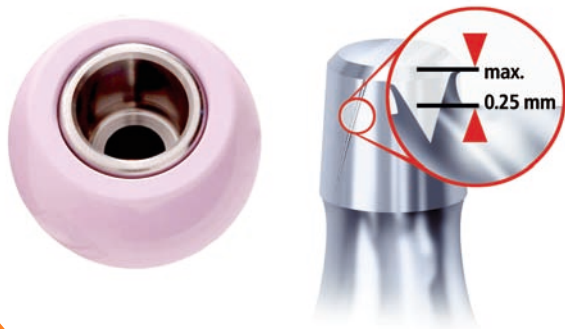




ICJR Pan Pacific
Hilton Waikoloa
Village Resort Hawaii
July 7, 2014



OPTIMIZING MODULAR TAPERS FOR TOTAL HIP ARTHROPLASTY

Timothy McTighe, Dr. H.S. (hc)
Executive Director,
Joint Implant Surgery & Research
Foundation (JISRF)

All tapers are
not equal in
design or
function.



Acknowledgement: Declan Brazil, PhD
John Keggi, MD, Louis Keppler, MD; Robert Kennon, MD, David
Campbell, MD; Edward McPherson, MD

JISRF is a 501 c3 Non-Profit Foundation (1971) By Prof. Charles O. Bechtol, MD

JISRF is dependent on outside funding to support many of its activities.

Since 1971 JISRF has received funding from +30 commercial affiliations.

JISRF has stock investments in a number of commercial affiliations.

**Executive Director: McTighe has vested interest in:
CDD, LLC; J&J; Signature Orthopaedics, Ltd; Omnilife; and has royalty interest in CDD, LLC**

Note: JISRF Board Members and Advisors have multiple commercial relationships.

Intent

To make JISRF available as a resource to all within the orthopaedic community.

www.jisrf.org



ISSUES WITH SELF-LOCKING TAPERS

A self-locking taper (Morse) works by producing a frictional force that holds the components together and is greater than the forces pushing the components apart.

The frictional force resists torsional and axial forces created at the modular junction, while careful tolerancing provides optimal contact along the length of the taper. The success of a self-locking taper is influenced by the design of the taper, particularly the taper angle, the roughness, and the mating materials between the “male” and “female” components.

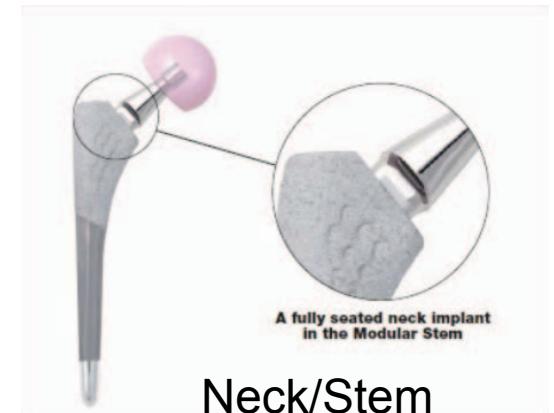


Head / Neck



Head / Neck Sleeve

Stem / Sleeve



Neck/Stem

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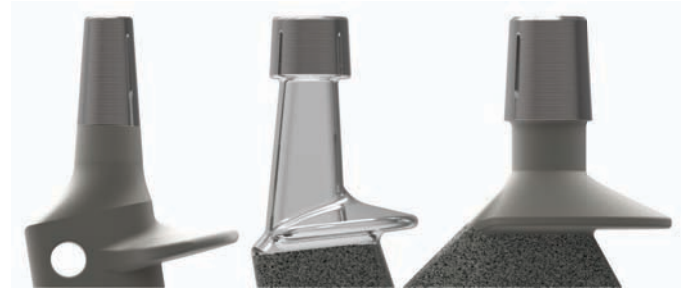
Types of self-locking tapers

In the last two decades, manufacturers have been altering femoral stem trunnions from various tapers such as 14/16 to 12/14. The original 12/14 Ceramtec taper was at one time referred to as a Euro taper, meaning a 12/14 off-the-shelf Ceramtec Taper.

This term was not trademarked, and some companies began altering the manufacturing tolerance as originally produce from Ceramtec. The term Euro taper still is referred to by most in Europe as an off-the-shelf 12/14 Ceramtec taper.

