait distance of the patients receiving accelerated physical therapy was significantly higher than the patients who did not (162.4 ± 12.9 feet vs. 118 ± 11.7 feet, p=0.019).

Conclusions: Although a statistically significant reduction in mean LOS was not shown, a greater percentage of patients in the Day 0 PT group were discharged on postoperative day one, which potentially justifies the use of accelerated PT. Accelerated physical rehabilitation represents a way to facilitate achievement of physical therapy goals required for discharge and discharge a greater percentage of patients on postoperative day 1 following elective, primary unilateral THA.

Significance: The study results provide useful information for providers managing total hip replacement patients, with the goal of continuous improvement in postoperative patient care and better resource allocation.
A Multi-Center, Prospective, Randomized Study of Outpatient Versus Inpatient Total Hip Arthroplasty

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The Rothman Institute¹, Anderson Orthopaedic Research Institute²
and Inova Mount Vernon Hospital³

Purpose: This study prospectively evaluates patient-reported satisfaction with outpatient (<12hr stay) versus inpatient (overnight stay) THA in a broad patient population and determines predictive factors for patients unable to be discharged on the planned day.

Methods: A prospective, randomized control trial was performed with two institutions from July 2014 to June 2015. Patients were included if BMI<40 kg/m², age<75 years at surgery, and they were not wheelchair- or walker-bound preoperatively. 209 patients were randomized to outpatient or inpatient hospital stay. Both groups received the same preoperative counseling, perioperative anesthesia/analgesia, and physical therapy. The following variables were measured: visual analog scale (VAS) satisfaction and pain scores, complications and unplanned physician visits, and the number of phone calls to the surgeon’s office.

Results: The outpatient and inpatient groups had similar age (60.0 versus 59.9 years, respectively, p=0.93), gender (p=0.78), BMI (27.3 versus 28.4 kg/m², p=0.07) and preoperative comorbidities (p=0.72).

At 4 weeks, satisfaction with the procedure was higher in the outpatient group (89 versus 81, p<0.001), while satisfaction with the discharge timing was the same (outpatient 90%, inpatient 87%, p=0.79). On the day after surgery, the outpatient group experienced more pain (VAS 4.0 versus 2.8, p<0.001). There were a similar number of complications, physician visits, and phone calls to the surgeon’s office between the groups (p>0.05). 24% (25/106) of patients randomized to outpatient required inpatient stay, and 16% (16/103) of patients randomized to inpatient left on the day of surgery, with no patient factors identified as predictive of discharge failure.

Conclusion and Significance: This Level 1 study demonstrates that patients discharged the same day as their THA have slightly higher satisfaction scores but higher pain scores on the day after surgery. There are no differences in early complications, physician visits, readmissions, and calls to the surgeon’s office postoperatively. However, even with standardized protocols, some patients may require an overnight stay.
The Global Position of the Acetabular Component

Lawrence D. Dorr, MD

To learn the global effect of spine-pelvis and femur on acetabular cup position in THR we studied the lateral spino-pelvic x-rays in three groups of patients: 10 year followup (25 patients); dislocation in the past 10 years (12 patients); and prospective primary THR (60 patients). The prospective group had intraoperative computer values of inclination, anteversion and center of rotation of the cup, and the femur anteversion (so the combined anteversion was known). Correlation was done of spine stiffness (sacral tilt) to the acetabular coverage in sitting and standing positions; wear in the 10 yr group; and the cause of dislocation in that group. Cup inclination changes with spine mobility; cup anteversion changes much less with sitting and these postural positional changes do have influence on the precision of cup placement.
Standing and Sitting Lumbosacral Alignment in Patients Undergoing Hip Arthroplasty - What is Normal?

Christina Ilona Esposito, PhD; Brian Barlow, MD; Han Jo Kim, MD; Theodore Miller, MD; Timothy M. Wright, PhD; Seth A. Jerabek, MD; David Jacob Mayman, MD; Douglas E. Padgett, MD

Purpose: The hip-spine relationship affects pelvic alignment and could impact THA stability, but this relationship is difficult to quantify. Lumbar spine mobility influences sacral slope, a surrogate for pelvic tilt. We measured standing and sitting pelvic alignment in patients with normal and degenerative spine pathology to assess change in pelvic alignment and lumbar lordosis.

Methods: 107 adults with unilateral hip osteoarthritis participated in this IRB-approved prospective study. All patients underwent preoperative standing and sitting simultaneous biplanar radiographic imaging from the thoracolumbar junction to the ankles. For sitting, patients sat on an adjustable stool with the goal for the femur to be parallel to the floor. Two independent observers graded patient lumbar spines as normal or as having multilevel degenerative disc disease (DDD). A third observer measured sacral slope and lumbar lordosis on the lateral standing and sitting images. The sitting hip flexion angle (between the anterior cortex of the femur and vertical) was measured to verify patients were aligned consistently when seated; the average hip flexion angle was 87°±7°.

Results: 56 patients were classified “normal” lumbar spines and 51 as degenerative disc disease. From standing to sitting, 102 patients (95%) had a decrease in sacral slope and lumbar lordosis, indicating forwarded pelvis rotation. In 5 patients, sacral slope increased from standing to sitting indicating forward pelvic rotation. Normal and DDD spines had similar standing and sitting sacral slopes and similar differences from standing to sitting. A strong linear correlation was found between the change in lumbar lordosis and change in sacral slope in all patients (R²=0.75). Seven patients (7%) sat with ≥40° of sacral slope (forward tilting pelvises).

Conclusions: This study showed no significant difference in pelvic alignment occurs for the simple function of sitting in a chair in preoperative THA patients with normal or DDD lumbar spines. This suggests that surgeons need not to increase acetabular component anteversion in patients with DDD to avoid instability. However, some patients sat with forward-tilting pelvis; these THA patients may benefit from increased acetabular cup anteversion.

Significance: While the majority of patients have predictable changes standing to sitting, outliers exist in whom pelvic rotation effectively reduces functional acetabular anteversion. In these patients, consideration of increasing acetabular component version may be appropriate.
Restoration of Normal Anatomy Improves Outcomes
Eight to Fourteen Years After Total Hip Arthroplasty
Paul F. Lachiewicz, MD; Charles R. Bragdon, PhD; Kevin L. Garvin, MD; John M. Martell, MD

Introduction: We evaluated the impact that restoration of normal anatomy has on the Harris Hip Score (HHS) 8 to 14 years after Total Hip Arthroplasty (THA). The binary logistic regression model was made robust by including patients from four academic hip centers.

Methods: To be included in this study patients were required to have an asymptomatic contralateral normal hip with no radiographic indications of arthritis at last follow up and an 8 to 14 year postoperative Harris Hip Score. We were able to find 53 eligible patients out of 300 nonconsecutive cases from the academic centers. Using the femoral head size as a marker, we calculated the following parameters for the prosthetic and normal hips: 1. Distance from the teardrop to the center of the femoral head. 2. The femoral offset. 3. The lever arm ratio. 4. A calculated estimate of the joint reaction force based on 5/6 body weight, the lever arm ratio, and the free body diagram assuming equilibrium in single leg stance.

Taking the normal hip as the ideal reconstruction, we calculated the difference in lever arm ratio between the normal and prosthetic side. To avoid correlation effects a logistic regression was modeled using body weight and the difference in lever arm ratios, (the key components in calculation joint reaction force).

Results: The Harris Hip Scores at long-term follow-up were not normally distributed. In 33 of the 53 cases the HHS scores were greater than 90. The minimum follow-up was 8.3 years with a maximum of 14.4 years. Acetabular inclination angle, radiographic anteversion, lever arm ratio, body weight moment arm, and the abductor moment arm on the prosthetic side were not significantly related to the follow-up Harris Hip Scores.

Although the individual prosthetic lever arm ratio values were not significantly related to Harris Hip Scores greater than 90 at long-term follow-up, the median difference between the prosthetic and normal lever arm ratios was 0.11, 95% CI 0.05-0.37). This value when combined with 5/6 body weight resulted in a significant relationship with long-term Harris Hip Scores. (p= 0.05).

Discussion and Conclusion: To our knowledge, this is the first demonstration that restoring normal anatomy during THA improves clinical outcomes at 8-14 years follow-up. This finding emphasizes the importance of careful preoperative templating and intra-operative implant positioning. Although this model demonstrates significance in predicting HHS at follow up, the biomechanical reconstruction of the hip can be complex. Due to sample size limitations we were unable to determine the most important components of the lever arm ratio for restoring normal anatomy.
Validation of a Simple, Laser-Guided System for Prescribing Acetabular Cup Inclination Angle in Total Hip Arthroplasty

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San Francisco Orthopedic Residency Program1
The Taylor Collaboration2

Purpose: Achieving an accurate inclination angle for the acetabular component in total hip arthroplasty can be technically challenging. The purpose of this study was to validate the accuracy and repeatability of a simple, laser-guided system to address the acetabular component inclination angle, first in a cadaveric model, and subsequently in vivo.

Methods: An inclinometer system was manufactured, consisting of a laser that attaches to both the inclinometer and the handle of a standard trial cup impactor. Whole, fresh human cadavers (N=4) were used in this validation study by three orthopaedic surgeons, one of whom was a novice to the system. A commercially available intra-operative navigation system served as a control. First, a repeatability test was performed by setting the inclinometer to a set angle, positioning it within the specimen, and measuring the linear distance between the resultant laser marks in each of 10 trials. To assess the effect of impaction on accuracy, the laser was mounted on the impactor and aligned to a set target point. After impaction, the final laser point was noted. The linear distance between the target point and final laser position was defined as linear error, and the deviation in inclination and anteversion angles compared to the control were defined as rotational error. 5 trials of the second test were conducted by each surgeon. A clinical validation was also performed in 5 hips in 4 patients. The inclination angle was measured radiographically before and after surgery, and this was compared to the intra-operative angle measured using the inclinometer.

Results: The inclination angle of the trial cup deviated from the desired orientation by 1.1±0.9°. The corresponding error in anteversion angle was 1.4±1.3°. There was no statistically significant difference in inclination angle between expert and novice surgeons. However, anteversion angle error was greater for the novice (2.2±1.7°) than the experts (1.1±1.1°; p=0.03). For all surgeons and across all specimens, linear repeatability was 2.2±1.2 cm/m. Linear error was 4.1±2.5 cm/m. Adjusted linear error and repeatability were not statistically different between expert and novice surgeons. In the clinical validation, the change in inclination angle measured by the inclinometer was -4.6±1.4°, and the change in inclination angle measured radiographically was -0.6±2.2°.
**Conclusion:** Using this system, inclination angles differed from prescribed angles by 1 degree on average, and malalignment in anteversion was subclinical. This suggest that the laser-guided system has sufficient accuracy and repeatability for routine intra-operative use.

**Significance:** A simple, user-friendly, laser-guided inclinometer can be as effective as more expensive and time consuming navigation systems in setting the acetabular cup inclination angle during total hip arthroplasty.
The Cross-Table Lateral Radiograph Remains a Useful Surrogate for CT Scan to Assess Cup Version After Total Hip Arthroplasty

Peter C. Noback, BA; Thomas A. Herschmiller, MBBS; Jonathan R. Danoff, MD; Jacob T. Bobman, MD; Roshan P. Shah, MD; Jeffrey Geller, MD; William Macaulay, MD

Purpose: This study compared cup version values measured from cross-table lateral (CTL) and anteroposterior (AP) pelvis radiographs with version found on computed tomography (CT) scan in a large cohort of total hip arthroplasty (THA) patients.

