Modularity
in Total Hip Arthroplasty

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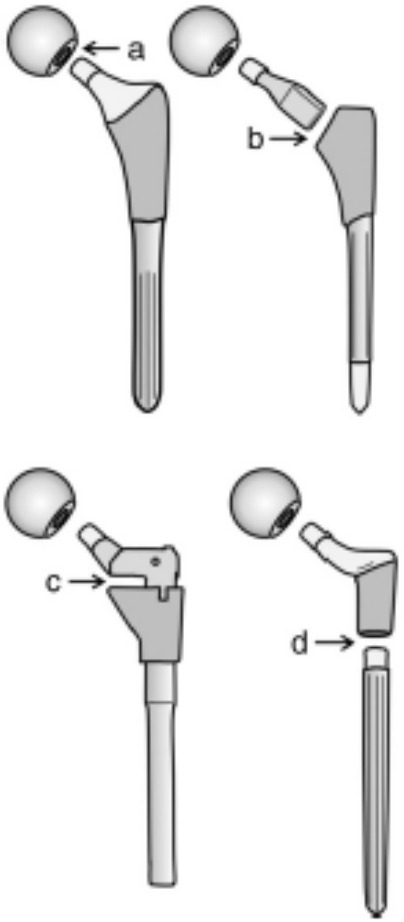
The Benefits of Modularity



Restoration of Femoral Anatomy

- Leg Length
- Offset
- Version

} **Stability**

Diaphysis ➔ Metaphysis

Modularity Works…

Head–Neck Modularity for Total Hip Arthroplasty

William J. Hozack, MD,*† Joseph J. Mesa, MD,†
and Richard H. Rothman, MD, PhD*†

The Journal of Arthroplasty Vol. 11 No. 4 1996

- 19% of cases had a change in neck length to optimize leg-length

Modular versus Nonmodular Neck Femoral Implants in Primary Total Hip Arthroplasty: Which is Better?

Clin Orthop Relat Res (2014) 472:1240–1245

Paul J. Duwelius MD, Bob Burkhart PA, Clay Carnahan PA, Grant Branam BSc,
Laura Matsen Ko MD, YingXing Wu MD, Cecily Froemke MS,
Lian Wang MS, Gary Grunkemeier PhD

- Less leg length discrepancy with neck modularity
- Less offset differences with neck modularity

But Do We NEED It?

Modular versus Nonmodular Neck Femoral Implants in Primary Total Hip Arthroplasty: Which is Better?

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Paul J. Duwelius MD, Bob Burkhart PA, Clay Carnahan PA, Grant Branam BSc, Laura Matsen Ko MD, YingXing Wu MD, Cecily Froemke MS, Lian Wang MS, Gary Grunkemeier PhD

- No difference in HHS or complications at 3 years

Midterm Results of a Femoral Stem With a Modular Neck Design: Clinical Outcomes and Metal Ion Analysis

The Journal of Arthroplasty 29 (2014) 1768–1773

Craig D. Silverton, DO [a,1], Joshua J. Jacobs, MD [b,1], Jeffrey W. Devitt, MD [a,1], H. John Cooper, MD

- 9% revision rate for Profemur Z stem-related failures at 8 years

Adverse Clinical Outcomes in a Primary Modular Neck/Stem System

Camilo Restrepo, MD, David Ross, BA, Santiago Restrepo, Snir Heller, MD, Nitin Goyal, MD, Ryan Moore, MD, William J. Hozack, MD

The Journal of Arthroplasty 29 Suppl. 2 (2014) 173–178

- Mean 17 months to symptoms with the ABG-II
- All revisions had evidence of corrosion between neck and stem