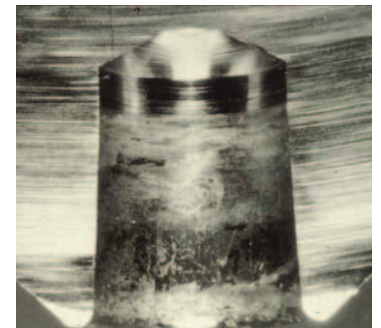
A 12/14 taper can have slightly different manufacturing tolerances by different manufactures and should not be used as a generic term.

Demand for Head/Neck Adjustment



Tapers have been reduced in diameter and length compromising optimal stability of the taper interface.

Corrosion
Growing Concern



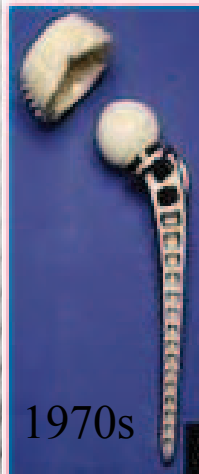
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HISTORICAL REFERENCE TO HEAD TAPERS



First C.C. head on a Titanium stem
11/13 taper (Preassembled in factory)



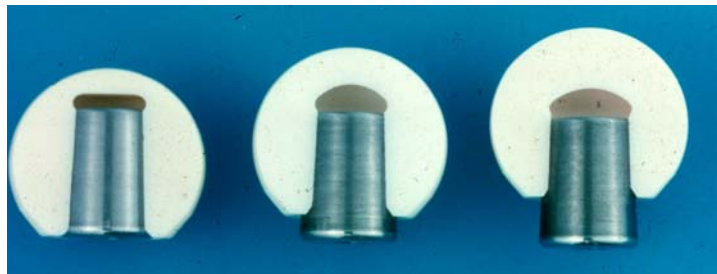
Mittelmeier Hip
Ceramic 14/16 taper



S-Rom
1980s
11/13 taper



	AML	
Fixed Head	14/16	12/14
1970s	1980s	1990s



All 12/14 tapers are not equal!
(A Euro 12/14 taper is different than
a ASTM 12/14 taper F1636)
Know what you are working with!

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**Modular Heads came about
during the 1960s**

Trends

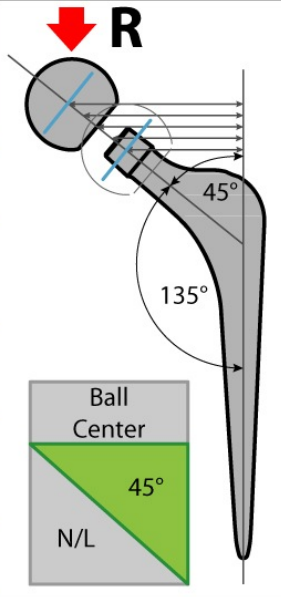
Large Heads
Increased Femoral Offset
Metal on Metal

All increase torque
moment at implant
interface!

8% increase (torque) per 1 mm in true lateral
ball-center offset.

6% increase (torque)
Per 1 mm increase in neck-length increase.

Offset	Neck Length	Nm
35mm	49.50mm	84
40mm	56.58mm	96
45mm	63.65mm	108
50mm	70.72mm	120
55mm	77.79mm	132



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TORSION IS OUR BIGGEST PROBLEM!

Large Head Diameter
High offsets
Metal on Metal
Reduced taper contact
Increases torsional loads

11mm of 12/14	Contact length Offset (S)	Contact length Offset (M)	Contact length Offset (L)	Contact length Offset (XL)
28mm	10.5mm	10.5mm	10.3mm	
32mm	10.5mm	10.5mm	10.5mm	8.8mm
36mm	10.5mm	10.5mm	10.5mm	9.2mm
40mm	10.5mm	10.5mm	10.5mm	9mm

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INCREASED DEMAND ON TAPERS

NEW S-ROM TAPER 9/10



11/13

9/10

RANGE OF MOTION (COMPARISON TABLE)