Methods: A retrospective review of acetabular cup radiographs in 143 patients (150 hips) who underwent THA. Patients were required to have AP and CTL radiographs, and a CT pelvis. Acetabular component version was digitally measured on CTL radiographs and CT scans by two authors blinded to each other’s measurements. Two researchers using a validated software-assisted technique measured cup version from AP pelvis radiograph. Inter-observer reliability was determined for all measured values using inter-class correlation coefficients (ICC). For each pair of measurements, an average angle measure was determined, from which Pearson regression analysis was used to assess the correlation between version angles measured by the three modalities. One-way ANOVA testing was conducted to determine if there was a difference in version values for the three measures, based on gender, age, and body mass index (BMI).

Results: There was high (r>0.8, p<0.01) inter-observer reliability, with ICC values of 0.908, 0.943 and 0.978 for version measured from CTL, CT, and AP pelvis, respectively. Mean version values for CTL and CT scan were 21.7 +/- 11.2 degrees and 23.9 +/- 12.7 degrees, while those calculated from AP pelvis radiographs were 12.4 +/- 12.4 degrees. CTL and CT scan values were closely correlated (r=0.804), while the AP pelvis measurements were only moderately correlated with CTL (r=0.591) and CT (r=0.696). One-way ANOVA testing found that as a whole, all three measures were significantly (p<0.05) different from each other. Furthermore, females had statistically higher version than males as measured on CTL (p=0.039), but this was not true in CT scan and AP pelvis measurements. Age and BMI did not influence any of the measures.

Conclusion: This is the largest cohort study to date comparing common modalities used to assess cup version. Version measures for CTL radiographs and CT scans were highly correlated. Version calculated from standing AP pelvis radiographs led to comparatively underestimated values. This may be due to postural changes in pelvic alignment. The CTL radiograph remains a useful and inexpensively attainable substitute for CT scan when assessing supine version in clinical practice.

Significance: Compare version measurements of acetabular cup position after Total Hip Arthroplasty when evaluated by cross-table lateral and anteroposterior radiographs, and computed tomography scan.
Long Term Follow-up of a Randomized Controlled Trial Using an Active Robotic System for Total Hip Replacement
Nathan Netravali, PhD; William L. Bargar, MD

Background: Two FDA randomized controlled studies (1993-1996, 2000-2006) were performed and these offer the first long-term follow-up of robot-assisted THA using the ROBODOC System for active robotic preparation of the femoral canal.

Methods: Combining the two studies, 125 THA's were performed on 113 patients. Of these 113 patients, 24 were confirmed to have died, 13 have been lost to follow-up, 5 declined to participate due to infirmity, 5 are still recruiting, and 66 currently enrolled. Complete data is available for 53 patients: 34 (39 hips) in the Robot group and 19 (20 hips) in the Control group. Data collected included: Harris Hip Scale, HSQ-12, WOMAC, UCLA Activity Score, VAS Pain Score as well as radiographic analysis. Patients were implanted with the Depuy AML, Howmedica Osteoloc, or Zimmer VerSys FMT. The demographics at follow-up were:

<table>
<thead>
<tr>
<th></th>
<th>Robot (±SD)</th>
<th>Control (±SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male/Female</td>
<td>34/5</td>
<td>8/12</td>
</tr>
<tr>
<td>Index Age</td>
<td>59.51 ± 8.49</td>
<td>59.79 ± 9.42</td>
</tr>
<tr>
<td>Age at Follow-up</td>
<td>74.29 ± 8.40</td>
<td>73.07 ± 7.45</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>29.52 ± 4.23</td>
<td>29.89 ± 6.40</td>
</tr>
<tr>
<td>Follow-Up Length (years)</td>
<td>13.76 ± 3.19</td>
<td>14.17 ± 4.71</td>
</tr>
</tbody>
</table>

Results: There was one revision of the femoral component in each group for a peri-prosthetic fracture. There were 3 reoperations in the Robot group, 2 for head and liner change and 6 in the Control group, 5 for head and liner change. Clinical results are given below:

<table>
<thead>
<tr>
<th></th>
<th>Robot</th>
<th>Control</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revision</td>
<td>3</td>
<td>6</td>
<td>0.04</td>
</tr>
<tr>
<td>HHS Pain Score</td>
<td>42.47 ± 3.52</td>
<td>38.74 ± 7.87</td>
<td>0.02</td>
</tr>
<tr>
<td>HHS Total</td>
<td>94.94 ± 6.60</td>
<td>89.68 ± 10.89</td>
<td>0.03</td>
</tr>
<tr>
<td>HSQ-12 Physical</td>
<td>91.36 ± 16.90</td>
<td>73.81 ± 26.73</td>
<td>0.01</td>
</tr>
<tr>
<td>HSQ-12 Total</td>
<td>706.47 ± 106.06</td>
<td>622.38 ± 99.12</td>
<td>0.02</td>
</tr>
<tr>
<td>WOMAC</td>
<td>6.85 ± 10.38</td>
<td>10.32 ± 10.56</td>
<td>0.25</td>
</tr>
<tr>
<td>UCLA Activity Score</td>
<td>6.44 ± 1.71</td>
<td>5.78 ± 1.52</td>
<td>0.17</td>
</tr>
<tr>
<td>VAS Pain Score (0 – 100 mm)</td>
<td>7.52 ± 18.58</td>
<td>3.61 ± 4.55</td>
<td>0.39</td>
</tr>
</tbody>
</table>

Radiographically, both groups (Robot vs. Control) had similar results for peri-acetabular osteolysis (9.5% vs 13.3%, p = 0.47). Femoral osteolysis was limited to the proximal Gruen zones in both groups and was present in 7 to 11% of hips. Stress shielding was seen primarily in patients receiving the Osteoloc implant.
Conclusions: Prior studies have demonstrated improved implant fit and alignment with the use of this active robot system. This long term study now shows no failures with favorable clinical outcomes for Harris Pain Scores, HSQ 12 Physical and Total Scores at mean follow-up of 14 years. Patient recruitment is still ongoing.
The Association of Acetabular Component Positioning with Total Hip Instability

Anita Sadhu, MD; Benjamin R. Coobs, MD; Denis Nam, MD, MSc; Toby N. Barrack; John C. Clohisy, MD; Ryan M. Nunley, MD; Robert L. Barrack, MD

Purpose: Acetabular component positioning is considered a surgeon-controlled variable affecting stability following total hip arthroplasty (THA). Recently, the relative importance of the traditional “safe-zone” for acetabular component alignment on the risk of dislocation has been questioned in primary THA. Numerous other factors influencing dislocation risk have been hypothesized, including pelvic mobility, functional hip position, femoral version and soft tissue laxity. However, the impact of acetabular alignment in patients who subsequently require THA revision for instability remains unclear. Our objective was to determine the percentage of patients undergoing THA revision for instability who had acetabular component alignment within the traditional “safe zone”.

Methods: This was a retrospective review of an IRB approved database from a single institution from January 2003 through December 2012. Patients undergoing revision THA at our institution for an isolated diagnosis of prosthetic instability who had adequate pre-operative imaging were identified.

Baseline patient demographic and pre-revision implant data was collected. Anteroposterior and cross-table lateral radiographs were analyzed and indices of component positioning prior to THA revision for dislocation measured. The percentage of patients within the current standard target range for inclination (30° to 50°) and anteversion (5° to 25°) as previously published was recorded.

Results: 3188 primary and 749 revision THAs were performed during the study period. 92 patients were identified that met our inclusion criteria (confirmed diagnosis of revision only for prosthetic instability and adequate imaging). All patients were treated by arthroplasty fellowship trained surgeons with strict indications for revision surgery. Of these, the pre-revision THA components were primary in 51 (55.4%) and revision in 41 (44.6%). 60 females (65.2%) and 32 males (34.8%) were included. The average pre-revision acetabular inclination was 48.4° (range 22.15° - 76.90°) and average acetabular anteversion was 22.5° (range p. Of the 92 patients 58.7% fell within the target for inclination (30-50°), 46.6% for anteversion (5-25°), but only 31.8% fell within the target range for both inclination and anteversion.

Conclusion: A prior report from our institution demonstrated 88% of primary THAs were in the target zone compared to only 31.8% of those revised for instability. This indicates that acetabular component position is a major factor, but not the only factor, leading to recurrent instability requiring revision.

Significance: Based on the findings of this study, it is apparent that both component position and other factors play a role in a substantial percentage of THAs revised for instability.
Intermittent PTH Stimulates Bone Formation Rapidly in the Human Femoral Neck

Mathias Bostrom, David Dempster, Jeri Nieves, Hua Zhou, Marsha Zion, Catherine Roimisher, Yvonne Houle, Felicia Cosman.

Background: Intermittent PTH (iPTH) rapidly increases bone formation in cancellous and cortical bone of the iliac crest, ultimately increasing bone mass and reducing risk of vertebral and nonvertebral fractures. However, hip BMD improvements with iPTH are modest and there are no data confirming that iPTH reduces hip fracture risk because the study was underpowered for that outcome.

Objective: In order to learn more about the effects of iPTH on the femur, we performed a double blind trial of iPTH vs Placebo (PBO) in patients about to undergo a Total Hip Replacement (THR) for osteoarthritis.

Methods: Participants were randomized to receive daily iPTH or PBO for an average of 6.1 weeks prior to THR (range 4.6-11.8 weeks). After an average of 3 weeks of study medication, tetracycline labels were administered following standard protocol. During the THR, an intact sample of the femoral neck (FN) was procured, fixed, and sectioned transversely. Four envelopes (cancellous, endocortical, intracortical and periosteal) were analyzed. Mineralized surface (MS/BS) and mineral apposition rate (MAR) were measured and bone formation rate (BFR) calculated. 40 individuals were enrolled (25 postmenopausal women, mean age 71.5+8.0 and 15 men, mean age 68.9+7.7).

Results: Mean BFR by treatment group for each bone envelope is shown in the Table. In both cancellous and endocortical bone, BFR was about 2 fold higher in iPTH than in PBO (p<0.05). In the periosteum, BFR was very high in both iPTH and PBO groups (relative to other envelopes), without significant differences by drug group. There was no difference in BFR between the superior and inferior segments within the placebo groups in any envelope (Table). BFR was greater in iPTH subjects in the superior as compared to inferior segments of the FN (Table) in both the intracortical and endocortical envelopes (p<0.05) and in cancellous bone (p=0.16). However, in the periosteal envelope, inferior segment BFR was higher than superior segment (p=0.08) in the iPTH group.
Conclusions: iPTH stimulates bone formation rapidly in the femoral neck, with prominent effects in cancellous and endocortical envelopes. iPTH had a greater effect in the superior as compared to inferior segments of the FN in all envelopes except the periosteum where the opposite relationship was seen. These findings suggest that there may be an interaction between mechanical load on the femur and iPTH effect and provide a mechanistic basis for iPTH-mediated improvement in hip strength.