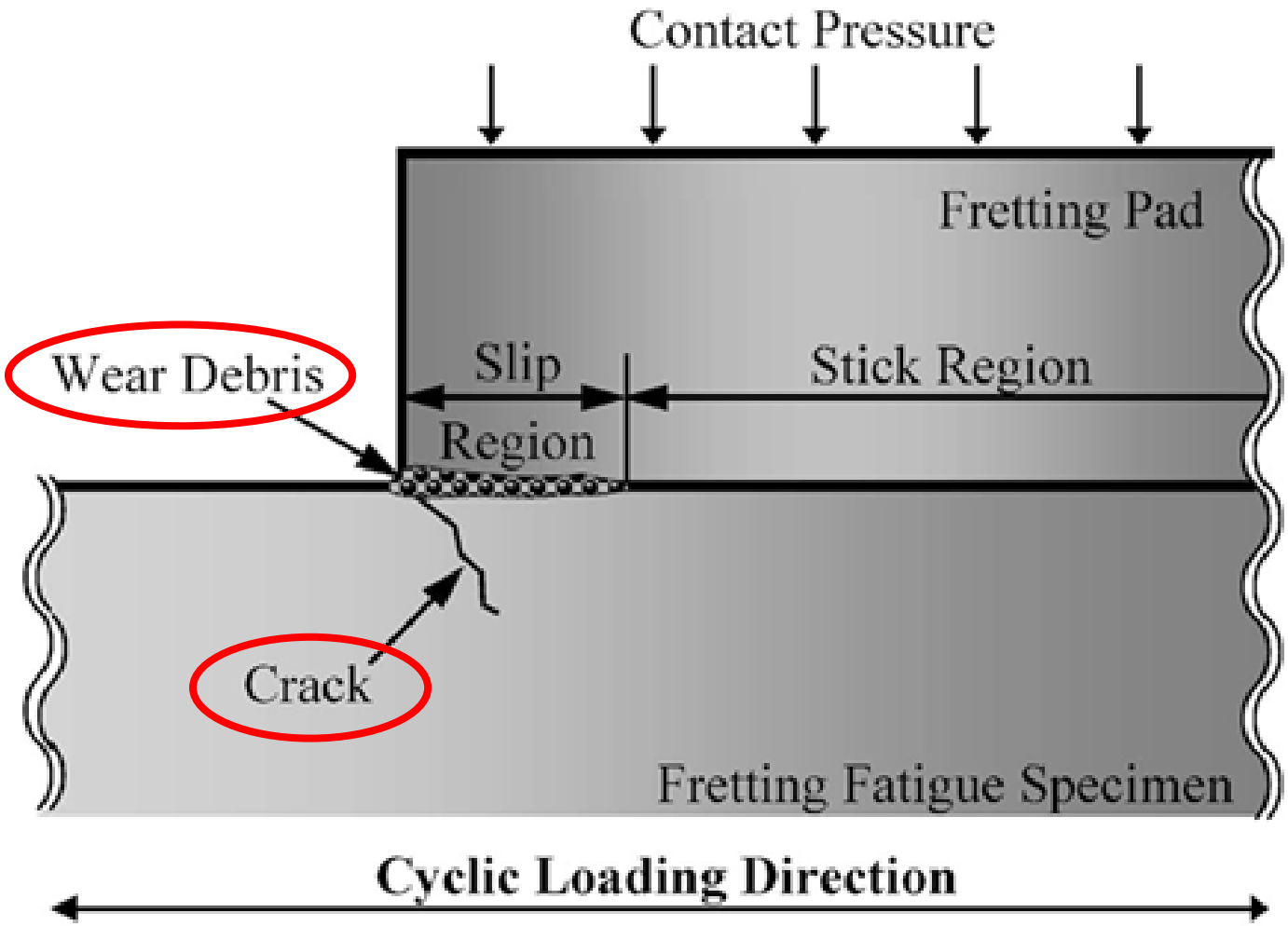
Stryker
ABG II (CoCr)
Rejuvinate (CoCr)

Wright Medical
Profemur-Z (Ti)

Corrosion

Corrosive Mode	Cause	Solution
Galvanic	Dissimilar Metals	Avoid Dissimilar Metals Passivation Layer
Fretting	Micromotion	Avoid Micromotion
Crevice*	Microscopic Isolation	Improved Tolerances Passivation Layer
Pitting*	Surface Defects	Polish Surfaces Passivation Layer
Intergranular	Carbide-Grain Boundaries	Molybdenum Alloys Low Carbon Alloys