<i>STEM MANUFACTURER</i>	<i>HEAD DIAMETER</i>	<i>RANGE OF MOTION</i>
<i>Versys</i>	22mm	125deg
	26mm	133deg
	28mm	136deg
<i>Aesculap</i>	28mm	134deg
	28mm	118deg
<i>Def inition</i>	22mm	124deg
	26mm	131deg
<i>S-Rom 11/13 Taper</i>	22mm	116deg
	28mm	125deg
<i>NEWS-Rom A 9/10 Tape.</i>	22mm	126deg
	28mm	145deg

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**Marketing Pressure often overrides sound
engineering principals**

S-ROM Slide from:

1984 Future Design
Leader in Cementless
THA



S-ROM® STEM SLEEVE EVOLUTION



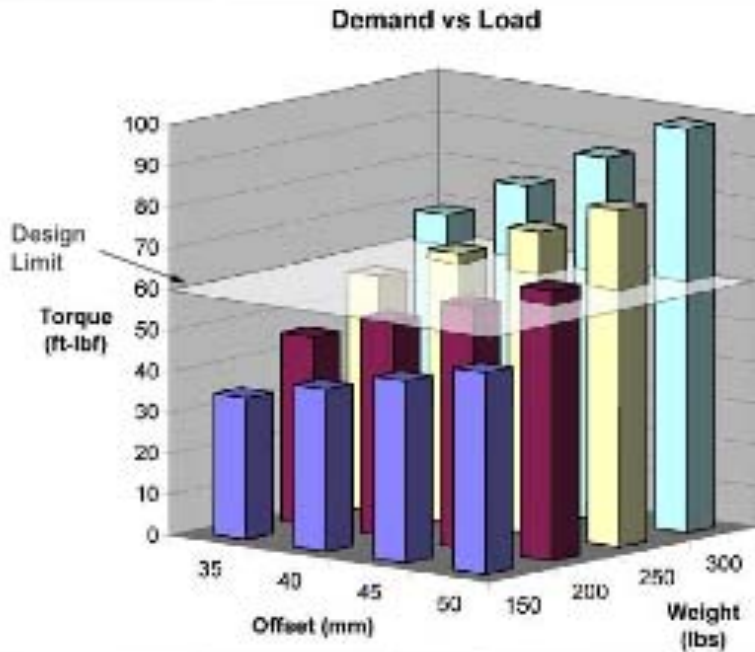
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Less We Forget to
Remember our History

250 lbs. patient w /50 mm
femoral offset generates
close to 80 ft-lbs of torque.
taper safety is 60 ft-lbs