<table>
<thead>
<tr>
<th>Bone Formation Indices in the Total Femoral Neck Superior and Inferior Regions by Treatment Group (Mean +/- SD)</th>
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<tbody>
<tr>
<td>BFR/BS (mm$^3$/mm$^2$/yr)</td>
</tr>
<tr>
<td>-----------------------------</td>
</tr>
<tr>
<td><strong>Cancellous</strong></td>
</tr>
<tr>
<td><strong>Endocortical</strong></td>
</tr>
<tr>
<td><strong>Intracortical</strong></td>
</tr>
<tr>
<td><strong>Periosteal</strong></td>
</tr>
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*P-values Wilcoxon 2 sided test (normal approx) **p<0.05 **p<0.01
Adult Reconstructive Surgery – A High Risk Profession for Work-Related Injuries

Michael Tanzer, MD, FRCSC

Introduction: Adult reconstructive surgery is an orthopaedic subspecialty characterized by surgical tasks that are physical, repetitive and require some degree of stamina from the surgeon. This can result in strain and/or injury of the surgeon’s musculoskeletal (MSK) system. Our study aims at highlighting the prevalence of these musculoskeletal disorders among arthroplasty surgeons, in addition to identifying risk factors that may increase their incidence.

Methods: A modified version of the physical discomfort survey was sent to surgeon members of the Hip Society, the International Hip Society and the Canadian Orthopedic Arthroplasty Society via e-mail. After data collection descriptive statistics were analyzed. One-way ANOVA (Analysis Of Variance) and Fisher Exact test were performed for statistical analysis. P values <0.05 were considered statistically significant.

Results: During the data collection period, 174 surgeons completed the survey. The majority of the cohort were male orthopaedic surgeons (97.7%), >55 years old (56.3%) working in an academic institution (67.8%) and have been in practice for >20 years (66.0%) (Figures 1-2).

Overall, 66.1% of the arthroplasty surgeons reported that they had experiences a work-related injury. The most common injuries that occurred were low back pain (28%), lateral epicondylitis of the elbow (15%), shoulder tendinitis (14%), lumbar disc herniation (13%) and wrist arthritis (12%). However, we could not find any association between the number of MSK disorders diagnosed and the age of surgeons, number of years in practice nor case-load.

Overall, 27% of surgeons took time off from work because of the injury. As the number of disorders diagnosed increased, there was significant increase in the incidence of requiring time off work due to the disorder (p<0.001) and also exacerbation of a previously diagnosed disorder (p<0.01). Factors that increased the risk of the surgeon requiring time off due to the disorder were age >55 years, practicing for more than >20 years and total hip arthroplasty procedure >100/year all significantly increased this risk (p<0.05 for all factors). In addition, 26% of the orthopaedic surgeons surveyed required surgery for their injury.

Discussion and Conclusion: Although most studies concentrate on the importance of patient safety and thus the quality of the health care system, the surgeon’s safety is also considered an integral part of this system’s quality. Our study highlights a high prevalence of MSK disorders among arthroplasty surgeons, which not only have a financial effect but also can psychologically affect the practicing surgeon. We aim to increase the awareness of this healthcare burden, leading the way identification of preventive measures directed towards improving the operative surgical environment and work ergonomics for the surgeons.
Surgeon’s Age Distribution (%)

- 30-45 Years Old: 19.8%
- 46-55 Years Old: 24.7%
- 56-65 Years Old: 38.5%
- >65 Years Old: 17.2%

Distribution of Surgeon’s Years in Practice (%)

- 1-10 Years: 14.4%
- 11-20 Years: 21.3%
- 21-30 Years: 46.2%
- >30 Years: 25.9%

Most Common MSK Disorders (%)

- Low Back Pain: 27.6%
- Elbow Lateral Epicondylitis: 14.9%
- Shoulder Tendinitis/Impingement: 14.2%
- Lumbar Disc Herniation: 12.6%
- Wrist OA: 11.5%
- Wrist/Pes Anserinus Tendinitis: 10.3%
**Initial Stability of a Standard Porous Coated Acetabular Component Compared to Highly Porous Component**

*Goldman A, Armstrong L, Owen J, Wayne J, Jiranek W*

*Dept. of Orthopaedic Surgery, VCU School of Medicine, Richmond, VA*

**Introduction:** Short term studies of “Highly porous metal” acetabular components have suggested a decreased rate of aseptic loosening compared to previous registry data. One proposed advantage of rougher “highly porous” acetabular components is an increased coefficient of friction which intuitively should improve initial stability. This study compared resistance to migration. The null hypothesis is that a standard porous coated acetabular cup would show no difference in initial stability as compared to a highly porous acetabular cup when subjected to a bending moment. Secondly, would bone mineral density (BMD) be a significant variable under these test conditions.

**Methods:** Ten fresh frozen human pelvis were prepared using standard surgical technique for a 1 mm press-fit implantation of a standard porous coated component (Depuy Porocoat™, Warsaw, Ind) on one side, with a more highly porous (Depuy Gription™, Warsaw, Ind) component implanted on the contralateral side. Bone mineral density data was also obtained from the femoral necks available for associated specimen. We assessed interface stability using a custom made device outfitted with three linear variable differential transformers attached to the hemipelvis. A cantilever bending moment was applied to each cup, and the force required to move each component was measured.

**Results:** There was no difference in the mean bending moment required to produce 150 microns of motion between the Gription™ (24.6±14.0 N-m) cups versus Porocoat™ (25±10.2 N-m)(p>0.84). There was also no difference in the peak bending moment between the two types of cups (p>0.92). No correlation between bone mineral density and bending moment at 150 microns of displacement could be identified for Porocoat™ (p > 0.34) or Gription™ (p > 0.68).

**Conclusion:** The rougher highly porous metal acetabular shells used in this study did not provide better resistance to migration under bending load when compared to a standard porous coated component. Clinically, the increased surface roughness may not provide as much improved initial stability as might be hypothesized when compared to a standard porous implant.
Sustaining a Teamwork Culture in an Orthopaedic Surgical Unit Through TeamSTEPPS

Soo-Hoon Lee, PhD; Harpal Singh Khanuja, MD; Jeanne Sedgwick, MS, RN; Kathleen Pressimone, MS, RN; Renee Blanding, MD, MPH; James R. Ficke, MD; Lynne C. Jones, PhD

Purpose. Teamwork has been shown to improve patient safety but organizational change toward a team culture has been elusive. The goal of this study was to explore the extent to which a teamwork and patient safety culture is sustained by reinforcement efforts.

Methods. 104 participants comprising surgeons, anesthesiologists/nurse anesthetists, and nursing from an orthopedic surgical unit of an academic hospital in a mid-Atlantic state participated in a 3-hour didactic training session introducing TeamSTEPPS at the end of 2013. Reinforcement Activities began in July 2014 and were comprised of 4 components: (1) 10-15 minute reinforcement of the TeamSTEPPS Leadership module using didactics and video clips during the weekly nursing staff meetings; (2) Powerpoint slides of the concepts covered during each of the nursing meetings was discussed with orthopaedic surgeons at each of their monthly meetings; (c) all TeamSTEPPS concepts were re-introduced during a Grand Round in October 2014 for the anesthesia staff; and (d) the TeamSTEPPS Communication module was reinforced in November 2014 through online self-paced learning. Orthopaedic surgical teams were evaluated before (n=12) and after (n=12) the Reinforcement Activities using the Observational Teamwork Assessment for Surgery (OTAS) tool. The Hospital Survey on Patient Safety Culture (HSOPSC) was completed by individuals at the Training Session and in July and November.

Results. The results of the OTAS Tool indicated that the Leadership and Communication components improved significantly after the Reinforcement Activities by 13.91% and 12.79% respectively (at p < .05). The other teamwork components showed improvement but were not significant at p < .05. The impact of improvements from the Leadership and Communications Modules on the HSOPSC’s Patient Safety Grade and Overall Perceptions on Patient Safety were mixed. While these patient safety scores improved from July to November 2014, the improvements were not significant at p < .05.

Conclusion. The results indicate that reinforcement significantly improved teamwork behaviors but had limited effect on their perception of patient safety.

Significance. Culture change in teamwork requires continual reinforcement. Reinforcement Activities must be customized for different groups based on their schedules, interests, and education.
Pulmonary Embolism Rates Following Total Hip Arthroplasty with Prophylactic Anticoagulation: Some Pulmonary Embolisms Cannot be Avoided

Jay R Lieberman\(^1\), Vincent Cheng\(^1\), Mark P Cote\(^2\)

\(^1\)Department of Orthopaedic Surgery, Keck School of Medicine, University of Southern California, Los Angeles, CA, USA
\(^2\)Department of Orthopaedic Surgery, Orthopaedic Surgery, University of Connecticut Health Center, Farmington, CT, USA

**Purpose:** To evaluate symptomatic pulmonary embolism (PE) rates over time in total hip arthroplasty (THA) patients enrolled in multicenter randomized clinical trials (RCT) assessing the efficacy of venous thromboembolism prophylaxis regimens.

**Methods:** We conducted a search of the MEDLINE database through PubMed to identify clinical trials assessing prophylactic anticoagulation in patients undergoing THA between January 1997 and December 2014. To be included in the analysis, a study had to be a Phase II or Phase III RCT evaluating apixaban, dabigatran, dalteparin, fondaparinux, rivaroxaban, or ximelagatran. The primary outcome was the ratio of PE events to the total number of patients at risk. Methodological quality of each study was assessed using the Cochrane Risk of Bias tool. Heterogeneity was evaluated with the \(I^2\) statistic. Freeman-Tukey Double Arcsine-transformation and random effect model was used to combine PE rates across studies. Meta-regression was used to explore the effects of time, defined as study year, on the PE rate.

**Results:** A total of 95 studies were identified; 19 studies (29,503 patients) were included. Of the 19 studies included, patients in the experimental group were administered apixaban (2,708 patients), dabigatran (3,583 patients), dalteparin (1,020 patients), fondaparinux (3,444 patients), rivaroxaban (4,140 patients), or ximelagatran (2,382 patients). Control group patients received dalteparin (204 patients), enoxaparin (11,353 patients), or warfarin (669 patients). No individual study indicated a significant difference in PE rates between the experimental and control groups. Across all included studies, the estimated PE rate was 0.2% (95% CI: 0.12%-0.28%). Between 1997 and 2011, the proportion of PEs did not change in regression analysis (coefficient=0.006% increase, \(p=0.453\)).

**Conclusion:** Despite the availability of more potent anticoagulants as well as improvements in the care of THA patients, the PE rate in these RCTs did not change over time.

**Significance:** The purpose of this study was to determine the symptomatic PE rate of patients participating in RCTs assessing the efficacy of various chemoprophylaxis agents. Although the PE rate was low (0.2%, 95% CI: 0.12%-0.28%), it persisted during the 14 year period when these RCTs were performed. These RCTs excluded patients with significant morbidity and evaluated the healthiest patients undergoing THA. Furthermore, the care of THA patients improved during this time period, yet the PE rate did not change. These results suggest that even healthy patients receiving optimal anticoagulation still have a risk for PE. Risk stratification strategies need to be further optimized to appropriately balance thromboprophylactic efficacy with bleeding concerns.
Natural History of Hip Impingement and Dysplasia
Over 10-35 Years in Patients without Initial Degenerative Changes

Rafael J. Sierra, MD; Cody C. Wyles, BS;
Mark J. Heidenreich, MD; and Robert T. Trousdale, MD
Mayo Clinic Department of Orthopedic Surgery, Rochester, MN

Purpose: Structural hip deformities including congenital hip dysplasia (CHD) and femoroacetabular impingement (FAI) are thought to predispose patients to degenerative joint changes. However, the natural history of these malformations is not clearly delineated. The purpose of this investigation was to compare the long-term natural history of CHD and FAI to patients without structural deformity and identify radiographic parameters that may be predictive of prognosis.