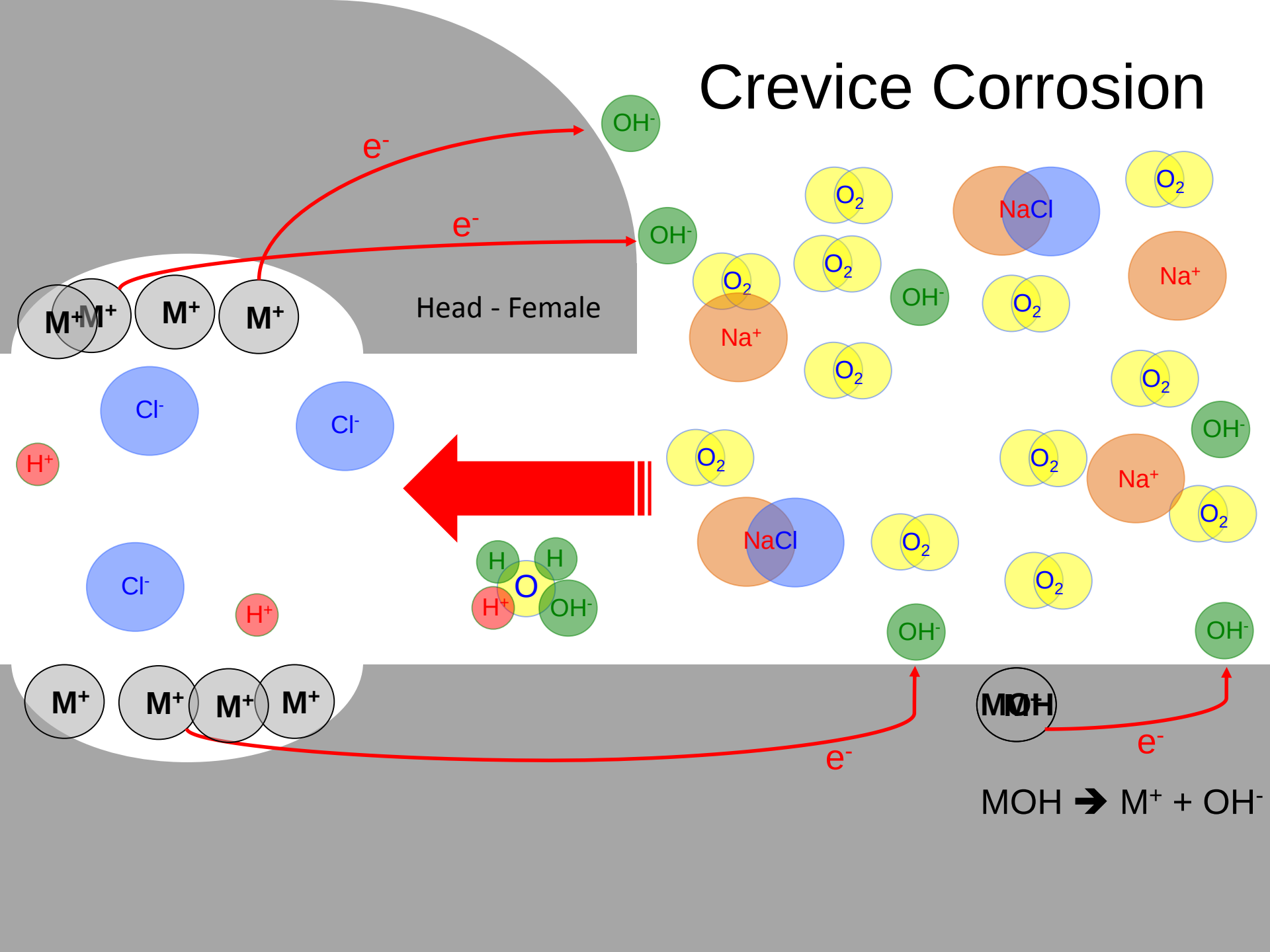
Fretting Corrosion



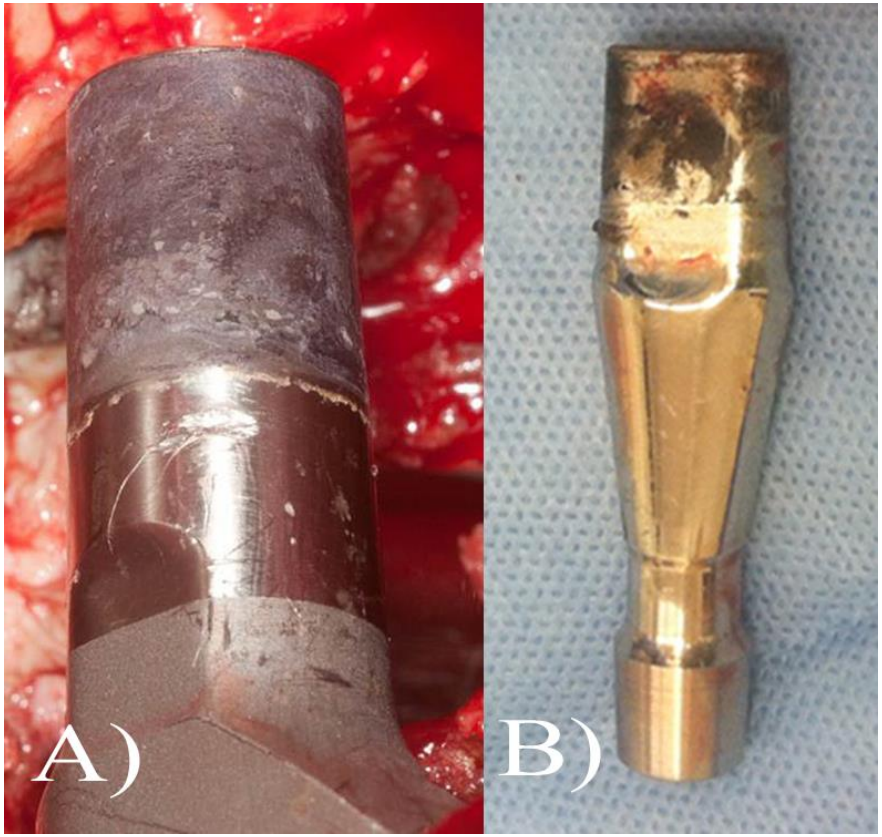
Fretting Corrosion

Fretting Corrosion - 4% head-neck and 94% dual modular

Collier+ 1995, AAOS+ 2014


Crevice Corrosion
e-
e-
OH-
OH-
Head - Female
M+
M+
M+
M+
Cl-
Cl-
Cl-
H+
H+
O2
NaCl
Na+
OH-
H
H
O
H+
OH-
M+
M+
M+
M+
e-
e-
MOH ➔ M+ + OH-