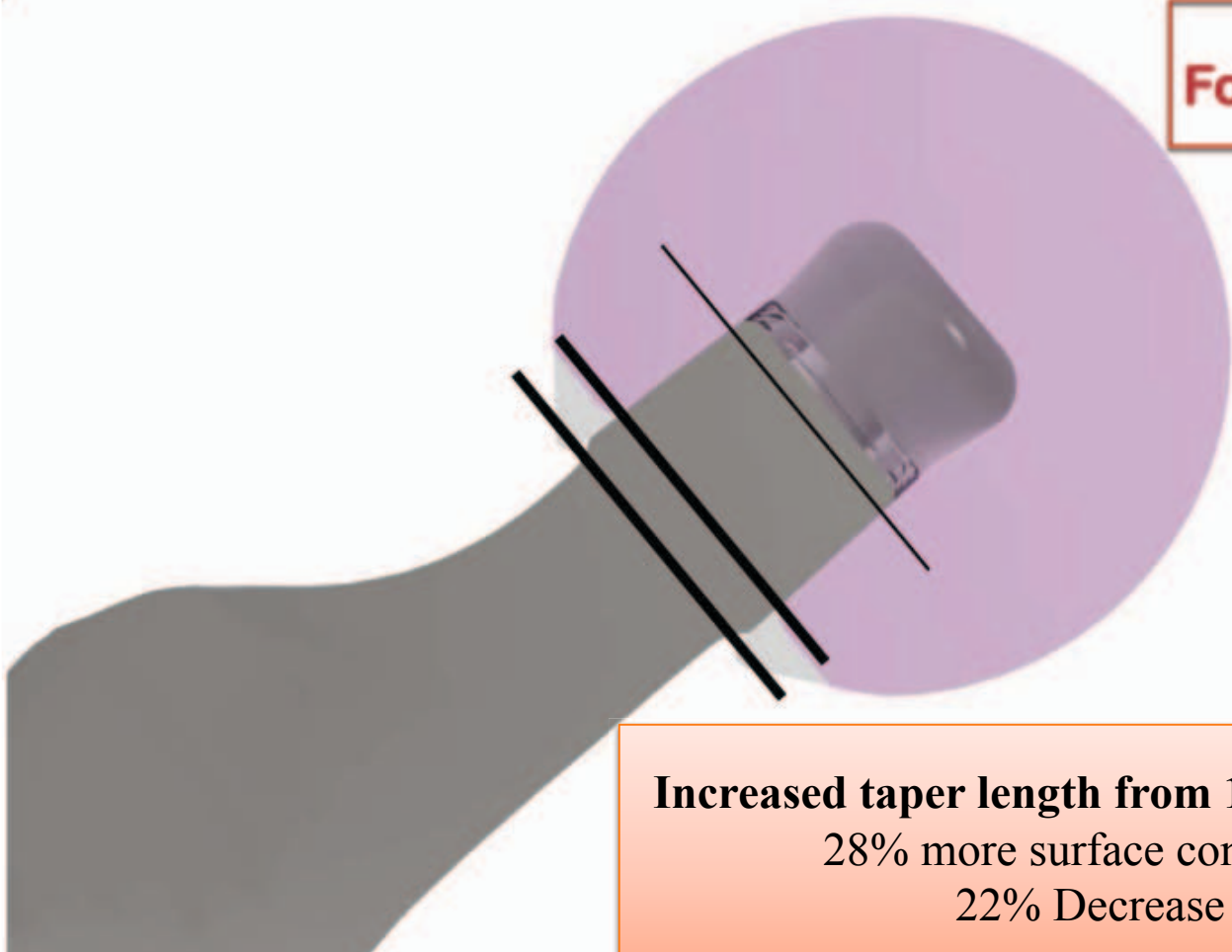
Examples



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MANY TAPERS DO NOT HAVE ENOUGH
INTRINSIC STABILITY FOR TODAY'S
HIGH DEMAND PATIENT


$$\text{Force} = \frac{\text{Torsional Load}}{\text{Distance (d)}}$$

Increased taper length from 11mm to 12.9mm (12/14 taper)
28% more surface contact area (36 mm Dia.)
22% Decrease in Torque Force

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ADVANCED TAPER SOLUTION
PATENT PENDING



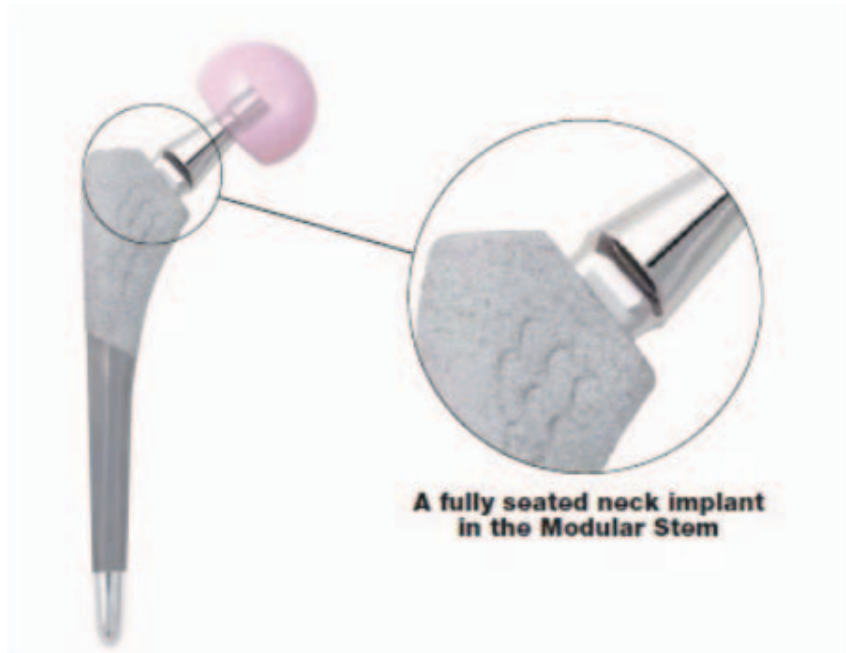
36mm head dia.	11mm 12/14 Taper	12.9mm 12/14 Taper	Loss
Flexion/Extension	199°	192°	7°
Abduction/Adduction	133°	130°	3°
Internal/External	210°	205°	5°