Methods: We retrospectively reviewed our institutional total joint registry to identify patients ≤55 years that received unilateral primary total hip arthroplasty (THA) from 1980-1990. Preoperative radiographs were reviewed on the contralateral non-operative hip with the following inclusion criteria: Tonnis Grade 0 degenerative change; diagnosis of “CHD”, “FAI”, or “normal” morphology; and minimum 10-year radiographic follow-up. Radiographic metrics in conjunction with the review of two experienced arthroplasty surgeons determined structural hip diagnosis. Every available followup AP radiograph was reviewed to determine progression from Tonnis Grade 0–3 until the time of last follow-up or operative intervention with THA. Survivorship was analyzed by Kaplan-Meier methodology.

Results: 162 patients met all eligibility criteria with the following structural diagnoses: 48 CHD, 74 FAI, and 40 normal. Mean age at the time of study inclusion was 47 (range 18-55), with 56% females. Mean follow-up was 20 years (range 10 – 35 years). 35 patients eventually required THA (16 CHD, 13 FAI, 6 normal; p=0.0757). Median survival for progression from Tonnis Grade 0–1, 0–2, and 0–3 and/or THA was as follows: CHD = 15.9 years, 27.2 years, 33.1 years; FAI = 12.6 years, 25.7 years, 29.9 years; normal = 17.9 years, 30.6 years, 33.6 years (p=0.0669). Amongst all analyzed radiographic parameters, acetabular depth-to-width index ≤0.38, femoral head extrusion index >0.25, and femoral head lateralization ≥10 millimeters increased rate of Tonnis Grade progression (p=0.0127, p=0.0038, p=0.0295, respectively). Age and sex did not change rate of progression.
**Conclusion:** This study defines the long-term natural history of CHD and FAI in comparison to structurally normal young hips with a presumably similar initial prognostic risk (Tonnis Grade 0 degenerative change and contralateral primary THA). Faster rates of degenerative change were observed in CHD and FAI patients; however, differences were minor and trended toward significance, suggesting a similar natural history between structurally normal and diseased hips in many cases. However, radiographic parameters were identified that predicted more rapid degenerative change in structurally diseased hips.

**Significance:** Over 10-35 year followup, patients with hip dysplasia or impingement have slightly more rapid progression of degenerative changes than patients with structurally normal hips. This provides valuable information for surgeons in counseling patients about prognosis with structural hip deformity.
T1rho Advanced Cartilage Mapping Correlates With Surgical Outcome of Patients Treated For Cam Type Femoro-Acetabular Impingement.

Paul E. Beaulé1,4, MD; Helen Andwander1, MD; Gerd Melkus2,3, PhD; Kawan Rakhra2,3, MD; Manisha Mistry, MD1,4

1Division of Orthopaedic Surgery, the Ottawa Hospital, Canada; 2Department of Medical Imaging, the Ottawa Hospital, Canada; 3Department of Radiology, Faculty of Medicine, University of Ottawa, Ottawa, Canada; 4Faculty of Medicine, University of Ottawa, Canada.

Introduction
Cam-type femoral acetabular impingement (FAI), is a common structural hip deformity and thought to be a leading cause of early hip osteoarthritis. Although patients who undergo surgical correction notice improved clinical function it is unclear what impact this has on the overall health of the cartilage. T1rho MRI cartilage mapping has been shown to be a reliable imaging technique to assess the proteoglycan (PG) content potentially serving as a biomarker. This study analyzes post surgical changes in T1rho levels in hip joints treated with cam FAI.

Methods
Eleven patients with a mean age of 38 (all males) underwent pre and post T1Rho Cartilage mapping of their hips at a mean time of 20 months post surgical intervention. The acetabulum was spatially divided into 4 main regions of interest (ROI), with levels of T1Rho in cartilage quantified as a whole and in each spatial segment. T1Rho signal is inversely correlated with level of PG content.

Results
All patients demonstrated loss of PG content on pre-op imaging with a T1Rho of 33.5ms±2.6ms. Preop T1rho levels were found to significantly correlated with the difference between pre-op and post-op T1rho in entire hip cartilage (R: 0.73; p=0.016). This correlation was reflected both in the anterolateral quadrant (R: 0.86; p=0.002), and in the posteriosuperior quadrant (R:0.70; p=0.035). Additionally, significant correlation was found between improvement of WOMAC pain score over time, and difference of T1rho values over time in the most lateral 3mm slice of the anterolateral quadrant (R: 0.81; p=0.045). Significant correlation was found between pre-op alpha angle at 1:30 and difference between pre-op and post-op total cartilage T1rho content (R: -065;p=0.038).

Conclusion
T1Rho Cartilage mapping of the hip is a useful biomarker in the assessment of the surgical management of Cam type FAI. This preliminary data provides some evidence that surgical correction of the deformity can help minimize disease progression.
Complications after Hip Arthroscopy: A Prospective, Multicenter Study
Using a Validated Grading Classification

Christopher M. Larson, John Clohisy, Paul Beaulé, Bryan T. Kelly, M. Russell Giveans,
Rebecca M. Stone, Kathryn M. Samuelson

Introduction: There is very little published literature looking at comprehensive complication rates after hip arthroscopy with current techniques and indications.

Methods: Between 01/2011 and 06/2013, 1,615 consecutive hips (810 males, 805 females) with a mean age of 30.5 years (range 12 - 76) underwent hip arthroscopy at four institutions. The diagnosis, demographic information, and procedures were recorded, and a validated complications grading classification for hip joint surgery (Clavian classification) was utilized for all patients prospectively.

Results: There were 1487 primary hip arthroscopies and 128 revision hip arthroscopies. Arthroscopy was performed for FAI in 1505 hips (93.2%), and 1273 hips (79%) had a labral repair and 311 hips (19%) had a labral debridement. The most common event (16.5% of hips) noted was post-operative sensory disturbance adjacent to the portals or involving the distal anterolateral thigh consistent with LFC nerve disturbance. This was typically not noticed by patients and found on physical examination and only persisted beyond 6 months in 27 hips (1.7%). Iatrogenic chondral injury was noted for 20 hips (1.2%), iatrogenic labral puncture in 14 hips (0.9%), superficial portal infection in 17 hips (1.1%), sensory deficit about the foot in 13 hips (0.8%), deep venous thrombosis in 3 hips (0.2%), pulmonary embolism in 1 hip (0.1%), pulmonary edema in 1 hip (0.1%), wound hematoma in 1 hips (0.1%), perineal numbness (pudendal nerve) in 23 hips (1.4%), heterotopic ossification in 13 hips (0.8%), femoral neck stress fractures in 2 hips (0.1%), deep portal infection in 1 hip (0.1%) and reflex sympathetic dystrophy in 1 hip (0.1%) There was no iatrogenic instability, AVN, or extra-abdominal fluid extravasation in this cohort. The overall complication rate not including temporary periportal and thigh numbness (sequalae) was 8.3% (134 hips). Overall 7.4% had a grade 1, 0.7% Grade 2, 0.4% grade 3, and 0% grade 4 complication. There was a significantly higher rate of complications for females as compared to males (10.0% vs. 6.7%, p=.016), yet no differences between primary vs revision cases (p=.123) or labral repair vs debridement (p=.192), and BMI had no effect on complication rate.

Conclusions: The overall complication rate after hip arthroscopy was 8.3% and higher than previously reported in the literature. This rate of complications is in line with complication rates after open surgical dislocation using the same classification system.
Risks for Conversion to THA after Primary Hip Arthroscopy in a Healthcare System
Russell P. Swan, MD; Hugh S. West Jr., MD; Jennifer Marland, PT; Krista Ellis; Christopher L. Peters, MD

Background: Reoperation rate following hip arthroscopy (HA) occurs in 6.3%-13% of patients. The most common reasons for reoperation include residual FAI and osteoarthritis with conversion to total hip arthroplasty (THA). [1,2]

Purpose: Using a retrospective review of a healthcare system, we investigated the percentage conversion to THA, and whether age, sex, and volume of surgeon predicted conversion.

Methods: Retrospective Review of all HA preformed. (IRB#1040265) Inclusion criteria were index hip surgery in the native hip for IPT codes 29914, 29915, 29916. Charts were reviewed for primary HA only. Exclusion criteria were previous surgery on the hip, mini open, trauma, peritrochanteric codes including IT band release, bursectomy, and abductor repairs. Statistics were analyzed with Kaplan Meir survivorship using Logrank test and hazard ratios (95% CI).

Results: Since 2003, 44 surgeons performed HA and the volume increased 3200% N=1864. [Figure1] Using exclusion criteria, N=1296. Table 1 displays the age breakdown as well as gender. The average age was 34.7 and 7.25% converted to THA at an average of 2.5 years (SD 3). Gender was not predictive of conversion to THA. (p=0.3) Figure 2 shows survivorship with analyses of age. With hazard ratios, the age group 40-45 had a 10X risk of conversion, and the age group >45 had near 30X risk conversion to THA and failure percentage was 20%. (p=.0001)[Table 2] Surgical volume increased the risk of conversion 7X if performing <50 a year compared to a group of >100. (p=.0001) [Table3]

Conclusion: HA has exponentially grown and the amount of providers is surprising. While age was predictive, we weren’t able to analyze for indications such as existing arthritis and THA in an older population is also an accepted solution. Lower volume surgeons had a higher risk failure to THA as a group, however there were individual surgeons that had no failures to THA.
### Table 1:

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<thead>
<tr>
<th>Age</th>
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### Table 2:

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### Table 3:

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<td>7.0073</td>
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<td>2.5561 to 6.9760</td>
<td>1.9376 to 25.3420</td>
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<tr>
<td>50-100</td>
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<td>0.4402 to 6.2557</td>
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<td>&lt;50</td>
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<td>-</td>
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<td></td>
<td>0.03946 to 0.5161</td>
<td>0.1599 to 2.2718</td>
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</table>

| Chi-squared | 48.1211 |
| DF          | 3       |
| Significance| $P < 0.0001$ |
**Does Articular Cartilage Damage Progress in Patients Requiring Revision Hip Arthroscopy?**

1,2Dwyer MK, 1,2Lee J, 1,2McCarthy JC

1Massachusetts General Hospital, Boston, MA
2Kaplan Joint Center, Newton Wellesley Hospital, Newton, MA

**Purpose:** Acetabular labral tears are associated with an increased risk for hip disease; however, the progression of chondral damage in patients undergoing repeat treatment for labral injuries is unknown. We examined intra-operative changes in articular cartilage health in patients from primary to revision hip arthroscopy.

**Methods:** We retrospectively identified 134 patients (85 females, 49 males; age: 34.5±11.0 years) who underwent both primary and revision hip arthroscopy by the senior author. Reason for revision for this series of patients was recurrence of symptoms. The articular cartilage of the posterior, superior, and anterior regions of the acetabulum and femoral head were assessed for signs of chondral damage during both procedures. The degree of damage was classified as normal, mild (grades I/II), or severe (grades III/IV). The average time to revision was 3.1±2.6 years. The degree of damage for each region was compared between primary and revision procedures using Chi-Square analyses. In addition, the total number of regions in which damage was observed was calculated and compared between the two procedures using Wilcoxon-Sign-Rank tests.

