Why Did We Leave Charnley Total Hip Replacement?

John J. Callaghan, M.D.
The Lawrence & Marilyn Dorr Chair
University of Iowa
Iowa City, IA

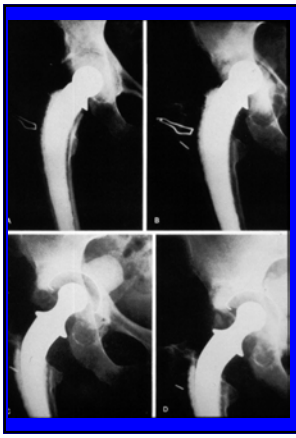
The Phillip Spiegel Memorial Lecture
University of South Florida
Orthopaedic Research Day
June 17, 2016

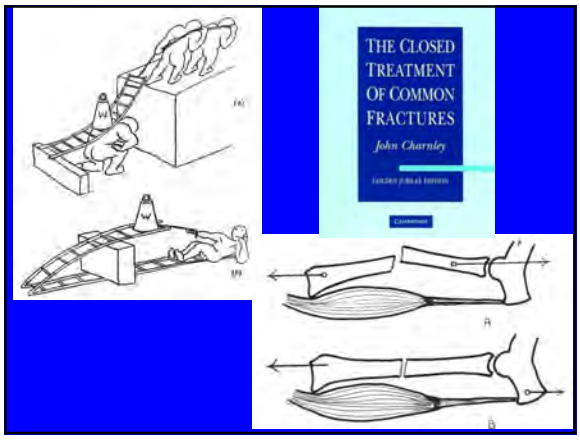
Disclosures

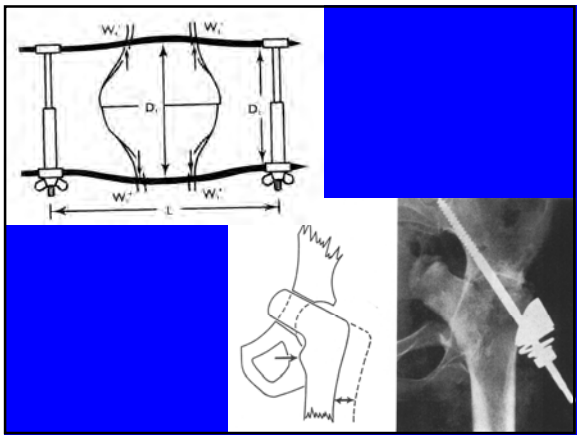
- Consultant and Royalties (DePuy) for intellectual property transfer for hip & knee implant designs.
- Royalties (Wolters Kluwer) for books edited.
- Board Membership
  - International Hip Society (President)
  - OREF (Orthopaedic Research and Education Foundation) (Chairman)
  - Journal of Arthroplasty (Assistant Editor-in-Chief)
  - Knee Society (Treasurer)

I am deeply honored for the opportunity to be the 2016 Phillip G. Spiegel Memorial Visiting Professor

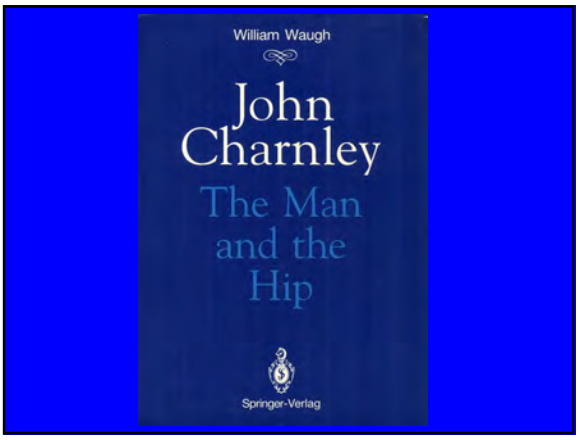
The Art of Teaching is the Art of Sharing One's Enthusiasm
- Adrian Flatt

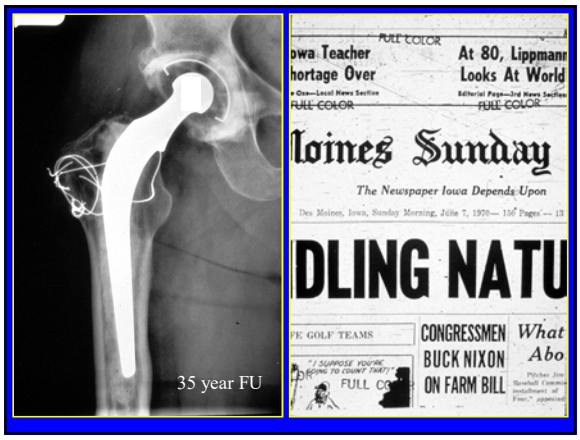


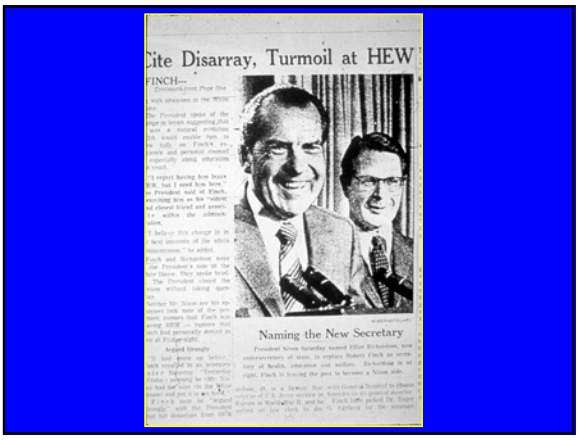

THE CLOSED TREATMENT OF COMMON FRACTURES
John Charnley




QUEEN ELIZABETH


William Waugh
John Charnley
The Man and the Hip
Springer-Verlag


35 year FU
Iowa Teacher Shortage Over
At 80, Lippmann Looks At World
Sunday
The Newspaper Iowa Depends Upon
DLING NATU
CONGRESSMEN BUCK NIXON ON FARM BILL
What Abo


ite Disarray, Turmoil at HEW
Naming the New Secretary

1,000 Cambodia Troops Sent To Stem Viet Cong Assault

Negro Police Vow to Arrest Officers Abusing Blacks

THE DAY IN WASHINGTON

'PEACE' SALES UP IN MIDWEST

PEACE—

...is the situation Miss Hazzard declines to unknot.

Hers is an effortless prose of great subtlety, marked always by such meticulous choice of the perfect word that the complex states of mind which attend love become readily believable under her telling. —Peter Stone

History

Black Freedom, by Carleton Mabee; Macmillan, $9.95.

IF ONE IS to comprehend the drive for black civil rights today, he must understand the past, and Pulitzer Prize-winner Carleton Mabee offers an enlightening insight into history in this new volume, subtitled "The Nonviolent Abolitionists From 1830 Through the Civil War."

Nonviolence in the cause of civil rights had its birth among these abolitionists and their leaders, including such well-known personalities as John Greenleaf Whittier, Frederick Douglass, William Lloyd Garrison and others.

How the nonviolent abolitionist move-

story you won't want to put down. —Nick Lam

Best Sellers

Fiction:

Love Story, by Erich Segal (Ha...
& Row); Deliverance, by James D...
ley (Houghton Mifflin); The Fr...
Lieutenant's Woman, by John Fo...
(Little, Brown); Great Lion of G...
by Taylor Caldwell (Doubleday);...
ing Battles, by Eudora Welty (R...
dom House).

Nonfiction:

Up the Organization, by Ro...
Townsend (Knopf); Everything
Have Always Wanted to Know Ab...
Sex, by David Reuben (McK...
Mary Queen of Scots, by Anto...
Fraser (Delacorte); The Sense...
Woman, by "J" (Stuart); The ...
English Bible (Oxford).

BOOKS FOR FATHER'S DAY

Be he guidepraman, scholar, garde

for the boys and coaching in 1970 is the same as it was in 1950 or 1940.

"I coach the same today as

The Baseball Scoreboard

National League

EASTERN DIVISION

	W.	L.	Pct.	G.B.
Chicago	27	21	.563	...
Pittsburgh	26	28	.481	4
New York	25	27	.481	4½
St. Louis	23	26	.469	4½
Philadelphia	22	29	.431	6½
Montreal	18	33	.353	10½

WESTERN DIVISION

	W.	L.	Pct.	G.B.
Cincinnati	29	15	.722	...
Atlanta	29	21	.580	6
Los Angeles	30	23	.566	6½
San Francisco	25	29	.463	14
Houston	25	30	.455	14½
San Diego	25	32	.439	15½

Saturday's Games

San Francisco 5, Chicago 3
Cincinnati 5, New York 1 (N)
San Diego 5, St. Louis 4 (N)
Pittsburgh 7, Los Angeles 6 (12 innings, N)
Montreal 12, Atlanta 4 (N)
Philadelphia 7, Houston 3 (N)

Today's Pitchers

American League

EASTERN DIVISION

	W.	L.	Pct.	G.B.
Baltimore	35	18	.660	...
New York	31	23	.574	4½
Detroit	24	25	.490	9
Boston	23	25	.479	9½
Washington	24	27	.471	10
Cleveland	20	30	.400	13

WESTERN DIVISION

	W.	L.	Pct.	G.B.
Minnesota	33	15	.688	...
California	33	19	.635	2
Oakland	28	25	.528	7½
Kansas City	19	31	.380	15
Chicago	19	33	.365	16
Milwaukee	16	35	.314	18½

Saturday's Games

Detroit 6, Oakland 4
New York 3, Chicago 1
Milwaukee 6, Baltimore 4
Minnesota 4, Washington 2 (N)
California 2, Cleveland 1 (N)
Kansas City at Boston, rain

Today's Pitchers

White End
USAC Slu
At Knoxv

By a Staff Writer

KNOXVILLE, IA. —
drivers are known for r
lizing top positions in late
stock car races and that
happened Saturday night
6,500 fans at the Marion
Fairgrounds.