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THEORETICAL DOWNSIDE OF ADVANCED TAPER DESIGN

Market went from “Taper Mad” to “Taper Bad”



Fretting Corrosion

Retrieved Rejuvenate Stem (Stryker Orthopaedics) with Modular Neck Demonstrating Significant Fretting Corrosion. Revised for pseudo tumor

Courtesy of Dartmouth Biomedical Center

Overly Concerned with Fatigue Levels
Ignored fretting issues (shot peened taper & reduced taper engagement)



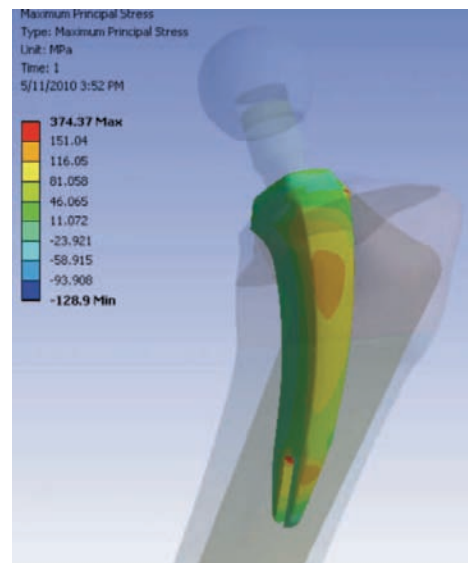
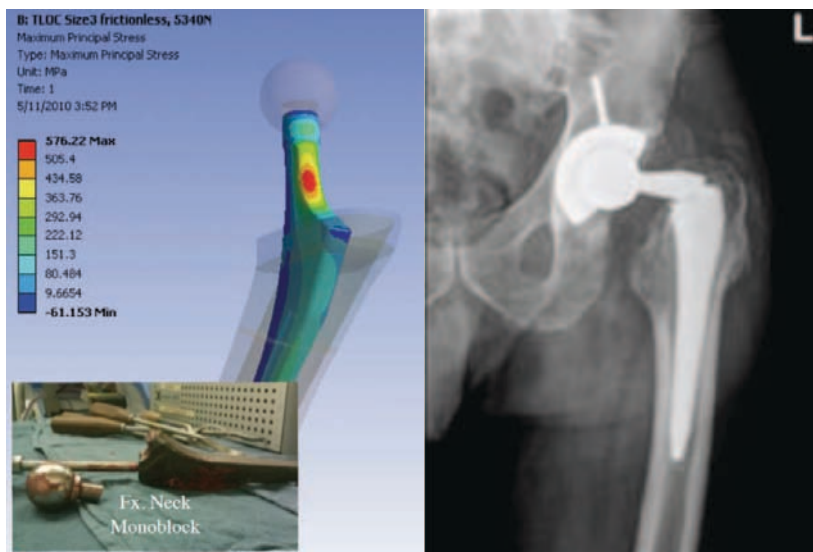
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NECK STEM TAPER JUNCTIONS