**Results:** The degree of articular cartilage damage progressed in 53% of patients at revision surgery. Patients who progressed were older (p=0.022) and had increased time to revision (p<0.001) compared to patients who did not; however, the prevalence of severe lesions at primary did not differ between the two cohorts (p=0.097). The degree of damage differed between primary and revision surgery for the superior region of the femoral head (p=0.002) and superior (p<0.001) and anterior (p=0.007) acetabular regions. The total number of regions in which damage was observed increased from primary to revision surgery (1.4±1.3 vs. 2.3±1.6;p<0.001). Patients with severe damage at primary exhibited an increase in the total number of regions with severe damage at revision compared to patients with only normal or mild changes at primary (p=0.008).

**Conclusion:** Our findings demonstrate that progression of articular cartilage damage can occur in patients undergoing repeat hip arthroscopy procedures and that certain regions of the joint are more susceptible to worsening damage over time. Progression of chondral damage was isolated to the superior femoral head and anterior and superior acetabular regions. In addition, the number of regions in which chondral damage was present also increased, suggesting a progression to more global joint disease.

**Significance:** Ours is the first study to identify changes in articular cartilage health following hip arthroscopy through direct visualization of the joint’s structures. Understanding the progression of hip disease in these patients is imperative to developing treatment strategies.
Average Ten Year Clinical Outcomes of the Bernese PAO for the Treatment of Classic Acetabular Dysplasia

Stephen T. Duncan, MD, Lexington, KY; Kayla Thomason, Geneva Baca, Gail Pashos Perry L. Schoenecker, MD, Saint Louis, MO; John C. Clohisy, MD, Saint Louis, MO

Introduction: Patients with symptomatic acetabular dysplasia, the Bernese periacetabular osteotomy (PAO) is an effective procedure for deformity correction and early relief of pain and hip dysfunction. There is a paucity of data regarding the longer term results of this procedure. The purpose of this study was to analyze the average 10 year clinical, radiographic, and total hip arthroplasty (THA) conversion results following the PAO for the treatment of symptomatic acetabular dysplasia.

Methods: A retrospective analysis of 186 consecutive hips (159 patients) treated with the PAO for symptomatic, classic acetabular dysplasia with an average follow-up was 10.3 years (6.9 to 17.9 years). Preoperatively, all patients had hip pain and sufficient hip joint congruency. Patient demographics, radiographic measurements, and patient-reported outcome scores [Modified Harris Hip score, UCLA, WOMAC] were analyzed.

Results: Average age at surgery was 25 years (range,10-60). There were 138 females (87%) and 21 males (13%) with an average BMI of 25.5 kg/m² Comparison of pre and post operative radiographs demonstrated an average improvement of 25.9° (from 12.0° to 36.2°, p <0.001) in the lateral center-edge angle and 26.3° (from 9.5° to 34.0°, p<0.001) in the anterior center-edge angle, and a significant decrease in Tönnis angle from 22.25° to 4.5° (p< 0.05) Improvements were seen in modified Harris Hip score [20.8 points; (65.4 to 85.3, p<0.001)], and the UCLA score [1.4 points (6.8 to 7.1, p<0.05)]. All WOMAC sub-scores demonstrated clinically significant improvement after the PAO. Ten hips (10.9%) required conversion to THA at an average of 82.3 months (range, 16-197 months). Two hips (2.2%) required revision in the early postoperative period: One for overcorrection of the deformity and loss of hip flexion and 1 for loss of reduction likely due to patient noncompliance with smoking/weightbearing instructions. One additional hip (1.1%) required revision at 11 years post-PAO surgery for relative overcorrection of the deformity and impingement. One patient (1.3% of patients) passed away of causes unrelated to her PAO surgery.

Discussion and Conclusion: The periacetabular osteotomy is an effective technique for surgical correction of a dysplastic acetabulum in adolescents and young adults. In this series, the average ten year results were very good with a low conversion rate to total hip arthroplasty and 86% survivorship of the reconstruction.
Long-Term Results Following Bernese Periacetabular Osteotomy

J Wells, E Bulat, T Matheney, YJ Kim, MB Millis
Boston Children's Hospital, Boston

Purpose: Determine long-term results of Bernese PAO: survivorship quality of life, activity-related outcomes, and predictors of failure at minimum followup 15 years

Methods: 158 hips (133 patients) were treated by a single surgeon with PAO between May 1991 and September 1998. All patients had symptomatic dysplasia prior to surgery. 37 hips (34 patients) were lost to followup. Remaining 121 hips (99 patients) were reviewed at mean 18 years (range 15 to 24). Patients were evaluated by UCLA Activity Score, SF-12, mHHS, WOMAC, and EQ-VAS. Preop and longterm followup radiographs were also reviewed. Failure defined as WOMAC-Pain >10 or having THR. Hips were divided into 3 groups: “asymptomatic”; “symptomatic” (WOMAC-Pain >10 at last followup); or “replaced”.

Results: 64 hips (53%) remained asymptomatic at most recent followup (mean 19 years; range 15 to 24). Asymptomatic hips reported significantly better activity and pain-related outcomes than symptomatic hips (p<.05): UCLA Activity; WOMAC-Pain; SF-12 Physical and Mental; mHHS, HOOS, and EQ-VAS.

31 hips (26%) were “symptomatic” and failed by WOMAC pain score >10, mean score 10.8 +/- 4.2 out of 20. 26 hips (21%) underwent THR at mean 8.9 +/- 4.8 years post PAO.

There were 93 native hips (77%) that had not undergone THR. Kaplan-Meier analysis with THR as end point revealed survival rate (95%CI) of 85% (79-92%CI) at 10 years; 80% (73-88%CI) at 15 years; and 74% (66-83%CI) at 18 years. A multinominal prediction model identified 3 predictors of having a “symptomatic” or “replaced” outcome: age > 25 years at time of PAO; “poor” or “fair” preoperative joint congruency; and joint space width < 2mm.

Conclusion: At long-term followup more than 15 years, the majority of hips which underwent PAO for dysplasia has minimal or no pain, were active, and had positive outcomes. This demonstrates the durability of PAO in most patients. A subset of patients had progression to failure over time, which corroborates findings in prior, smaller studies of PAO outcomes. Predictors of failure to THR include preoperative age > 25 years, poor/fair preoperative joint congruency, and preoperative cartilage space < 2mm.

Significance: In well-selected patients, Bernese periacetabular osteotomy can provide satisfying longterm function in a majority of patients. Identified predictors of a symptomatic outcome or need for THR may allow improved treatment selection in the future. Improved contemporary treatment methods employed for patients undergoing PAO will likely lead to even better outcomes after PAO than reported here.
Flat Tapered Stem Revision for End of Stem Pain  
Below a Well-Fixed Long Cementless Femoral Stem  

Vincent D. Pellegrini, Jr, MD  
Medical University of South Carolina

**Purpose.** End of stem pain below a well-fixed cementless stem remains a challenging treatment problem in total hip arthroplasty. Cortical strut grafting of the femoral diaphysis at the end of the stem has met with some success, but has a protracted convalescence and some uncertainty about bone graft incorporation. Alternatively, a flat tapered stem may be utilized to gain rotational stability in the proximal femur while decompressing distal stem impingement in the diaphysis.

**Methods.** This is a retrospective review of 10 femoral revisions performed with short flat tapered stems between 2008 and 2014. Indications for revision were either radiographic evidence of a loose tapered cementless stem (5) or a well-fixed proximally coated long cementless stem (5) with a minimum of 2 years of unrelenting thigh pain related to activity. Stem revision was accomplished through an anterolateral approach with or without a traditional chevron osteotomy of the greater trochanter. A broach-only technique was employed with a prophylactic circlage wire through the lesser trochanter utilizing a proximally porous coated flat tapered stem in all cases. Allograft cancellous cubes were used as graft to grout the spaces anterior and posterior to the stem. In each instance the revision stem was shorter than the index stem that was removed and the distal pedestal was not violated. Minimum follow-up after revision is 18 months.

**Results.** All ten patients reported complete resolution of their preoperative pain within one month after stem revision and ambulated independent of assistive devices by three months postoperatively. All stems were radiographically stable with no measurable radiographic subsidence. There was one trochanteric nonunion with escape, but the patient was pain free and ambulated with a mild limp and no cane. There were no fractures, infections, reoperations, or episodes of instability.

**Conclusion.** Short flat tapered stems represents an alternative revision option for end of stem pain below a proximally coated well-fixed cementless stem. Rotational stability of the stem in the proximal femur is essential, and prophylactic circlage wiring through the lesser trochanter reduces the risk of intraoperative fracture.

**Significance.** Short stem revision of long cementless stems plagued by end of stem pain secondary to stem impingement represents a logical alternative to “barrel stave” cortical strut bone grafting of the femoral diaphysis at the end of the stem. It provides more rapid, and perhaps more reliable, resolution of pain by removing the endosteal impingement and stiffness gradient at the end of the stem.
Pap	Paper #: 74

**FIXATION OF ALLOGRAFTED TITANIUM AND HYDROXYAPATITE IMPLANTS IN REVISION SETTINGS WITH & WITHOUT CRACKING OF SCLEROTIC CAVITY**

Joan E. Bechtold, PhD, Minneapolis, MN; Kjeld Soeballe, MD, PhD, Aarhus, Denmark

**Purpose:** Recognizing that revision arthroplasty is complex and success is multifactorial, one strategy to help increase longevity of revisions is through improving metaphyseal fixation. We previously introduced a low energy surgical technique that locally perforates (cracks) the sclerotic metaphyseal bone cavity that typically forms during the process of aseptic loosening (“crack” revision technique). Perforating the shell can allow marrow and vascular elements to access the bone surface. Based on positive results for non-grafted revisions, here we evaluate the crack revision technique with grafted implants having Titanium (Ti) and Hydroxyapatite (HA) coatings.

**Methods:** Under approvals from our Institutional Animal Care and Use Committee, we implemented our paired controlled revision protocol in groups with bilateral Ti and HA implants. All groups received impacted bone allograft. Revision technique (crack, non-crack) was evaluated in paired implants and implant surface (Ti, HA) was compared unpaired. Hypotheses were evaluated with outcome measures of mechanical and histomorphometric fixation. This revision protocol includes a cylindrical implant pistoning 500 microns in a 0.75 mm gap, in presence of particulate polyethylene, for 8 weeks. This engenders a bone and tissue response representative of the metaphyseal region of an aseptically loosened component, featuring a dense fibrous membrane, sclerotic bone shell, high inflammatory cytokine profile, dense joint capsule and increased joint fluid under pressure, and compromised mechanical fixation. At eight weeks, the original implants are revised and followed for an additional four weeks. Here, Ti and HA implant surfaces were studied; morselized fresh frozen allograft was impacted in all peri-implanteric gaps.

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<td><strong>Implant surface</strong></td>
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<tr>
<td>Non-crack revision</td>
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<tr>
<td>Crack revision</td>
<td>n=8</td>
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**Results:** The grafted crack revision significantly improved mechanical shear strength, stiffness and energy. The relative improvement for the crack revision was greater for Ti implants than for HA, but highest overall fixation was achieved with HA implants and crack revision. The histomorphometrical analysis demonstrated primarily fibrous membrane ongrowth for the non-crack revisions and consistently supports mechanical findings for both Ti and HA implants.