Crevice Corrosion



Crevice Corrosion – Chromium (III) Phosphate Precipitation
30% at mixed-alloy junctions
10% of all-titanium-alloy junctions
6% of all-cobalt-alloy junctions

Collier+ 1995, Kop+ 2009

Any Modular Junction Can Be Affected

Modularity	Stem Design	Manufacturer	Junction	Failure Mode(s)
Metaphyseal	S-ROM	DePuy-Synthes	Ti/Ti	Fracture
Dual Taper	Kinectiv	Zimmer	Ti/Ti	Fracture
	Profemur-Z	Wright	Ti/Ti (1st Gen)	Fracture
			CoCr/Ti (2nd Gen)	Corrosion
	ABG II	Stryker	CoCr/Ti	Corrosion
	Rejuvinate	Stryker	CoCr/Ti	Corrosion
	Adaptor GHE	Eska	CoCr/Ti	Corrosion
	Bionik	Eska	CoCr/Ti	Corrosion
	M-series	Exacttech	Ti/Ti	Damage
	Apex	Global	Ti/Ti	Damage
Diaphyseal	ZMR	Zimmer	Ti/Ti	Fracture
	Link	Microport	Ti/Ti	Fracture
	MRP-Titanium	Peter Brehm	Ti/Ti	Damage
Multiple	Margron	Portland	CoCr/Ti	Corrosion
	GMRS	Stryker	CoCr/Ti	Corrosion

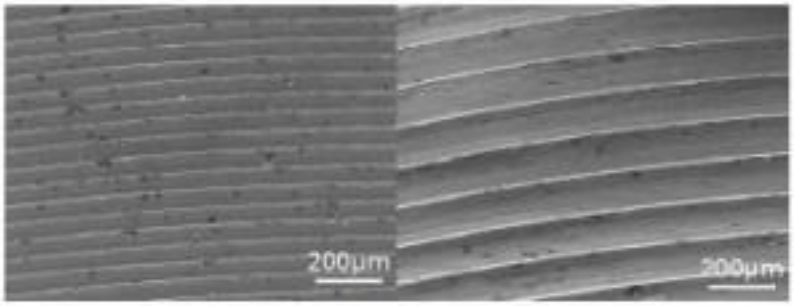
Risk Factors for Taper Corrosion

1) Taper Design/Geometry

NO STANDARD (V40, C-taper, 14/15, 12/13, etc.)

Taper Length Short Tapers (Increased Corrosion)

3D Topography 64% have Peaks and Troughs (Increased Corrosion)



Kop+ 2009, Jacobs+ 2014, Goldberg+ 2002, Shareef+ 1996
Gilbert+ 2009, Bernstein+ 2011, Meyer+ 2012, AAOS+1014

Risk Factors for Taper Corrosion

2) Mechanical Environment

Less Rigidity of the Femoral Neck Increased Micormotion

Wet or Contaminated Assembly Increases Micromotion

Off-Axis Impaction Increases Micromotion

Femoral Head Offset Increases Torque

Highly Cross-linked or Vitamin E Polyethylene Increases Friction

Increased Head Size Remains Controversial

Kop+ 2009, Jacobs+ 2014, Goldberg+ 2002, Shareef+ 1996
Gilbert+ 2009, Bernstein+ 2011, Meyer+ 2012, AAOS+1014