Don White, senior mem
a trio from the river c
for 78 of the 100 laps
United States Auto Club
and recorded his first t
of the season. He also
feature here last year.

Lem Blankenship, the
driving sensation from
that presently boasts th

1. He had never been to award a full scholars any player, black or wh

owans Test Plastic Hip Replacement

Scholarships to 30 at Wartburg

WAVERLY, IA. —

Great mentors can really help in the early development of time management skills

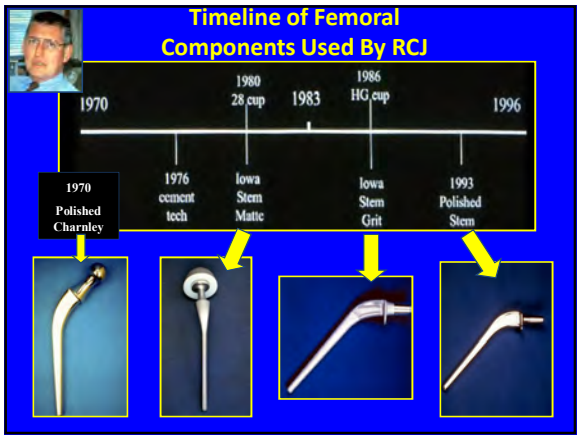
When you see a turtle on a fence post, remember it didn't get there by itself.

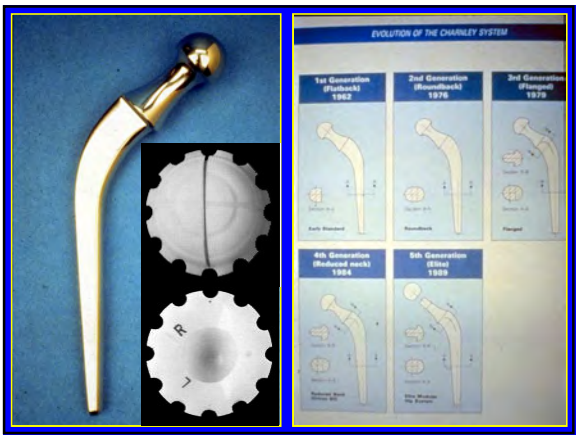
CLINICAL ORTHOPAEDICS AND RELATED RESEARCH
Number 369, pp. 25–38

The John Charnley Award

Practice Surveillance: A Practical Method to Assess Outcome and to Perform Clinical Research

John J. Callaghan, MD; Richard C. Johnston, MD, MS; and Douglas R. Pedersen, PhD





Survivorship of a Charnley Total Hip Arthroplasty

A Concise Follow-up, at a Minimum of Thirty-five Years, of Previous Reports*

By John J. Callaghan, MD, Peter Bracha, Steve S. Liu, MD, Somvot Piyaworakhun, MD, Devon D. Goetz, MD, and Richard C. Johnston, MD

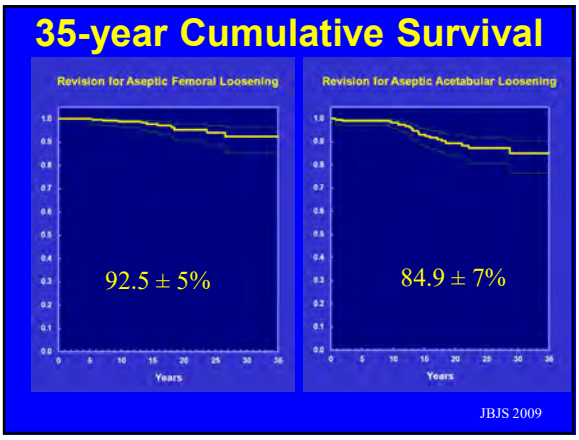
Investigation performed at the University of Iowa, Iowa City, Iowa, and Des Moines Orthopaedic Surgeons, West Des Moines, Iowa

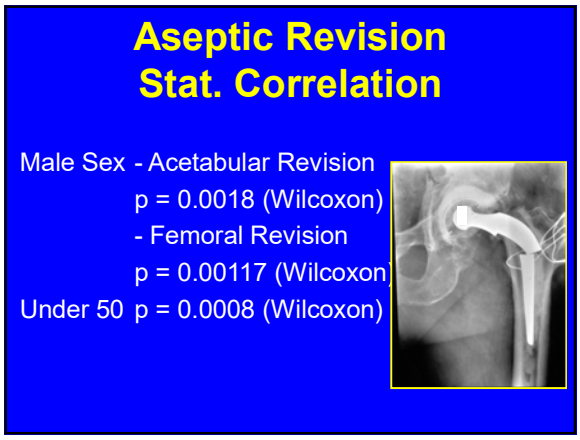
Thirty-five-Year Results After Charnley Total Hip Arthroplasty in Patients Less Than Fifty Years Old

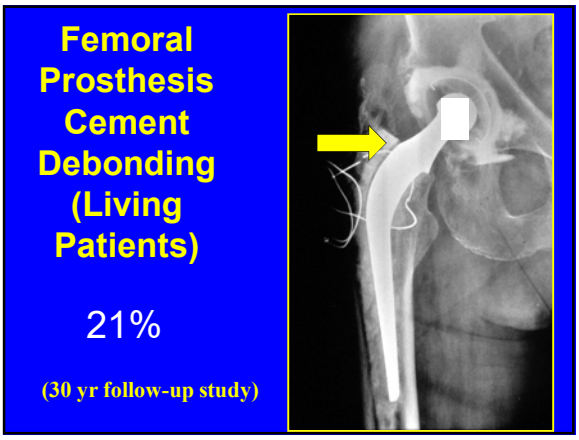
A Concise Follow-up of Previous Reports*

Lucian C. Warth, MD, John J. Callaghan, MD, Steve S. Liu, MD, Alison L. Klassen, MA, Devon D. Goetz, MD, and Richard C. Johnston, MD

Investigation performed at the Department of Orthopaedic Surgery, University of Iowa Hospitals and Clinics, Iowa City, and Des Moines Orthopaedic Surgeons, West Des Moines, Iowa







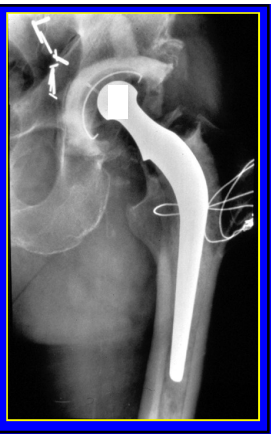
Lysis

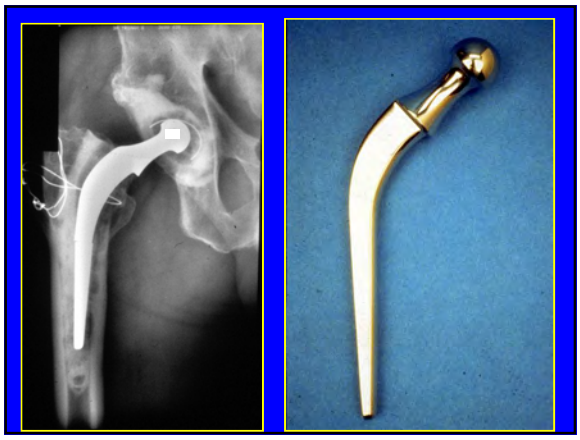
Femoral:

Zone 1 & 7: 53.2%

Zones 2-6: 3.2%

(30 yr follow-up study)