**Conclusion:** Experimental grafted revisions perforating the sclerotic shell achieved higher mechanical and histomorphometric measures of implant fixation than revisions without perforation. Ti achieved highest relative gain, but HA had highest overall fixation.

**Significance:** This experimental study suggests surgical and implant-based methods to improve fixation of grafted revision implants. However, given the multifactorial nature of complex revisions, the final impact on patient outcome will await further clinical study.

**Support:** NIH AR42051
Prior Operative Notes are Inadequate for the Planning of Revision Total Hip Replacement

Ali Electricwala, MD; Rapeepat Narkbunnam, MD; Katherine Hwang, MS; Derek F. Amanatullah, MD, PhD; James I. Huddleston, MD; William J. Maloney, MD; Stuart B. Goodman, MD, PhD
Department of Orthopaedic Surgery, Stanford University

Background: Adequate preoperative planning is the first and most crucial step in the successful completion of a revision THR. A detailed knowledge of implants used in the primary operation makes it possible to make appropriate arrangements for the necessary extraction operation tools, components and instrumentation to accomplish the revision surgery. The purpose of this study was to evaluate the availability, adequacy and accuracy of operative notes of primary THR surgeries in patients requiring subsequent revision, and to construct a template of minimum necessary information required in the operative notes to further simplify re-operations, if they should become necessary.

Methods: The operative notes of 160 patients (80 primary THRs and 80 revision THRs) performed in 2013 were randomly selected from our database and reviewed. We assessed the availability of operative notes and implant stickers prior to revision THR, and reviewed the primary THRs performed at our institution. The availability of implant details in the operative notes was compared with the available surgical stickers for adequacy and accuracy. The categorical variables were compared using the Fischer-exact test. A P-value of less than 0.05 was considered statistically significant.

Results: Despite exhaustive attempts, operative notes and implant stickers were difficult to obtain prior to revision THR. The operative notes were available in 39 of 80 revision THR cases (49%) and 77 of 80 primary THR cases (96%, P < 0.001). The implant stickers were available in 26 of 80 revision THR cases (32%) and 78 of 80 primary THR cases (98%, P < 0.001). When implant stickers were unavailable, operative notes were available in 17 of 54 remaining revision THR cases (32%) and 1 of 2 remaining primary THR cases (50%). Utilizing the operative notes and implant stickers combined, accurate implant details were obtained in 40 of all 80 revision THR cases (50%) and 79 of all 80 primary THR cases (99%, P < 0.001).
Conclusion: This study demonstrates that operative notes are often unavailable and inadequate in providing the necessary information required for planning a revision. Furthermore, some patient-related information may be lost from databases over time and is potentially unavailable to the surgeon at the time of revision surgery. This highlights the need for improved database and electronic medical record systems. Moreover, operative templates have been shown to produce more comprehensive operative notes. Based on our findings, we provide a template of the minimal necessary information required in the operative notes of patients undergoing primary or revision hip arthroplasty surgery to facilitate later revision.
The Hip Society
Bylaws


The Articles of Incorporation of The Hip Society were filed on December 30, 1969, as provided by the Office of Non-Profits Development in South Carolina.

ARTICLE I: NAME, SEAL, PURPOSE, and PRINCIPLE OFFICE

Section 1: Name
1. The name of the organization shall be The Hip Society.

Section 2: Seal
1. The Society's seal shall be circular in form and shall have inscribed upon it the name of the Society and the year of its founding, 1968.

Section 3: Mission
1. The Mission of The Hip Society is to advance knowledge of hip disorders, promote evidence-based treatment, and refine surgery of the hip in order to improve the lives of patients.

Section 4: Principal Office
1. The principal office of the Society shall be in the State of Illinois. The Society also may have offices in other places, as the Board of Directors shall determine to be desirable.

ARTICLE II: MEMBERSHIP

Section 1: Membership Year
1. The membership year shall begin on January 1 and conclude on December 31 of the same year.

Section 2: Qualifications
1. Qualification for membership in the Society shall be established by the Membership Committee and outlined in the Society's Policies and Procedures Manual, which shall be adopted by the Board of Directors from time to time.
2. The Society's Policies and Procedures Manual shall include information related to the different categories of membership, the application process, the election process, the reinstatement process, Membership benefits, and Member duties.

Section 3: Requirements
1. Membership shall be by invitation only.

Section 4: Nondiscrimination
1. Individuals shall not be denied or abridged of membership because of sex, color, creed, religion, or ethnic origin.

Section 5: Size
1. The size of the Active membership shall not exceed 100.
2. The size of the Adjunct membership shall not exceed 25.
**The Hip Society Bylaws**

**Section 6: Member Categories**

1. There shall be six (6) categories of membership in the Society: Active, Senior, Adjunct, Senior Adjunct, Honorary and Emeritus as outlined in the Society’s Policies and Procedures Manual.

**Section 7: Initiation Fees, Annual Dues and Special Assessments**

1. Membership initiation fees, yearly dues, and special assessments shall be determined by the Board of Directors and ratified by three-fourths (3/4) of the voting membership present at a Member Business Meeting and shall be outlined in the Society’s Policies and Procedures Manual.

2. The yearly dues of the Society shall be payable in advance or postmarked by April 1st of each membership year.

3. A Member, whose dues remain unpaid after April 1st, shall be assessed a special fee that is determined by the Board of Directors and ratified by three-fourths (3/4) of the voting membership present at a Member Business Meeting.

4. If a Member fails to pay yearly dues and any applicable assessments after three (3) notifications, and payment is not received by the Summer Meeting of the same membership year, and a written statement from the individual citing reasons for the delinquency that is satisfactory to the Board of Directors is not received, the Secretary shall send an official letter to the Member stating that the individual has forfeited his membership due to unpaid membership dues.

5. No initiation fees, dues or assessments shall be refunded to a Member if the individual’s membership has been terminated for cause.

**Section 8: Notification of Membership**

1. All new Active, Adjunct, and Honorary Members shall be notified of Membership by the Secretary of the Society. New Members shall be sent a copy of the Bylaws of the Society, a membership certificate, and other materials as appropriate.

2. The Secretary shall be responsible for informing the candidate Member of unfavorable action concerning his membership application.

**Section 9: Resignations**

1. Any Member may withdraw from the Society after fulfilling all obligations and submitting a written notice of such intention to the Secretary. This notice shall be presented to the Board of Directors.

**Section 10: Termination of Membership**

1. Membership in the Society may be terminated by the Society for ethical, moral, or legal reasons.

**ARTICLE III: BOARD OF DIRECTORS**

**Section 1: Composition and Numbers**

1. The Board of Directors shall consist of ten (10) individuals: the President, the First Vice-President, the Second Vice-President, the Secretary and the Treasurer (who shall be the five (5) Officers of the Society), the immediate Past President, and four (4) additional Members, one (1) of whom shall be the Chair of the Education Committee, one (1) of whom shall be the Chair of the Membership Committee, one (1) of whom shall be the Chair of the Research Committee, and one (1) of whom shall be a Member-at-Large.

2. The Board of Directors may also have one (1) or more ex-officio members, one (1) of whom shall be the Chair of the Fellowship and Mentorship Committee. Ex-officio members shall have no vote on any matters considered by the Board of Directors and shall not be considered Officers of the Society. Ex-officio members shall not attend executive sessions of the Board of Directors except by specific invitation.

**Section 2: Duties of the Board of Directors**

1. The Board of Directors shall serve as the administrative authority of the Society and shall consider all its activities and determine its policies.

2. The Board of Directors shall receive and consider the reports of committees and review their activities, and shall direct the Secretary to prepare an annual report reviewing the work of the previous year, to be submitted to the membership of the Society.

3. The Board of Directors shall determine all initiation fees, annual dues, special assessments, and scientific meeting registration fees.
The Hip Society Bylaws

4. The Board of Directors shall review the proposed scientific program of the Winter Meeting and rule concerning approval or disapproval of such program.

5. The Board of Directors shall rule on the acceptance or rejection of proposed international guest speaker(s) to any meeting of the Society.

6. The Board of Directors shall announce at the Summer Meeting of the Society the new Emeritus and Honorary Members.

7. Members of the Board of Directors may be compensated for their time and/or society-related expenses provided that this is approved by a majority vote of the voting membership in attendance at a Summer Member Business Meeting.

Section 3: Election, Terms and Criteria

1. Education Committee Chair
   A. This individual shall be selected by the Second Vice-President and shall serve when the Second Vice-President serves as the Society's President.
   B. The chair shall be responsible for the development of the annual program and shall serve as the chair of the Education Committee.
   C. The term for this individual is one year.
   D. The individual may be reappointed.

2. Member-at-Large
   A. The voting Membership elects the Member-at-Large based on recommendations from the Nominating Committee.
      i. The individual shall be an Active, Senior, Adjunct, or Senior Adjunct Member of the Society for more than three (3) years, during the second Member Business Meeting at the Summer Meeting.
      ii. The individual will serve as a one-year member of the Research Committee, the Fellowship and Mentorship Committee, and the Technology Subcommittee.
      iii. The term for this individual is one year.
      iv. The individual may not be reappointed for consecutive terms.
   B. Duties
      i. The individual shall serve as a representative to the American Academy of Orthopaedic Surgeons' Board of Specialty Societies.
      ii. The individual shall serve as a liaison between the Society's Membership and the leadership.
      iii. The individual shall serve on the Fellowship and Mentorship Committee.
      iv. The individual shall serve on committees as requested by the President.

Section 4: Vacancies and Removal

1. Any Director may be removed at any time and without assigning any cause by an affirmative vote of three-fourths (3/4) of the remaining Directors of the Society. Vacancies in any position arising from any cause may remain vacant until the next election.

2. Should any vacancy be filled, the policies related to nominations and elections processes shall be followed.

Section 5: Meetings

1. The Board of Directors shall convene at least twice yearly as determined by the officers.

2. The Board of Directors may hold special meetings at the discretion of the President or upon request by no less than two (2) Members of the Board.

3. Meetings may be held at any time with one (1) day meeting notice.

4. Members of the Board may invite any Active, Senior, Adjunct, or Senior Adjunct Member of the Society to participate in its deliberations at any meeting.

Section 6: Notice

1. Unless otherwise provided in these Bylaws, notice of meetings, both regular and special, shall be given not less than one (1) day in advance of said meeting. Such notice may be by mail, electronic transmission, telephone, or verbal.

Section 7: Quorum

1. A majority of the Board of Directors shall constitute a quorum for the transaction of business.
ARTICLE IV: OFFICERS

Section 1: Composition and Numbers
1. The Officers of the Society shall consist of five (5) individuals who shall be the President, the First Vice-President, the Second Vice-President, the Secretary, and the Treasurer.

Section 2: Term
1. The term of office for the President, the First Vice-President and the Second Vice-President shall be one (1) year or until their respective successors are elected and qualified for. The term of office for the Secretary and the Treasurer shall be for three (3) years, or until their respective successors are elected and qualified.
2. A Member shall hold only one officer position at any one time.
3. The terms of office shall begin at the close of the Winter Meeting of the Society following the election, and shall terminate at the close of the final scheduled activity of the next Winter Meeting of the Society.

Section 3: Election of Officers
1. Election of Officers shall take place at the second Member Business Meeting during the Society’s Summer Meeting. Candidates for the Second Vice-President, the Secretary, the Treasurer, and the Member-at-Large of the Board of Directors shall be nominated by the Nominating Committee.
2. Election of Officers shall be by closed ballot of the voting Membership in attendance at the second Member Business Meeting. Candidates who receive the majority of the votes shall be elected.