Clinical Presentation Similar to MOM

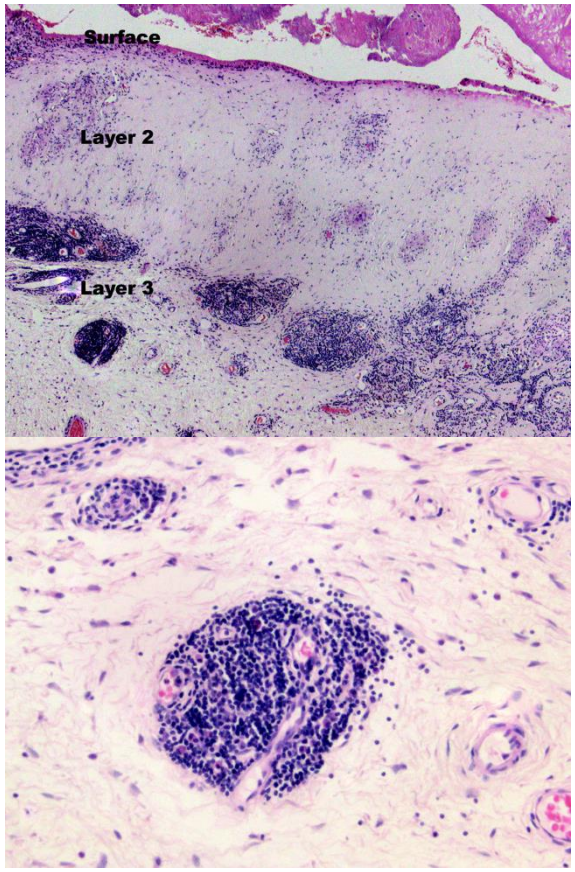
History: s/p THA
± Pain at Rest
± Pain with Loading

Physical: ± Palpable Mass
± Fluid Collection
± Loss of Abduction

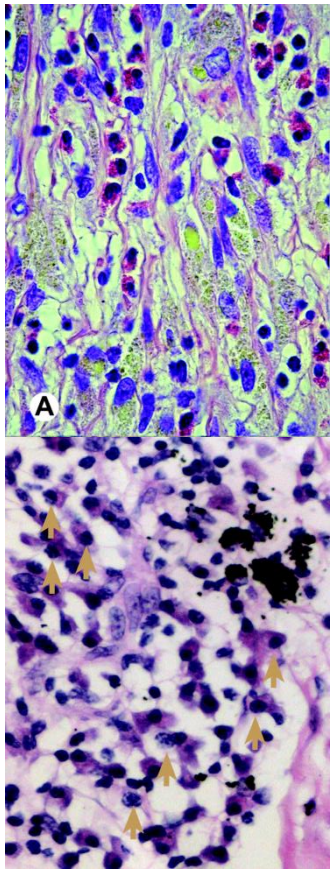
Labs: ± Negative for Infection

Aseptic Lymphocyte-dominated Vasculitis-associated Lesion (ALVaL)