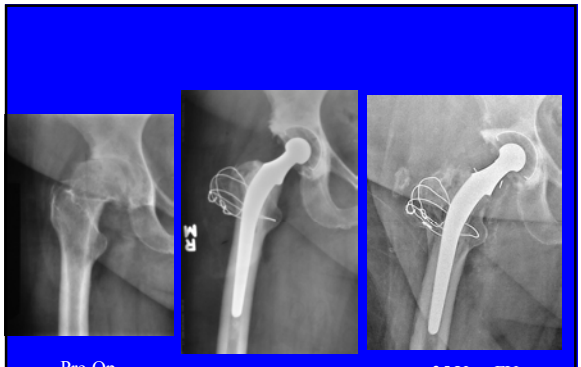


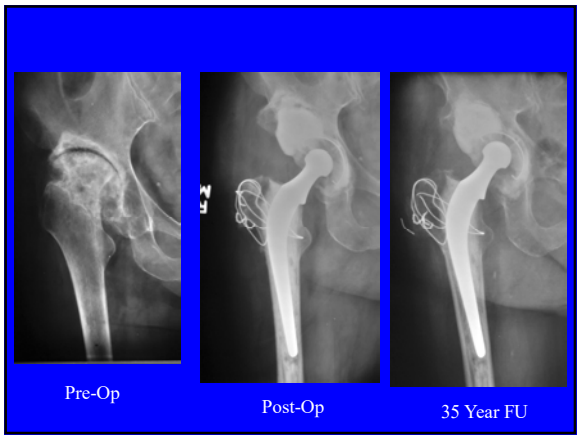
Acetabular Component Wear

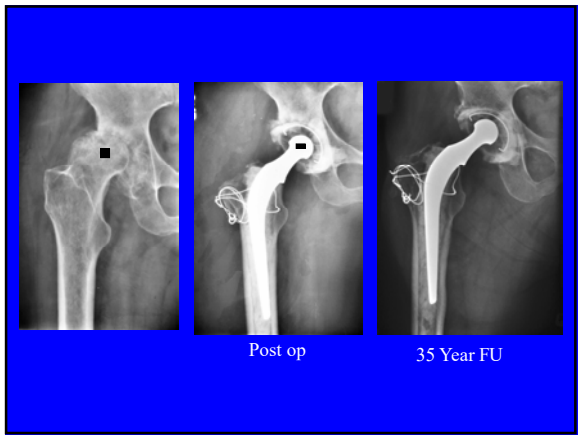
Avg All Hips	0.10 mm per year (Range 0.04 to 0.26)
Avg Revised	0.14 mm per year
Avg Non Revised	0.09 mm per year

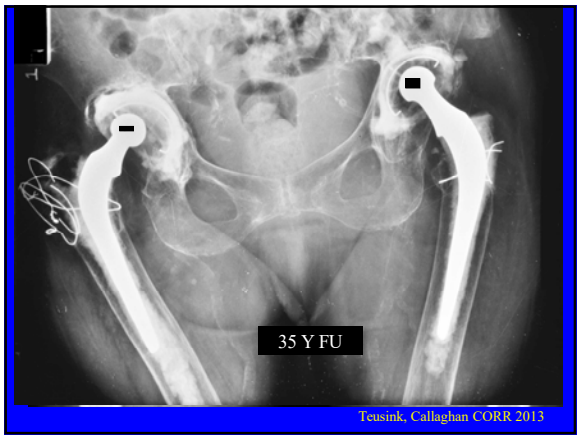
Final Outcome: All Patients

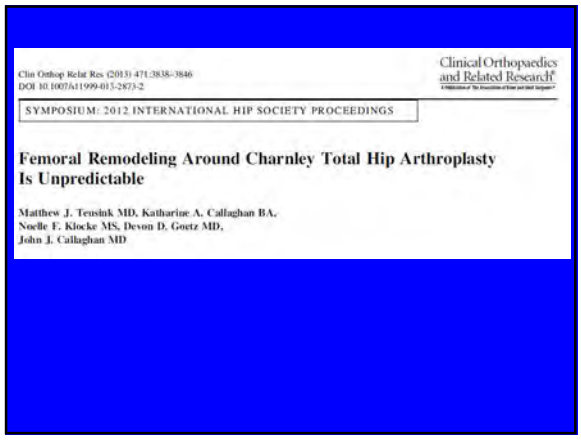
	Hips	%
Original prosthesis	295	88.2
2nd hip	22	
for aseptic loosening	20	6.1
for dislocation	2	0.6
3rd hip, for aseptic loosening	3	0.9
4th hip, for dislocation	1	0.3
Girdlestone	9	2.7











Clin Orthop Relat Res (2013) 471:3838–3846
DOI 10.1007/s11999-013-2873-2

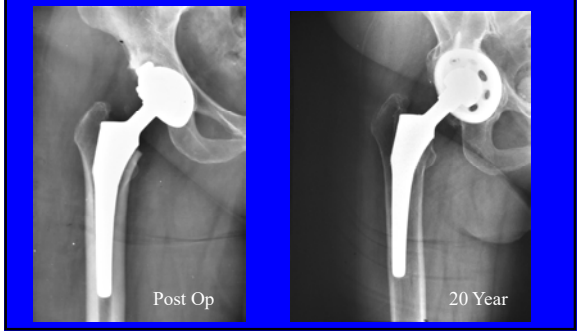
Clinical Orthopaedics and Related Research®

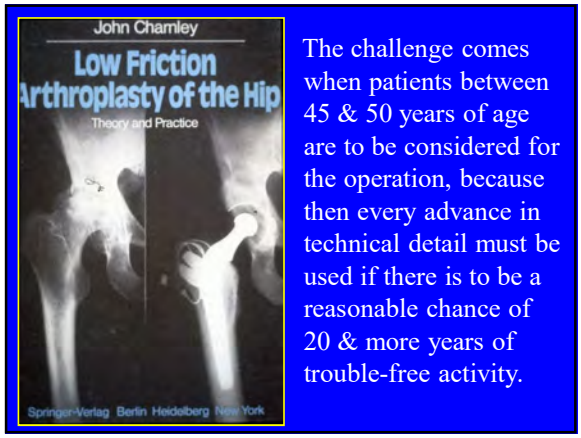
SYMPOSIUM: 2012 INTERNATIONAL HIP SOCIETY PROCEEDINGS

Femoral Remodeling Around Charnley Total Hip Arthroplasty Is Unpredictable

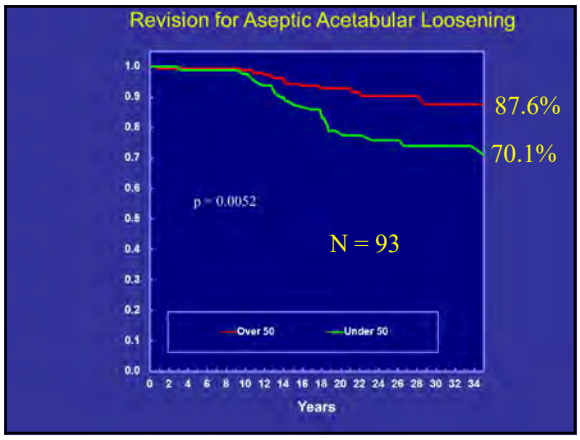
Matthew J. Teusink MD, Katharine A. Callaghan BA, Noelle E. Klocke MS, Devon D. Goetz MD, John J. Callaghan MD