Section 4: Vacancies and Removal
1. In the event of the death, resignation or incapacity of the First Vice-President, the Second Vice-President, the Secretary, or the Treasurer, the Nominating Committee, which was elected during the Summer Meeting preceding the event, shall be reconvened to select a nominee for the vacant office and empowered to poll the voting Membership by mail or electronically. A majority of the voting Membership shall elect.
2. The Board of Directors may remove any officer, with or without cause, at any time by an affirmative vote of three-fourths (3/4) of the remaining directors.

Section 5: Duties of the Officers
1. Duties of the Officers shall include the following, but are not limited to the information provided within these Bylaws. Full descriptions of the Officers’ responsibilities shall be outlined in the Society’s Policies and Procedures Manual.
   A. The President
      i. Shall serve as the Executive Officer of the Society, shall perform all duties incident to the office of President, and other duties as prescribed by the Board of Directors from time to time, shall control all of the business affairs of the Society, and is empowered to sign contracts and documents which the Board of Directors has authorized to be executed.
      ii. Shall preside at all meetings of the Society and of the Board of Directors.
      iii. Shall create ad hoc committees and appoint Members.
      iv. Shall appoint all committee Members not otherwise provided for in these Bylaws, and shall be an ex-officio Member of all committees except the Nominating Committee.
      v. Shall fill all vacancies that occur on committees between meetings of the Society unless otherwise provided for in the Bylaws.
   B. The First Vice-President
      i. Shall be responsible for performing all duties assigned by the President and for assuming the duties of the President in the event of his inability or refusal to act.
      ii. Shall, when acting on behalf of the President, be given all powers of the President with all attendant restrictions.
      iii. Shall succeed to the Presidency at the termination of office as First Vice-President.
   C. The Second Vice-President
      i. Shall appoint the Program Chair for the Winter Meeting over which he will later preside.
      ii. Shall appoint a Member to the Membership Committee.
      iii. Shall succeed to the office of First Vice-President at the termination of office as Second Vice-President.
      iv. Shall perform the duties of the First Vice-President in his absence or inability to act.
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D. The Secretary
   i. Shall carry on official correspondence of the Society and shall keep a record of the proceedings of all Society committees and Board of Directors meetings.
   ii. Shall keep a roster of Members of the Society, a record of Members’ attendance at all meetings, and a record of papers submitted for presentation.
   iii. Shall present a report of the Society’s activities to the Membership at all Member Business Meetings.
   iv. Shall send notices of meetings to Members and shall conduct such other correspondence as may be requested by the President or the Board of Directors.
   v. Shall notify all committee Members of their appointments.
   vi. Shall notify candidates of their election to Membership, and shall prepare and distribute relevant Membership materials to all new Members.
   vii. Shall inform an Active, Senior, or Adjunct Member who had proposed a candidate for Membership of unfavorable action on that candidate’s application.
   viii. Shall keep the Seal of the Society.
   ix. Shall perform the duties of the Second Vice-President in his absence or inability to act.
   x. Shall conduct a review of the Society’s Policies and Procedures Manual at least annually and suggest revisions as needed to the Board of Directors.
   xi. Shall serve on the Fellowship and Mentorship Committee.

E. The Treasurer
   i. Shall keep a record of all Members and shall notify the Board of Directors of those delinquent in payment of dues, assessments, and/or other fees.
   ii. Shall be custodian of all saleable properties of the Society and shall submit an inventory of these properties to the Board of Directors annually.
   iii. Shall present a financial report to the Board of Directors at regular intervals and to the Membership at each Member Business Meeting.
   iv. Shall serve as Chair of the Finance Committee.

ARTICLE V: COMMITTEES

Section 1: Standing Committees

1. Standing Committees shall be created by and shall report to the Board of Directors. Such committees shall advise and aid the Board of Directors in all matters designated by the Board of Directors. The Society supports six (6) Standing Committees: Membership Committee, Education Committee, Finance Committee, Fellowship and Mentorship Committee, Research Committee, and Nominating Committee.

2. These committees shall serve the Society only in an advisory capacity and none shall have any authority of the Board of Directors.


4. Committees
   A. Membership Committee
      i. Composition and Term
         a) This committee shall consist of not less than six (6) Active, Senior, Adjunct, or Senior Adjunct Members.
         b) The term of each appointment shall be six (6) years.
         c) The Second Vice-President, upon his election, shall appoint a Member whose term of service will begin immediately upon appointment.
         d) The Chair of the committee shall be a member of the committee in his fifth year, and shall serve a one (1) year term as Chair, and a one (1) year term as a Past Chair.
         e) The term of service of the Past Chair will terminate immediately at the conclusion of the Summer Meeting.
      ii. Duties
         a) Shall consider all completed applications for Membership.
         b) Shall investigate all credentials and qualifications of applicants.
         c) Shall recommend candidates for Active and Adjunct Membership to the Board of Directors, which shall then make recommendations to the Membership at the Summer Member Business Meeting.
B. Education Committee

i. Composition and Term
   a) The Education Committee shall be made up of seven (7) Members consisting of the Education Committee Chair (who is the Program Chair), the Education Chair for the First Vice-President, the Education Chair for the Second Vice-President, the past Education Chair, the President, and an Adjunct or Senior Adjunct Member who is appointed in odd years by the President.
   b) The Education Committee may also have two (2) or more ex-officio members, one (1) of whom shall be the Chair of the Technology Subcommittee, and one (1) of whom shall be The Hip Society’s representative on the BOS Education Committee. Ex-officio members shall have no vote on any matters considered by the Education Committee and shall serve in the advisory capacity to the Committee. The Second Vice-President, upon his election, shall appoint a Member who shall serve as the Program Chair at the Winter Meeting over which the Second Vice-President presides as President. The term of appointment shall be one year for the all Members except for the Adjunct or Senior Adjunct Member who shall serve two (2) years.

ii. Duties
   a) Shall plan, implement and review educational activities of the Society.
   b) Shall review all papers submitted for special awards, and select winners in each category according to the process outlined in the Society’s Policies and Procedures Manual.
   c) Shall seek additional partnerships and co-branding opportunities to enhance and complement the traditional educational offerings of the Society and to identify potential revenue-generating opportunities.
   d) Shall perform other duties as determined by the Board of Directors.

iii. Technology Subcommittee:
   a) Composition and Term
      1) The Technology Subcommittee shall be made up of three (3) Members. The Chair of the Committee, who shall be an ex-officio member of the Education Committee, shall be selected by the Board of Directors for one (1) three-year term. One (1) member of the Technology Subcommittee shall be The Hip Society’s representative on the BOS Communications Committee. The term of service shall be three (3) years, and coincide with the BOS term. One (1) member of the Technology Subcommittee shall be the Board of Director’s Member-at-Large. The term of their service on this Subcommittee shall be by virtue of their office. All members but the Board of Director’s Member-at-Large are eligible for one (1) additional term upon consensus of the Board of Directors.
   b) Duties
      1) Shall be responsible for investigating new technology and communication partnerships to advance the mission of the Society.
      2) Shall work closely with the Education Committee to integrate technology into traditional and new education offerings of the Society, specifically focusing on potential revenue-generating options.
      3) Shall be responsible for oversight of the Society’s website, including design, layout, and content of the pages.
      4) Shall work with other committees of the Society to maintain relevant and current web pages related to the activities of these committees.
      5) Shall provide oversight of electronic and/or printed newsletters of the Society, and all other communications to the membership.
      6) The Chair of the Technology Subcommittee shall be responsible for preparing and submitting a biannual report to the Board of Directors regarding the activities of the Subcommittee.
      7) Shall perform other duties as determined by the Board of Directors.

C. Research Committee

i. Composition and Term
   a) The Research Committee shall be made up of five (5) Members. The Chair of the Committee shall be selected by the Board of Directors for one (1) three-year term. One (1) member of the Research Committee shall be The Hip Society’s representative on the BOS Research Committee. The term of service shall be three (3) years, and coincide with the BOS term. One (1) member of the Research Committee shall be the Board of Director’s Member-at-Large. The term of their service on this Committee shall be by virtue of their office. The Board of
Directors shall appoint the initial two (2) members with the terms of two (2) and three (3) years respectively. All subsequent members shall be elected by the general membership. The term of office shall be three (3) years. All members but the Board of Director’s Member-at-Large are eligible for one (1) additional term upon consensus of the Board of Directors.

ii. Duties
   a) Encourage members to contribute annually to the OREF designated giving Hip Society fund.
   b) Explore and identify funding options to support The Hip Society’s research programs.
   c) Develop, plan, promote and provide oversight of The Hip Society’s research programs, including but not limited to research grants.
   d) Provide an annual report to the Board of Directors for approval, regarding the financial accounting of all grant activities, completion of pending grants projects, and the newly approved grant proposals.
   e) Initiate and conduct surveys of the general membership regarding subjects of timely and relevant interest.
   f) The Chair of the Research Committee shall provide to the Chair of the Education Committee an annual report of the approved grant applications, who shall then arrange for the approved studies to be presented at the annual Summer Meeting.
   g) At the recommendation of the Board of Directors, create position statements on selected topics of importance. Make these position statements available to the public, orthopaedic community, and relevant organizations.
   h) Perform other duties as determined by the Board.

C. Finance Committee
   i. Composition
      a) The Committee shall consist of the President, the Treasurer, and the Immediate Past President. The Treasurer shall be the chair. The term of service on the committee shall be by virtue of committee members’ office.
   ii. Duties
      a) Development of fiscal policy.
      b) Ensure the implementation of sound financial management practices.
      c) Ensure the accuracy and validity of the financial and statistical information used by the Board of Directors or by external agencies to evaluate the fiscal affairs of the Society.
      d) Review, guide and monitor the performance of invested funds including endowment, restricted and unrestricted funds.
      e) Perform other duties as determined by the Board.

D. Fellowship and Mentorship Committee
   i. Composition
      a) The Committee shall consist of five (5) voting members. The Chair shall be appointed by the Board of Directors and shall serve an initial term of six (6) years. The Chair shall be an ex-officio member of the Board of Directors. The Board of Directors’ Secretary and Member-at-Large also shall serve; the term of their service on this Committee shall be by virtue of their office. Upon creation of the Committee, the Board of Directors shall appoint the remaining two (2) voting members. Of the Committee composition, one (1) appointed voting member shall serve a term of three (3) years, with the possibility of being reappointed by the Board of Directors for one (1) additional three (3) year term; one (1) appointed voting member shall serve a term of four (4) years, with the possibility of being reappointed by the Board of Directors for one (1) additional two (2) year term. The Chair also may select up to three (3) non-voting members of the Committee, at his or her discretion, to serve in the advisory capacity. The term of service of the three (3) non-voting members shall be three (3) years, with the possibility of reappointment for one (1) additional three (3) year term. After the initial composition of the Committee is appointed by the Board of Directors, the general membership shall elect individuals to fill unslotted vacancies during the Society’s Summer Meeting through the nomination process outlined in these Bylaws. These positions shall be three (3) years and may be re-elected by the membership for one (1) additional three (3) year term.
   ii. Duties
      a) Solicit funds in support of fellowship and mentorship initiatives.
      b) Review applications by members of The Hip Society who wish to host the traveling Fellows and select twelve (12) or more sites for visitation.
      c) Evaluate on an annual basis the visitation sites.
      d) Review all applications for the Fellowship and select three (3) Fellows.
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c) Maintain the biennial commitment to the British Hip Society by selecting two (2) North American Fellows to travel to the UK in even years.
f) Perform an annual review of the Fellowship Program. The annual review to the Board of Directors shall determine the value of the program, and provide recommendations for enhancements.
g) Perform other duties as determined by the Board.