Fibrinous Exudate

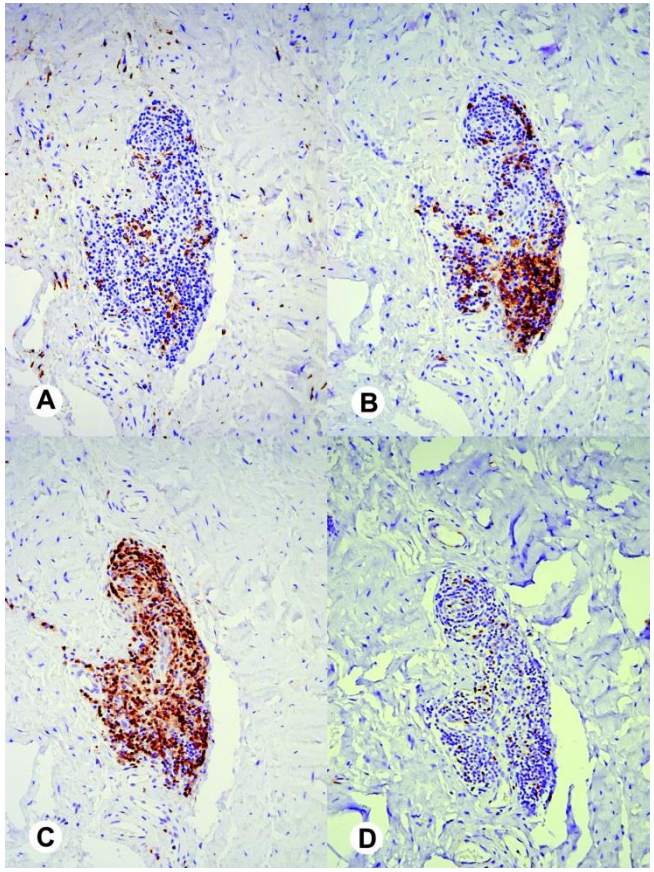


Perivascular Infiltration



Macrophages

B-Cells

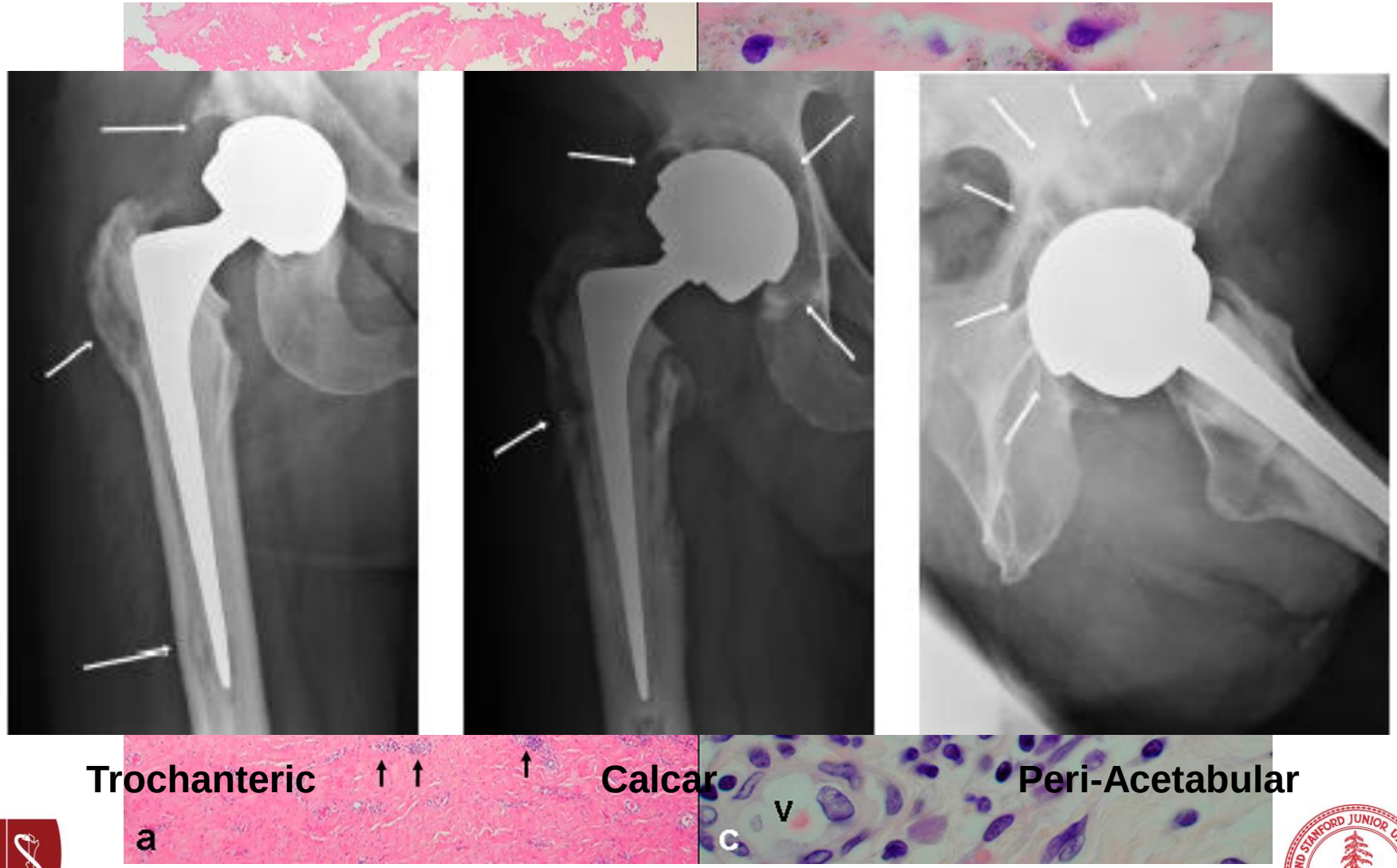


T-Cells

T-Cells+

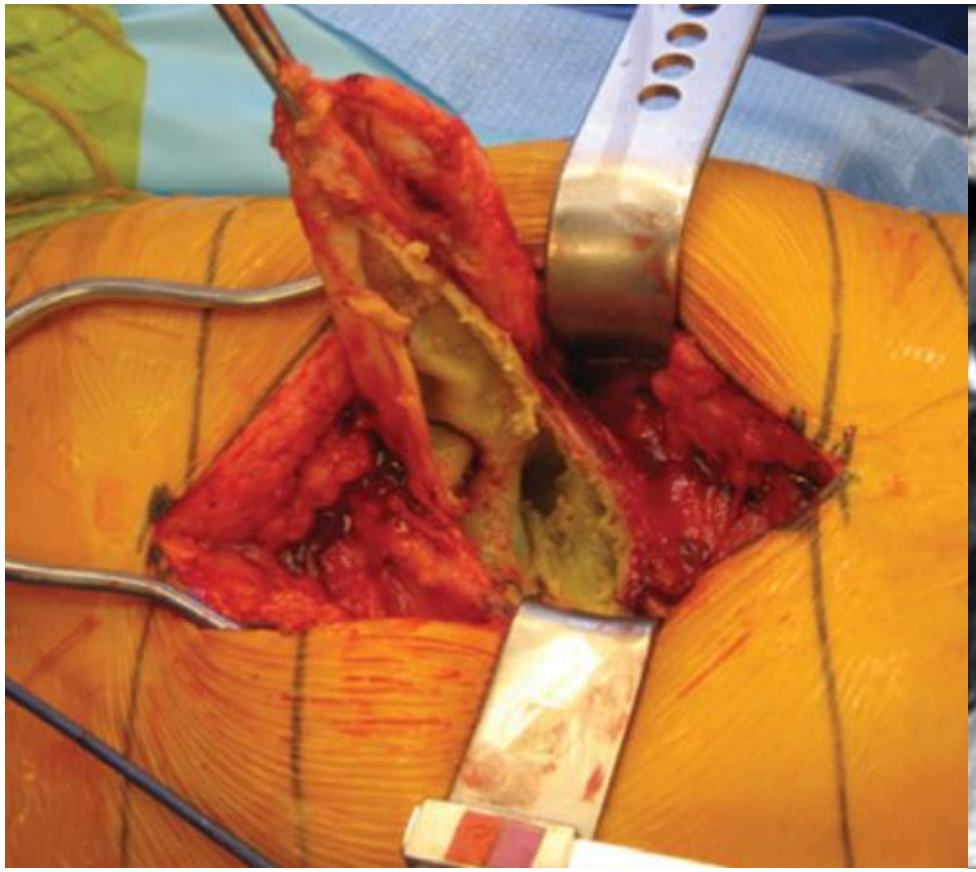
Campbell+ 2001, Willert+ 2003 and 2005, Davies+ 2005, Witzleb+ 2007, Korovessis+ 2006

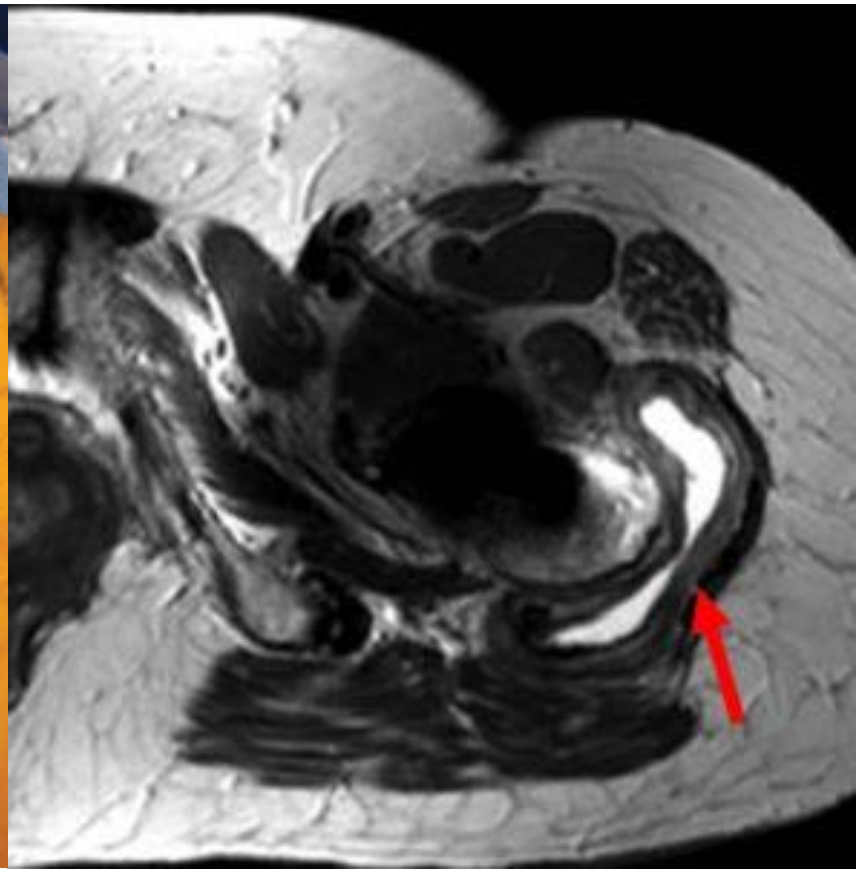
Osteolysis



Korovessis+ 2006, Huber+ 2009

Pseudotumor





Pandit+ 2003

Management Algorithm

Risk Stratification Algorithm for Management of Patients with Metal-on-Metal Hip Arthroplasty

Consensus Statement of the American Association of Hip and Knee Surgeons, the American Academy of Orthopaedic Surgeons, and The Hip Society

Young-Min Kwon, MD, PhD, Adolph V. Lombardi, MD, FACS, Joshua J. Jacobs, MD, Thomas K. Fehring, MD, Courtland G. Lewis, MD, and Miguel E. Cabanela, MD

J Bone Joint Surg Am. 2014;96:e4(1-6)