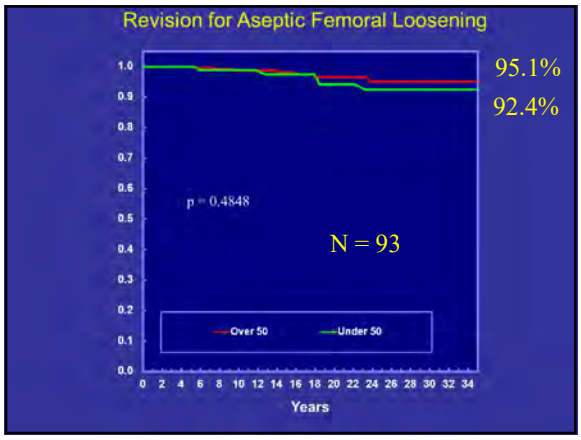
PCA PROXIMALLY COATED UNCEMENTED

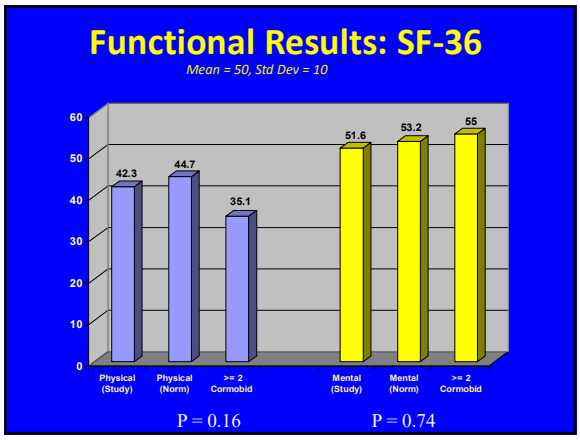


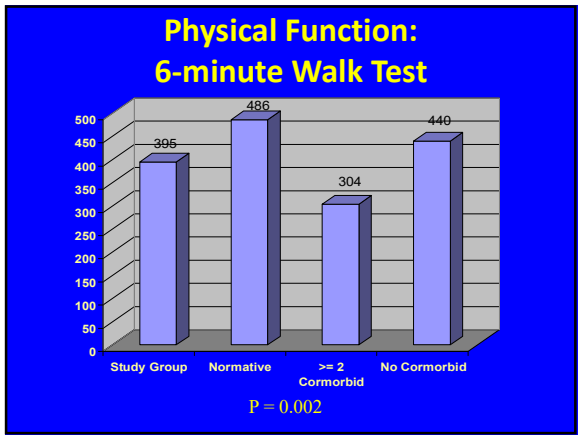


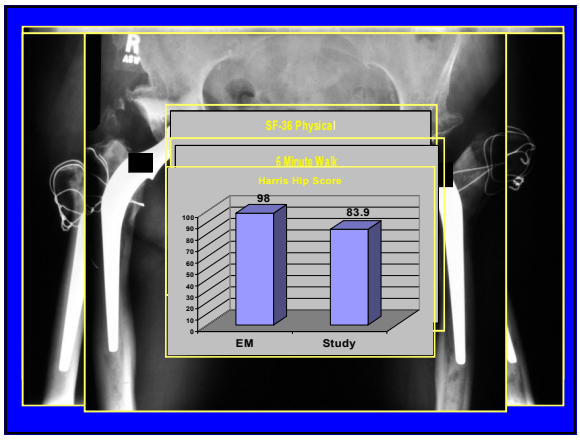
The challenge comes when patients between 45 & 50 years of age are to be considered for the operation, because then every advance in technical detail must be used if there is to be a reasonable chance of 20 & more years of trouble-free activity.

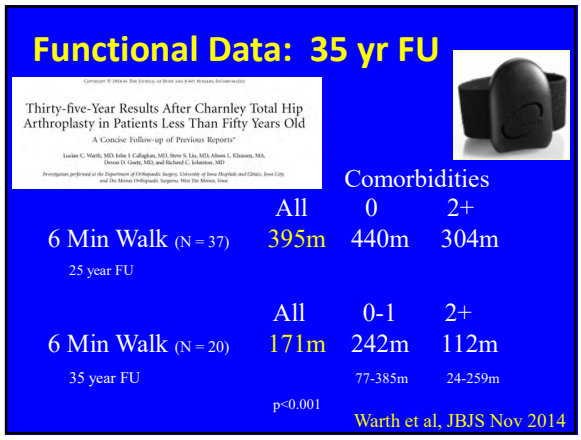

Revision for Aseptic Acetabular Loosening
87.6%
70.1%
p = 0.0052
N = 93
Over 50
Under 50
Years

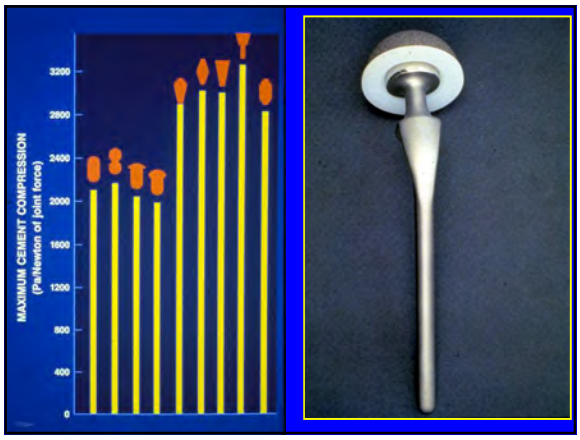

Revision for Aseptic Femoral Loosening
95.1%
92.4%
p = 0.4848
N = 93
Over 50
Under 50
Years


Functional Results: SF-36
Mean = 50, Std Dev = 10
42.3
44.7
35.1
51.6
53.2
55
Physical (Study)
Physical (Norm)
>= 2 Cormobid
Mental (Study)
Mental (Norm)
>= 2 Cormobid
P = 0.16
P = 0.74


Physical Function:
6-minute Walk Test
395
486
304
440
Study Group
Normative
>= 2 Cormorbid
No Cormorbid
P = 0.002


SF-36 Physical
6 Minute Walk
Harris Hip Score
98
83.9
EM
Study


Functional Data: 35 yr FU
Thirty-five-Year Results After Charnley Total Hip Arthroplasty in Patients Less Than Fifty Years Old
A Concise Follow-up of Previous Reports*
Comorbidities
All
0
2+
6 Min Walk (N = 37)
395m
440m
304m
25 year FU
All
0-1
2+
6 Min Walk (N = 20)
171m
242m
112m
35 year FU
77-385m
24-259m
p<0.001
Warth et al, JBJS Nov 2014

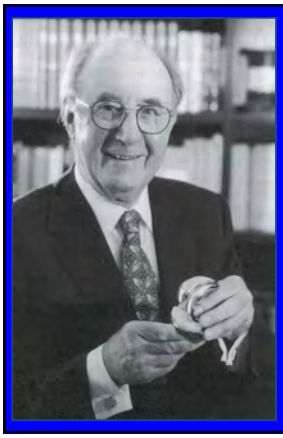


Results:
Revision and Loosening Prevalence
All Patients at 10 Years

	Matte (30 Ra)	Grit (80 Ra)	Polished (5 Ra)
Revision for Aseptic Femoral Loosening	2.0%	10.8%	0%
Radiographic Femoral Loosening	3.6%	13.0%	0%

Everything you work on in the lab does not work out in the body.
- Salvati

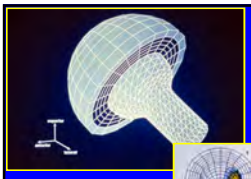
JBJS 89-A, 2007



"Choices and Compromises"
Presidential Address
Knee Society 1988

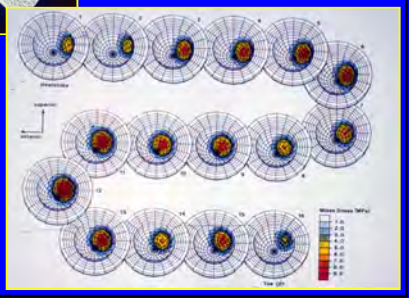
Grit blasted stems:
- Great for fixation to cement
- Terrible, if cement debonds from prosthesis

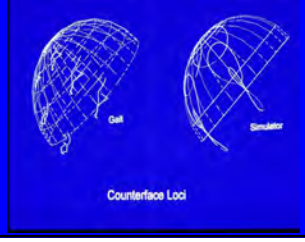
My wife Kim would say the same about our marriage.



Maxian et al.
Stinchfield Award. 1996
CORR 333

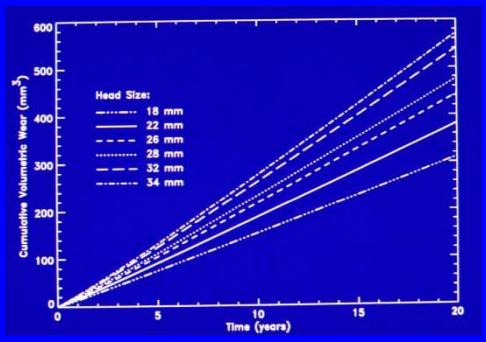
Why the low wear rate with Charnley THR?





Gait Analysis

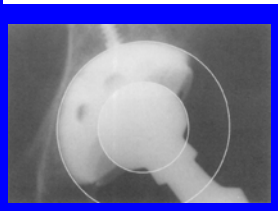
Effect of Head Size

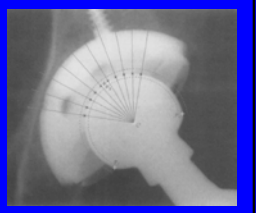


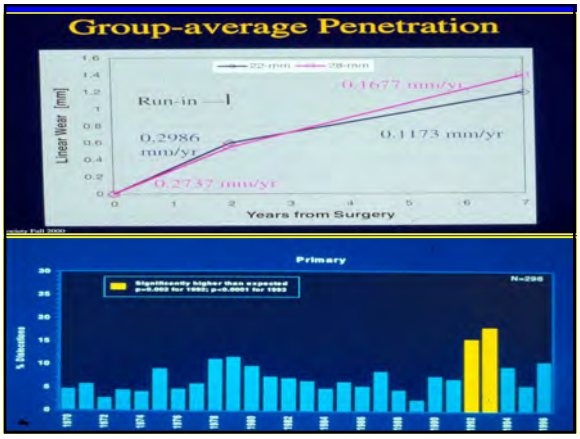
Digital Edge-Detection Measurement of Polyethylene Wear after Total Hip Arthroplasty*

BY SCOTT M. SHAVER, M.S.†, THOMAS D. BROWN, PH.D.‡, STEPHEN L. HILLIS, PH.D.‡, AND JOHN J. CALLAGHAN, M.D.‡, IOWA CITY, IOWA