E. Nominating Committee

i. Composition and Term
   a) The Committee shall consist of three (3) Active, Senior, Adjunct, or Senior Adjunct Members.
   b) The Chair shall be the Immediate Past President of the Society.
   c) Two (2) Active, Senior, Adjunct, or Senior Adjunct Members, who are not Members of the Board of Directors, shall be nominated and elected by a majority vote at the Member Business Meeting of the Winter (Open) Meeting.
   d) The term is one year, beginning immediately upon election.
   e) No Member may serve consecutive terms.

ii. Duties
   a) The Nominating Committee shall prepare a list of nominees for the following positions every year for a vote during the Member Business Meeting at the Summer Meeting:
      - Second Vice-President
      - Member-at-Large of the Board of Directors
   b) The Nominating Committee shall recommend a nominee for the Treasurer’s position every three (3) years for a vote during the Member Business Meeting at the Summer Meeting.
   c) The Nominating Committee shall recommend a nominee for the Secretary’s position every three (3) years for a vote during the Member Business Meeting at the Summer Meeting.
   d) The Nominating Committee shall recommend nominees for the Fellowship and Mentorship Committee positions, at appropriate intervals, and as specified in the Fellowship and Mentorship Committee composition above.
   e) The Nominating Committee shall present its recommendations to the membership at the Member Business Meeting of the Summer Meeting.

Section 2: Ad-Hoc Committees

1. Ad-Hoc Committees shall be formed on an as-needed basis to accomplish short-term tasks or objectives and shall be sunsetted at the conclusion of the assigned task or objective by President.
2. The President shall define an Ad-Hoc Committee’s purpose and timeline, as well as outline measurements to aid in the Board of Directors in assessing the success of the Committee and to determine if the Committee shall continue or disband.
3. Ad-Hoc Committees shall report to the Board of Directors.
4. The Ad-Hoc Committees shall advise and aid the Board of Directors of all matters designated by the Board and shall not have any authority of the Board of Directors.
5. The Society’s Policies and Procedures Manual shall outline the charges and composition of each formed Ad-Hoc Committee.

Section 3: Vacancies

1. Should any vacancy occur within a committee or an ad hoc committee, the President shall determine if an appointment is necessary and shall make an appointment or maintain the vacancy.

Section 4: Committee Meetings

1. The Chair shall determine the meeting schedule of his respective committee.
2. The Chair shall appoint an individual within the committee to document the meeting and submit the meeting minutes to the Secretary for record keeping.
3. A quorum shall be met when the majority of the voting Members are present in order to transact business.

ARTICLE VI: MEETINGS

Section 1: Meetings

1. The Members of the Society shall meet at least twice yearly.
2. There shall be a Summer (Closed) Meeting held preferably in the city of the President.
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3. There shall be a Winter (Open) Meeting held in conjunction with the Annual Meeting of the American Academy of Orthopaedic Surgeons.
4. Member Business Meetings and scientific sessions shall be conducted at both meetings.

Section 2: Special Meetings
1. Special Member Meetings of the Society shall be called by the Board of Directors, or by the majority of Membership, on notice sent by mail or electronically to all voting Members at least sixty (60) days prior to the date of the meeting. Business to be transacted at these Special Member Meetings shall be stated in the notice.

Section 3: Quorum
1. A majority of Active, Senior and Adjunct Members eligible to vote who are present shall constitute a quorum for the transaction of business at regular or special Member meetings.

ARTICLE VII: FINANCE

Section 1: Fiscal Year
1. The fiscal year of the Society shall begin on January 1 and conclude on December 31 of the same year.

Section 2: Accounts and Audits
1. The books and accounts shall be kept in accordance with sound accounting practices and shall be audited annually by a certified public accountant.

Section 3: Loans
1. Under no circumstances shall the Society make loans.

Section 4: Reserves.
1. The Society shall fund a percentage of its net assets appropriated for contingencies in an amount to be determined by the Board of Directors and reviewed annually.

ARTICLE VIII: INDEMNIFICATION

Section 1: Indemnification in Actions Arising Out of Capacity as Officer, Director, or Employee Acting in a Management Capacity on Behalf of the Society
1. The Society shall indemnify any person who was or is a party or is threatened to be made a party to any threatened, pending or completed claim, action, suit or proceeding, whether civil, criminal, administrative or investigative, including appeals (other than an action by or in the right of the Society), by reason of the fact that the person is or was a director, officer, or employee acting in a managerial capacity on behalf of the Society, or is or was serving at the request of the Society as a director, officer, partner, employee or agent of another Society, partnership, joint venture, trust or other enterprise, against any and all expenses (including attorneys’ fees), judgments, fines and amounts paid in settlement actually and reasonably incurred by him in connection with such claim, action, suit or proceeding if he acted in good faith and in a manner he reasonably believed to be in, or not opposed to, the best interests of the Society, and, with respect to any criminal action or proceeding, had no reasonable cause to believe his conduct was unlawful, provided he is not adjudged in such action, suit or proceeding to be liable for negligence or misconduct in the performance of his duty. The termination of any claim, action, suit or proceeding by judgment, order, settlement, conviction, or upon a plea of nolo contendere or its equivalent, shall not, of itself, create a presumption that the person did not act in good faith and in a manner which he reasonably believed to be in, or not opposed to, the best interests of the Society, and with respect to any criminal action or proceeding, had reasonable cause to believe that his conduct was unlawful.

Section 2: Indemnification in Actions by or in Right of Society
1. The Society shall indemnify any person who was or is a party or is threatened to be made a party to any threatened, pending or completed claim, action or suit by or in the right of the Society to procure a judgment in its favor by reason of the fact that he is or was a director, officer, employee acting in a managerial capacity on behalf of the Society, or is or was serving at the request of the Society as a director, officer, partner, employee or agent of another Society, partnership, joint venture, trust or other enterprise
against expenses (including attorneys’ fees) actually and reasonably incurred by him in connection with the defense or settlement of such action or suit if he acted in good faith and in a manner he reasonably believed to be in, or not opposed to, the best interests of the Society, and except that no indemnification shall be made in respect of any claim, issue or matter as to which such person shall have been adjudged to be liable for negligence or misconduct in the performance of his duty to the Society unless and only to the extent that the court in which such action or suit was brought shall determine upon application that, despite the adjudication of liability but in view of all circumstances of the case, such person is fairly and reasonably entitled to indemnity for such expenses which such court shall deem proper.

Section 3: Indemnification When Successful
1. To the extent that a director, officer, or employee acting in a managerial capacity on behalf of the Society has been successful in defense of any action, suit or proceeding referred to in Section 1 and Section 2 of this Article VIII, or in defense of any claim, issue or matter therein, he shall be indemnified against any and all expenses (including attorneys’ fees) actually and reasonably incurred by him in connection therewith, notwithstanding that he has not been successful on any other claim, issue or matter in any such action, suit or proceeding.

Section 4: Determination of Meeting Applicable Standard
1. Any indemnification under Section 1 or Section 2 of the Article VIII (unless ordered by a court) shall be made by the Society only as authorized in the specific case upon a determination that indemnification of the director, officer or employee is proper in the circumstances because he has met the applicable standard of conduct set forth in Section 1 and Section 2 of this Article VIII. Such determination shall be made either:

(a) by the Board of Directors by a majority vote of a quorum consisting of Directors who were not parties to, or who have been wholly successful with respect to, such claim, action suit or proceeding; or

(b) if such a quorum is not obtainable, or, even if obtainable, if a quorum of disinterested directors so directs, by independent legal counsel in a written opinion.

Section 5: Payment of Expenses in Advance of Disposition of Action
1. Any and all expenses (including attorneys’ fees) incurred in defending a civil or criminal claim, action, suit or proceeding shall be paid by the Society in advance of the final disposition of such claim, action, suit or proceeding as authorized in the manner provided in Section 4 of this Article VIII upon receipt of an undertaking by or on behalf of the director, officer, or employee to repay such amount if and to the extent that it shall be ultimately determined that he is not entitled to be indemnified by the Society as authorized in the Article VIII.

Section 6: Non-Exclusivity of Article VIII
1. The indemnification authorized in and provided by this Article VIII shall not be deemed exclusive of and shall be in addition to any other right to which those indemnified may be entitled under any statute, rule of law, provisions of Articles of Incorporation, Bylaws, agreement, or vote of the Board of Directors, both as to action in his official capacity and as to action in another capacity while holding such office, and shall continue as to a person who has ceased to be a director, officer, or employee and shall insure to the benefit of the heirs, executors and administrators of such a person.

Section 7: Insurance
1. The Society may purchase and/or maintain insurance on behalf of any person who is or was a director, officer, or employee acting in a managerial capacity on behalf of the Society, or is or was serving at the request of the Society as a director, officer, partner, employee or agent of another Society, partnership, joint venture, trust or other enterprise against any liability asserted against him and incurred by him in any such capacity or arising out of his status as such, whether or not the Society is required or permitted to indemnify him against such liability under the provisions of this Article VIII or any statute.

ARTICLE IX: DISSOLUTION OF THE SOCIETY
1. If it is determined that The Hip Society should dissolve, two-thirds (2/3) of the voting Membership must agree with the action. All debts owed shall be paid in full prior to dissolution. In addition, any monies remaining shall be designated to a charitable Society as designated by the Board of Directors.
ARTICLE X: EXEMPT ACTIVITIES

1. Notwithstanding any other provision of these Bylaws, no director, no management, or representative of this Society shall take any action or carry on any activity by or on behalf of the Society not permitted to be taken or carried on by a Society exempt under Section 501(c)(3) of the Internal Revenue Code and its Regulations as they now exist or as they may hereafter by amended.

ARTICLE XI: PARLIAMENTARY AUTHORITY

1. All meetings of the Society shall be conducted according to these Bylaws, Parliamentary Procedures according to Roberts' Rules of Order (Revised), and the Society's Policies and Procedures Manual.

ARTICLE XII: GENDER DISCLAIMER

1. The Society is open to persons of both sexes and does not discriminate against any person because of sex or gender; therefore, the working document herein importing the masculine or feminine gender includes the other gender and imports no such discrimination.

ARTICLE XIII: AMENDMENTS

Section 1: Proposed Amendments
1. All proposed amendments to the Bylaws must be signed by three (3) Active, Senior, Adjunct, or Senior Adjunct Members and submitted in writing to the Secretary. Proposed amendments approved by the Board of Directors shall be submitted to the voting membership for a mail or electronic vote at least three (3) months prior to the date of the actual vote. The Board of Directors may modify the proposed revisions to the Bylaws prior to submission of the ballot to the voting membership.

Section 2: Proposed Changes Requirements
1. A two-thirds (2/3) affirmative vote of the Members who are eligible to vote when a written notice of the proposed revisions to the Bylaws have been issued and who respond to a mail or electronic ballot sent three (3) months prior to the ballot receipt deadline, or a unanimous vote of those present at a Member Business Meeting.

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Amended 10/04/2013