Low Risk

TABLE II MoM 'Low' Risk Group

'Low' Risk Group Stratification	
Patient factors	Patient with low activity level
Symptoms	Asymptomatic (including no systemic or mechanical symptoms)
Clinical examination	No change in gait (i.e. no limp, no abductor weakness)
	No swelling
Implant type	Small-diameter femoral head (<36 mm) modular MoM THA; hip resurfacing in males <50 with osteoarthritis
Radiographs (2 views ± serial for comparison when available)	Optimal acetabular cup orientation (40° ± 10° inclination for hip resurfacing)
	No implant osteolysis/loosening
Infection work-up (ESR, CRP, ± hip aspiration)	Within normal limits
Metal ion level test (if available)	Low (<3 ppb)
Cross-sectional imaging (if available): these studies include MARS MRI; ultrasound or CT when MRI contraindicated or MARS protocol not available	Within normal limits
Treatment recommendation	Annual follow-up

Moderate Risk

TABLE III MoM 'Moderate' Risk Group

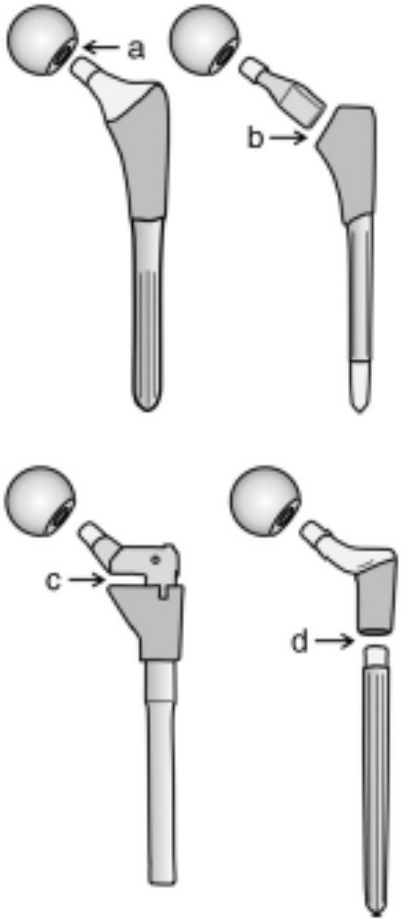
'Moderate' Risk Group Stratification	
Patient factors	Male or female
	Dysplasia (for hip resurfacing)
	Patient with moderate activity level
Symptoms	Symptomatic
	Mild local hip symptoms (e.g., pain, mechanical symptoms)
	No systemic symptoms
Clinical examination	Change in gait (i.e., limp)
	No abductor weakness
	No swelling
Implant type	Large-diameter femoral head (≥36 mm) modular or nonmodular MoM THA
	Recalled MoM implant
	Hip resurfacing with risk factors (female with dysplasia)
	Modular neck device
Radiographs (2 views ± serial for comparison when available)	Optimal acetabular cup orientation
	No implant osteolysis/loosening
Infection work-up (ESR, CRP, ± hip aspiration)	Within normal limits
Metal ion level test	Moderately elevated (3-10 ppb)
Cross-sectional imaging (MARS MRI; ultrasound or CT when MRI contraindicated or MARS protocol not available)	Presence of abnormal tissue reactions *without* involvement of surrounding muscles and/or bone
	Simple cystic lesions or small cystic lesions without thickened wall
Treatment recommendation	Follow-up in 6 months
Revision surgery	Consider revision surgery if symptoms progress, imaging abnormality progresses, and/or there are *rising* metal ion levels over 6 months

High Risk

TABLE IV MoM 'High' Risk Group

'High' Risk Group Stratification	
Patient factors	Female with dysplasia (for hip resurfacing)
	Patient with high activity level
Symptoms	Symptomatic
	Severe local hip and/or mechanical symptoms
	Systemic symptoms
Clinical examination	Change in gait (i.e., limp)
	Abductor weakness
	Swelling
Implant type	Large-diameter femoral head (≥36 mm) modular or nonmodular MoM THA
	Recalled MoM implant
Radiographs (2 views ± serial for comparison when available)	Suboptimal acetabular cup orientation
	Implant osteolysis/loosening
Infection work-up (ESR, CRP, ± hip aspiration)	Within normal limits
Metal ion level test	High (>10 ppb)
Cross-sectional imaging (MARS MRI; ultrasound or CT when MRI contraindicated or MARS protocol not available)	Presence of abnormal tissue reactions *with* involvement of surrounding muscles and/or bone
	Solid lesions
	Cystic lesions with thickened wall
	Mixed solid and cystic lesions
Treatment recommendation	Consider revision surgery

Modularity is Here to Stay



Restoration of Femoral Anatomy

- Leg Length
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Diaphysis ➔ Metaphysis

It is up to us to use it Wisely

THANK YOU