Investigation performed at The University of Iowa, Iowa City

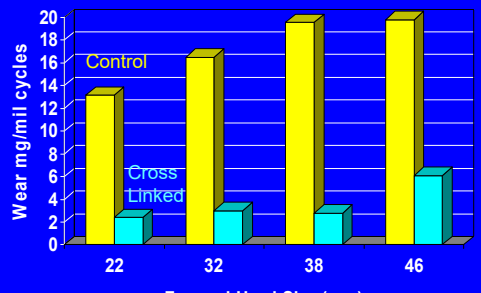




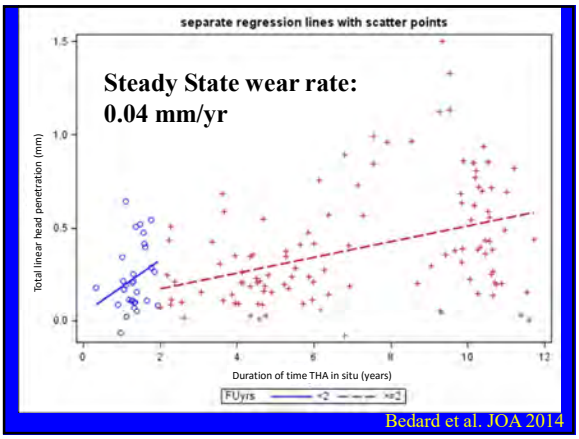


Hip Simulator Wear Rate

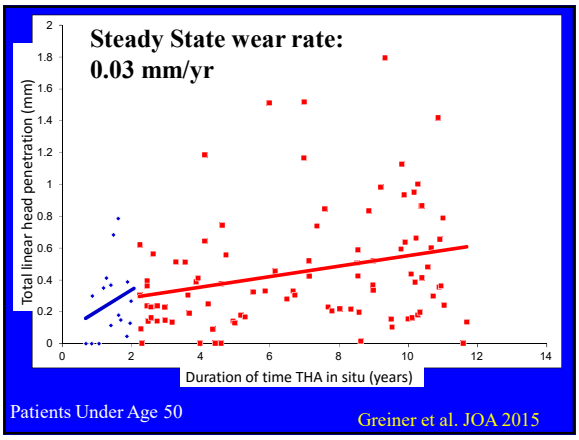
Four serum changes / million cycles



Crowninshield



Bedard et al. JOA 2014



Patients Under Age 50

Greiner et al. JOA 2015

Concerns with Metal on Crosslinked Polyethylene

Wear and Osteolysis of Highly Crosslinked Polyethylene at 10 to 14 Years: The Effect of Femoral Head Size

Paul F. Lachiewicz MD, Elizabeth S. Soileau BSN, John M. Martell MD

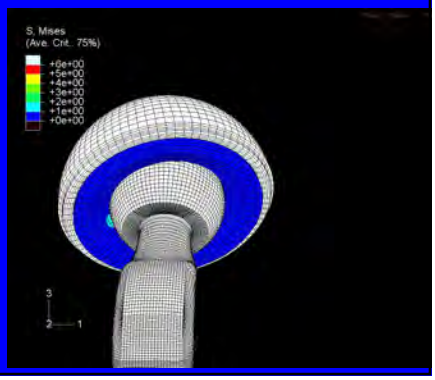
Lachiewicz et al. CORR 474, 2016

- 10 Mrad remelt polyethylene
- Linear wear rate: 0.024 mm/yea
- Volumetric wear rates:
  - 32 mm head: 57 mm³/year
  - 36/40 mm head: 156 mm³/year

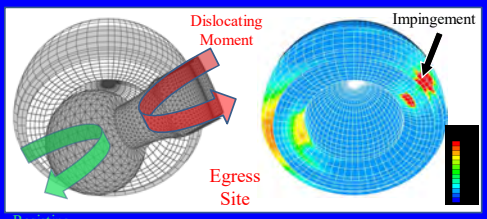
  p = 0.0005

14% small osteolytic lesions

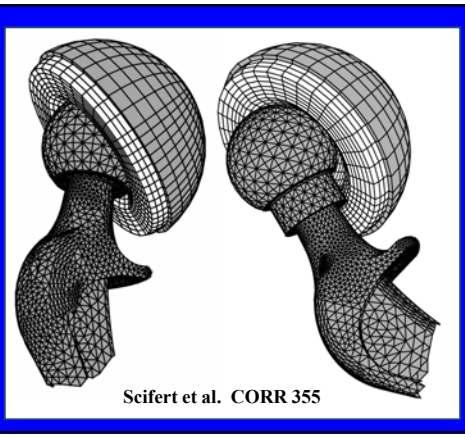
Finite Element Model of Dislocation



Engagement Kinetics



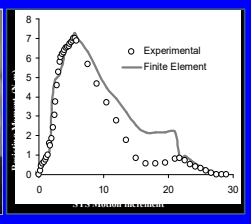
Resisting
Moment



Scifert et al. CORR 355

"Trans-pelvic THA"

Physical Validation



Elkins et al. *JOR* 2011

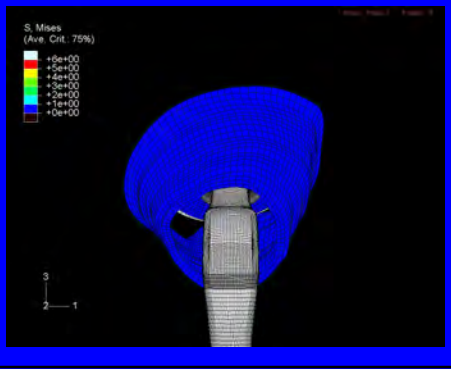
Dislocation Challenges

- Sit-to-stand (STS)
- Low STS
- Seated crossleg
- Stooping
- Squatting
- Shoe tie

- Supine roll-over
- Standing pivot

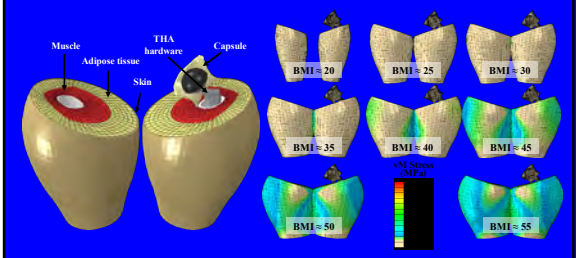
Nadzadi et al, JBiomech 2003

FEM with Joint Capsule



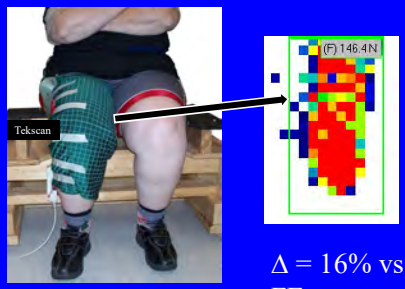
Obesity

RR ~ 2.0 – 5.0



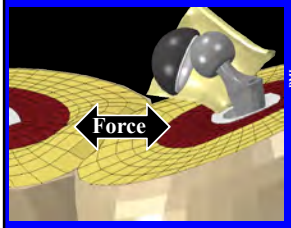
Elkins et al. CORR 2013

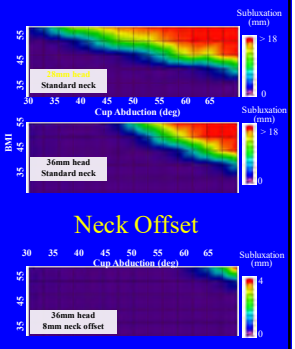
Validation



Δ = 16% vs. FE

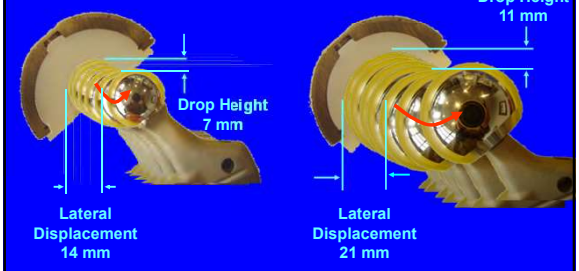
Head Size



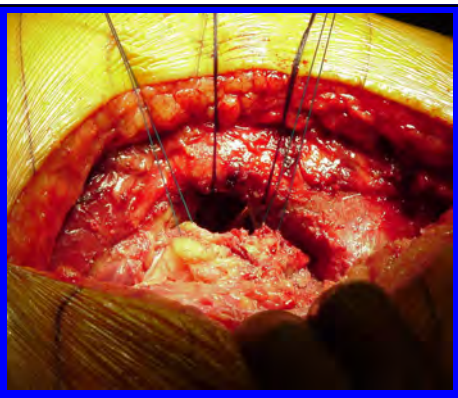


Neck Offset

@ 45 degrees of cup abduction

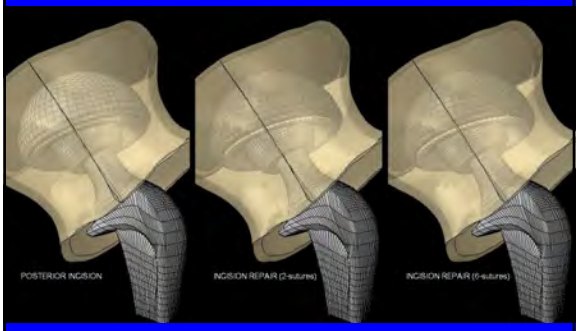


Crowninshield et al



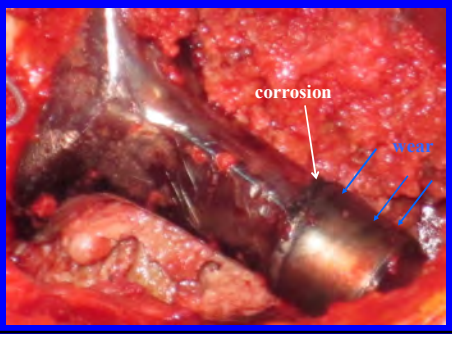
Posterior Capsular Repair (Right Hip)

Results



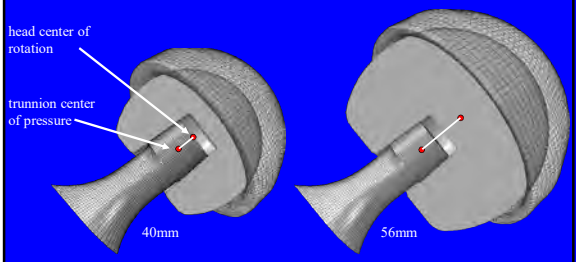
Leaving Charnley's 22 mm Heads was a Good Idea, But Might have some Concerns Going to Heads 36 mm and Above

"Trunnionosis" wear

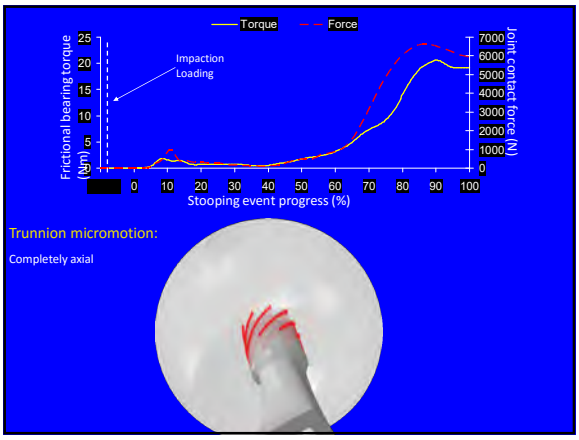


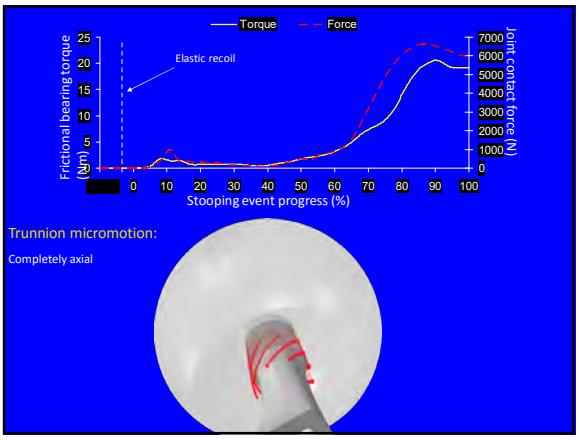
Large heads in MoM THA

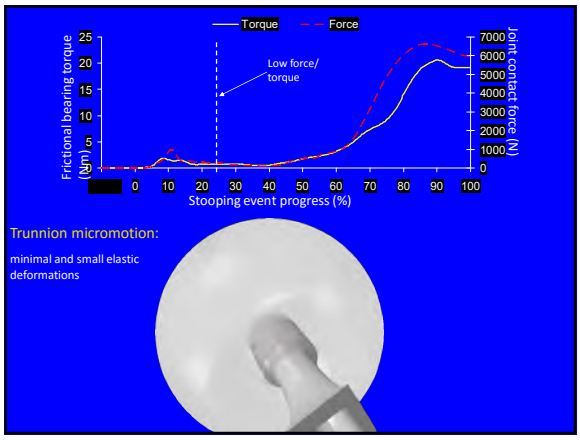
Large heads create large moment arm

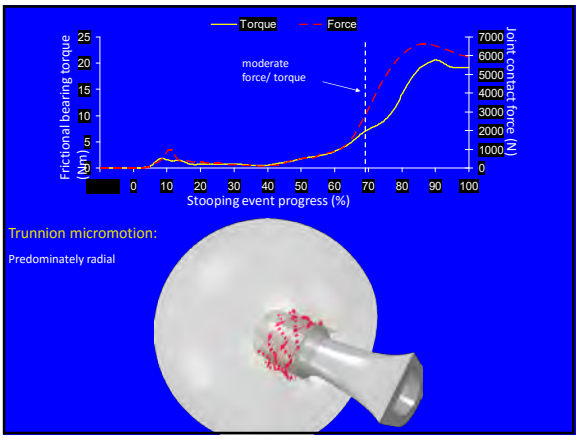


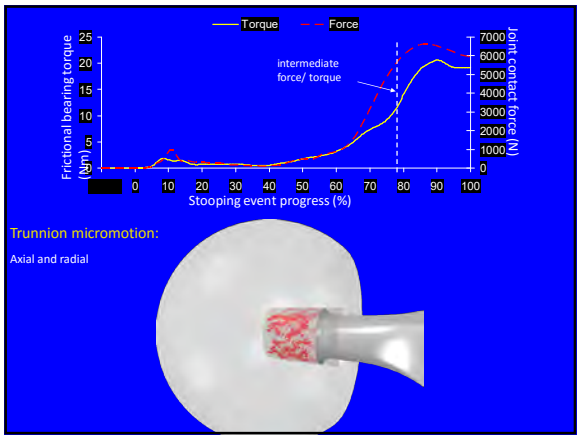
Elkins et al. CORR 2014

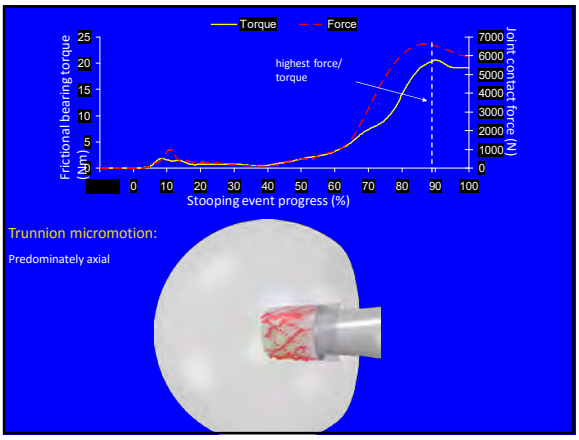


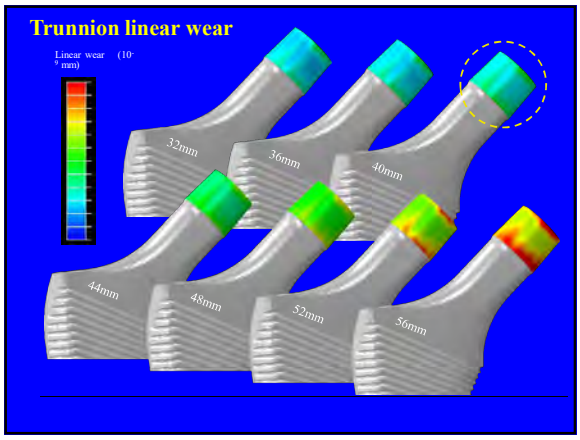












We Left Cemented Fixation for Cementless Fixation

25 Year Follow-up PCA Cementless THA

100 hips (91 patients)
Age at surgery: 58 yrs (range 22-81)
Femoral revision: 7%
- 3% loosening
- 4% osteolysis (only proximal osteolysis)

Acetabular revision: 23%
- 22% loosening and osteolysis
- 1% dissociation

JBJS, 85-A, 2003

HGI Min 20 Y FU

Hips	120
Patients	108
Age at Surgery	62.8 years avg (26 to 86)

Revision for loosening: 0.8% (no additional rad loose)
Wear rate: 0.1186 mm/year
Osteolysis: 12% of living patients

JBJS, 94-A, 2012

Fiber Mesh Acetabular Components

HG-I

HG-II

10-18 Year Follow Up Patients Under Age 50

Hips	144
Patients	118
Age at Surgery	40.5 years avg (22 to 50)

Revision: loosening: 1.4%, osteolysis 15%
Wear rate: 0.19 mm/year

J Arthroplasty 2012

- 0% revised
- 0% radiographically loose
- 0.03-0.04 mm/yr wear rate
- 1 case osteolysis

Prodigy Extensively Coated Stem Results Min 10 year fu

100 hips
91 patients
63:28 MF
No Revision Femoral Loosening
No Radiographic Loosening
2 Reoperations (dislocation, fem fx)

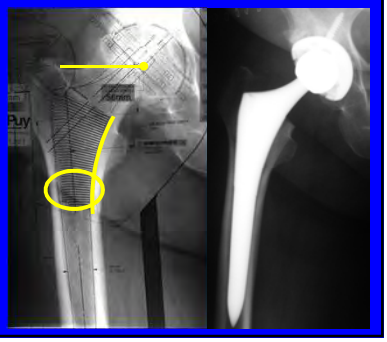
CORR 2009

Prodigy Extensively Coated Stem Results
Min 10 year fu
Under Age 50

115 hips
100 patients
63:37 MF
No Revision for Loosening
No Radiographic Loosening

Takenaga et al. JBJS 2012

Tapered Femoral Stems

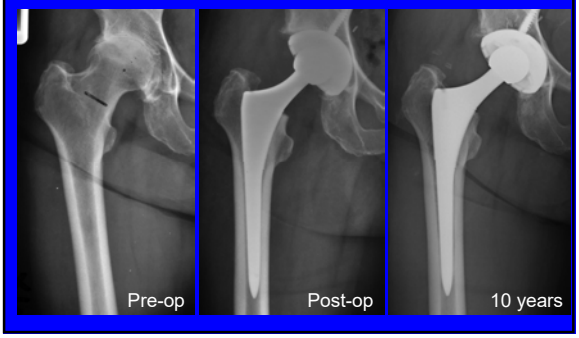


Tapered Stem 10 Year Follow-Up

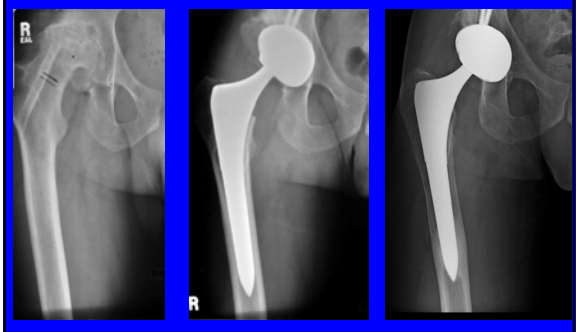
- 100 hips
- All bone ingrown
- Only 1 with significant stress shielding
- Min 10 year, no clinical or radiographic loosening

JOA ePub 2016

Bone Remodeling:
None or minimal stress shielding – 87%



Can Get Stress Shielding



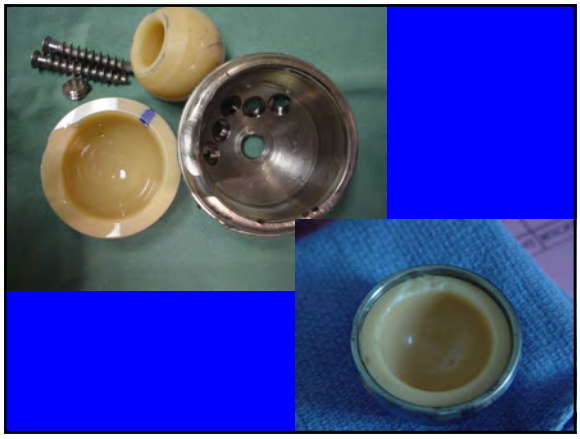
CERAMIC-ON-CERAMIC

Alumina Ceramic on Poly Twenty years (17-21)

- Survivorship = 79%
- Linear Wear = 0.034mm/yr
- No Fractures

Urban, Callaghan, et al
JBJS, 2001

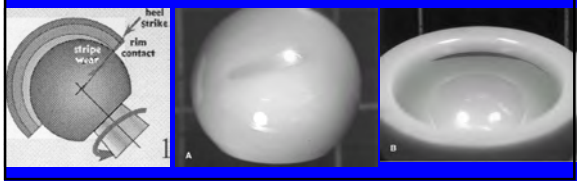
- Fracture: 0.01 - 0.4% In Recent Extensive Reviews
- Etiology Multifactorial
  - Material Quality
  - Manufacturing Techniques
  - Taper Geometry
  - Surgeon Application
  - Patient Factors



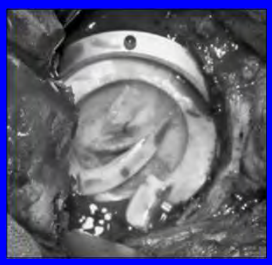
Microseparation (MSX) in Hip Simulator Studies

- "Stripe Wear"
- Rim contact can occur at very small separations (0.1mm)

Squeaking Hip



Fracture of Ceramic Liners

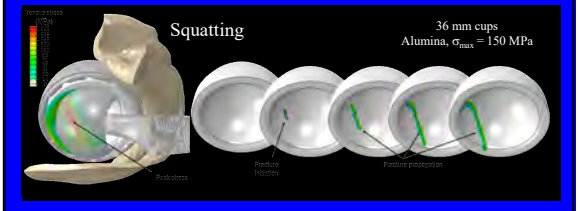


Prevalence ~ 1%

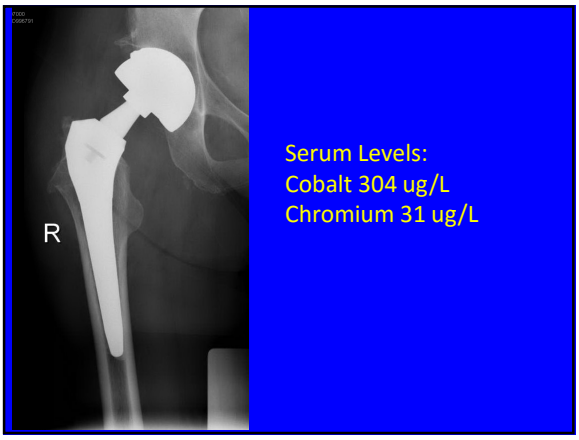
3.5% (Ha et al. *CORR* 2007)
1.12% (Park et al. *JBJS* 2006)
0.22% (Toni et al. *JBJS* 2006)

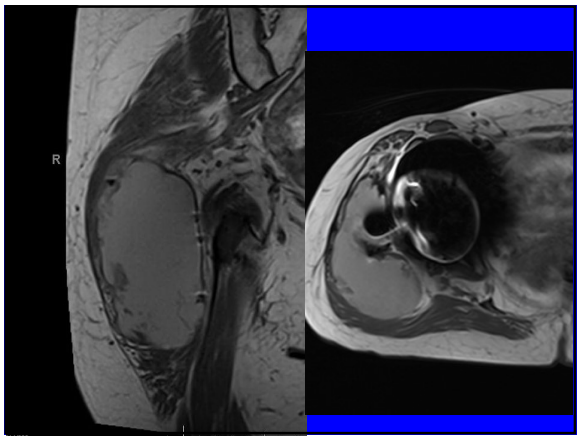
Catastrophic Crack Propagation

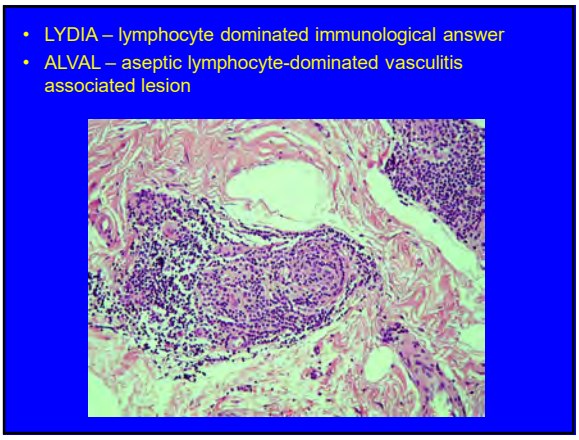
eXtended Finite Element Modeling (XFEM)

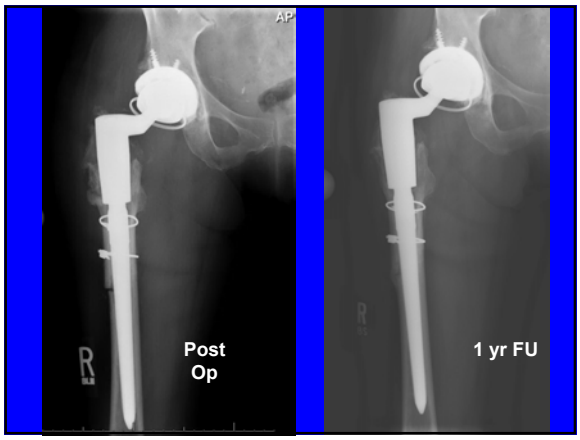


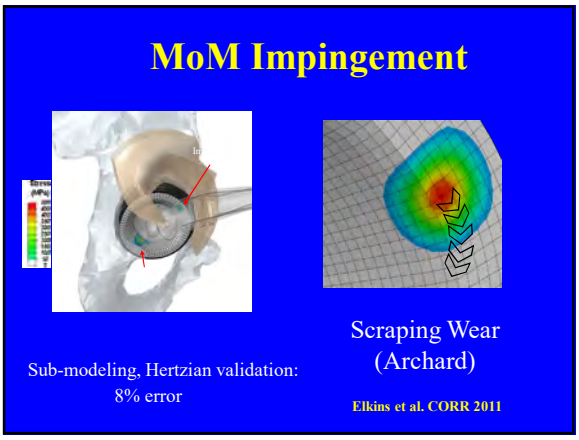

Metal on Metal
ONLY
ALL-METAL
WORLD'S BEST
PERFORMING

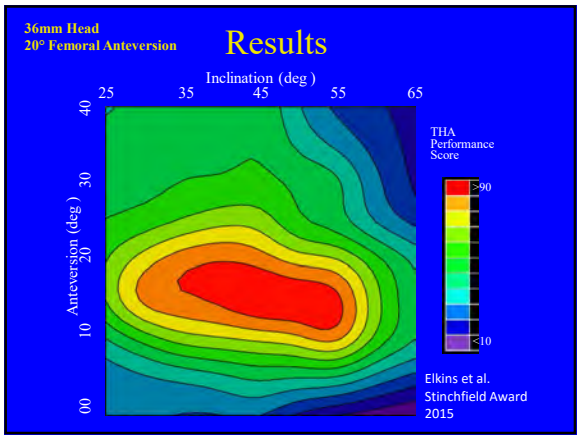

R
Serum Levels:
Cobalt 304 ug/L
Chromium 31 ug/L

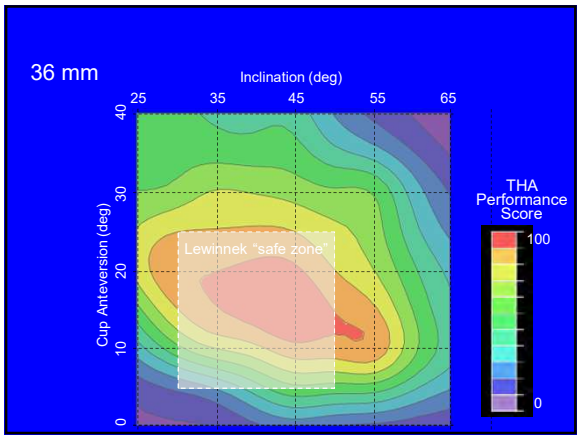

R

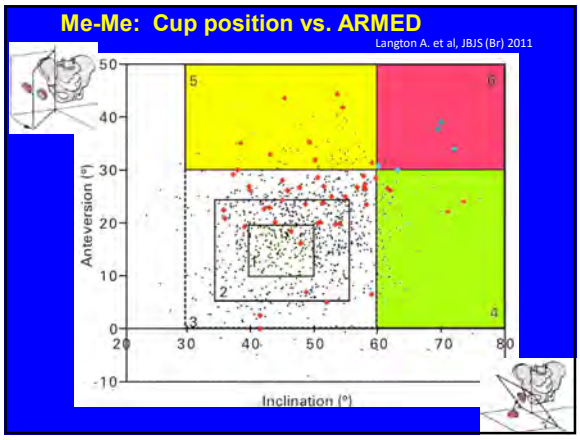

• LYDIA – lymphocyte dominated immunological answer
• ALVAL – aseptic lymphocyte-dominated vasculitis associated lesion


AP
R
Post
Op
R
1 yr FU


MoM Impingement
Sub-modeling, Hertzian validation:
8% error
Scraping Wear
(Archard)
Elkins et al. CORR 2011







MoM Modular Acetabular Component at 5-12 Years

Components revised:

- Femoral components:
  - 3-5 yr: 0% for ALVAL
  - 5-12 yr: 3.8% for ALVAL
- Acetabular components: 0
- Osteolysis: 4.4% to 13.3%

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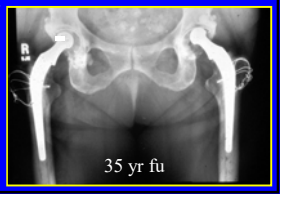
Why did the Charnley Total Hip Replacement work?

1. 22 millimeter head
2. Thick polyethylene (9 or 11 mm)
3. Two stem sizes
4. Cement friendly design (geometry, polished)
5. Lateralization of greater trochanter



What did we learn from our Charnley experience?

1. Cemented fixation provides durable results in THR.
2. Small head size good for reducing wear.
3. Polished flatback Charnley stem extremely durable at 35 years.
4. Acetabular fixation is less durable long term than is femoral fixation.

What aspects of the Charnley Total Hip Arthroplasty have we abandoned?

1. Cemented acetabular fixation for cementless acetabular fixation.
2. Cemented femoral fixation for cementless femoral fixation in the high demand patient (more and more liberal with our indications for cementless femoral fixation).

What aspects of the Charnley Total Hip Arthroplasty have we abandoned?

3. Clean air for clean air with antibiotics.
4. Smaller head sizes for larger head sizes (only because of dislocation, and hopefully better polyethylene available). Large heads were also optimal for hard bearings (ie ceramics & MoM)
5. Trochanteric osteotomy for other approaches.

Remember

The Important Thing is
What Works
not
What's New!!!

Remember

The Charnley THR worked.

Hopefully, what we are doing today will work as well.

OREF ORTHOPAEDIC RESEARCH AND EDUCATION FOUNDATION

National Institutes of Health
NIAMS National Institute of Arthritis and Musculoskeletal and Skin Diseases

U.S. Department of Veterans Affairs

Remember, you can't take it with you!

Thank You

Sound Bites from Talk

- Institutional culture
- Turtle/fencepost
- Efficiencies, discipline, organization
- Big clouds, small clouds
- Back end one side of the day
- Choices and compromises
- Get in the Red Zone and across the Goal Line
- Plan-work-audit
- Punctuality is lonely
- Team-loyalty-longevity
- No Nobel Laureate research
- 7 Eleven story
- Family communication on their time
- Travel time is work time (or personal time)

Telemachus and Mentor from The Odyssey

When Odysseus left for war in Troy, he entrusted Mentor with the care of his son Telemachus.

Mentor became not only a teacher, but role model and guardian responsible for the emotional and intellectual development of Telemachus.

Mentoring

I fundamentally practice the principles and concepts I learned from my mentors:

- Practice surveillance, go slowly with new technology
- Choices and compromises
- In the end, clinical results are the only relevant results for our patients.

- Four phases of life:
  - Thrill of Victory
  - Agony of Defeat
  - There is a God and it's not me
  - Giving back

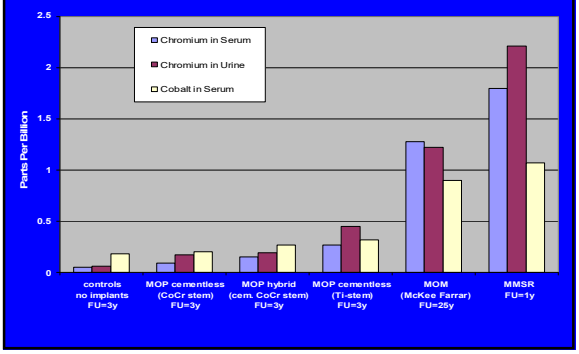
Dick Johnston

John Insall

Eduardo Salvati

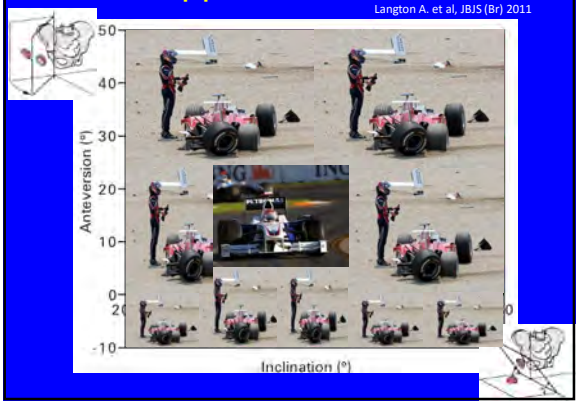
Larry Dorr

Mean Ion Levels



Me-Me: Cup position vs. ARMED

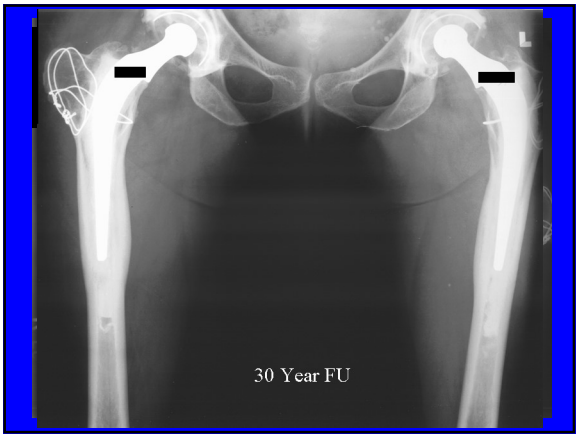
Langton A. et al, JBJS (Br) 2011



Minimum 3-5 year Follow-Up

	Patients	Hips
• Clinical follow-up:		
–Living	142	163
–Deceased	5	5
–Lost to follow-up	1	1

J Arthroplasty 2013



The Squeaking Hip