PROBLEM

FATIGUE FAILURE OF FEMORAL NECKS OCCURS IN BOTH MODULAR AND MONOBLOCK DESIGNS



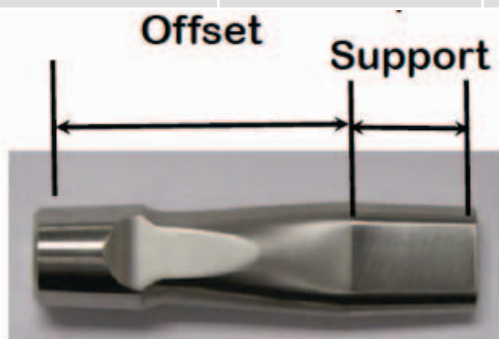
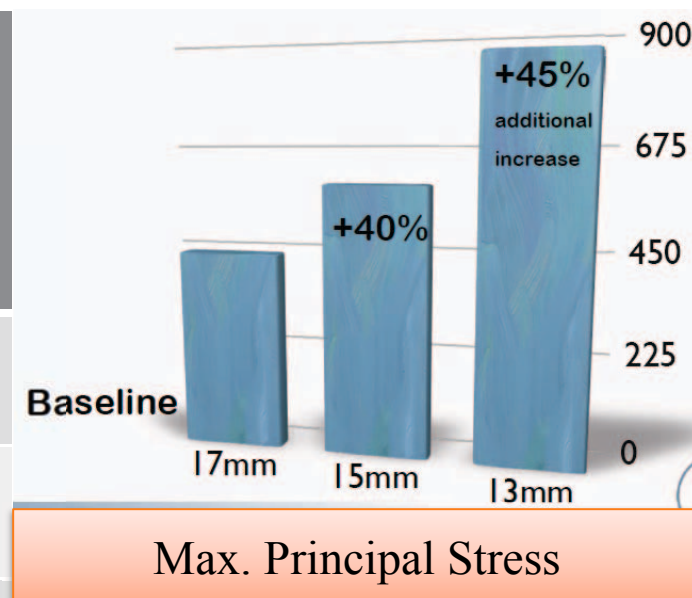
The maximum principal tensile stress in the neck retained stem was **35% less** than that of the monoblock design.

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Solution for fatigue failure of necks change material from titanium to Cobalt Chrome and change design to retain femoral neck.

	Taper Support	Femoral Offset	% Increase head center length
TSI™ / ARC™	17mm	27.5mm	
Wright Medical	15mm	42mm	55%
Stryker	13mm	42mm	53%



- Shorter Bending Moment and Shorter Torsional Moment with Neck Retention results in less stress at modular implant interface.

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NOT ALL TAPERS ARE
CREATED EQUALLY



ISO7206-6 SETUP

5340N - 10 MILLION CYCLES

MEASURED ABRASIVE WEAR

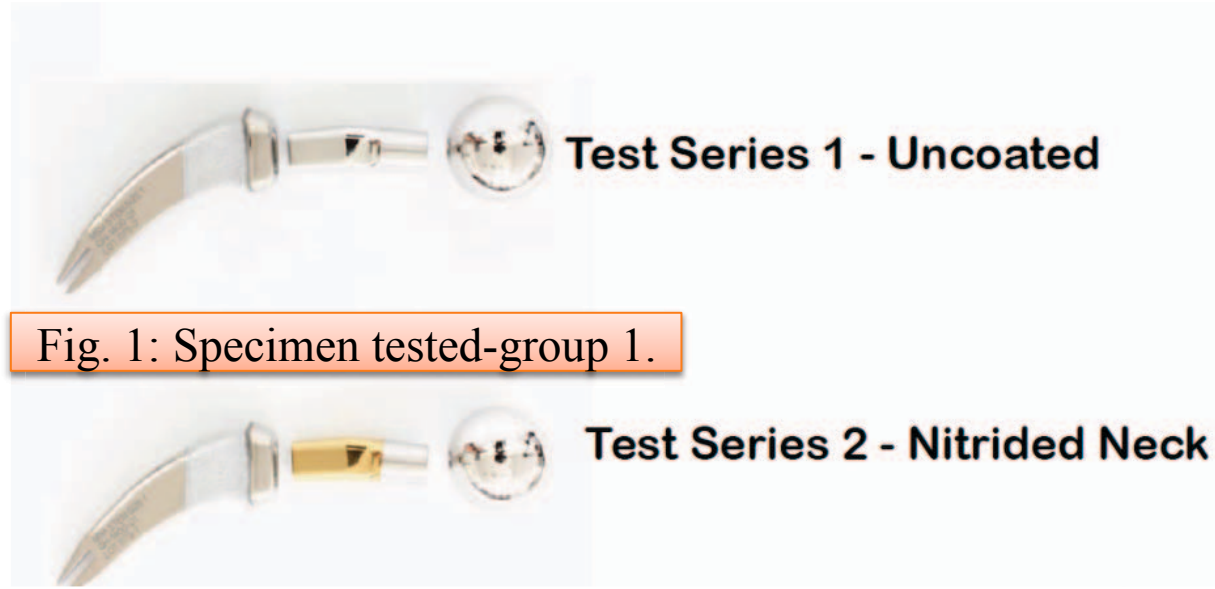
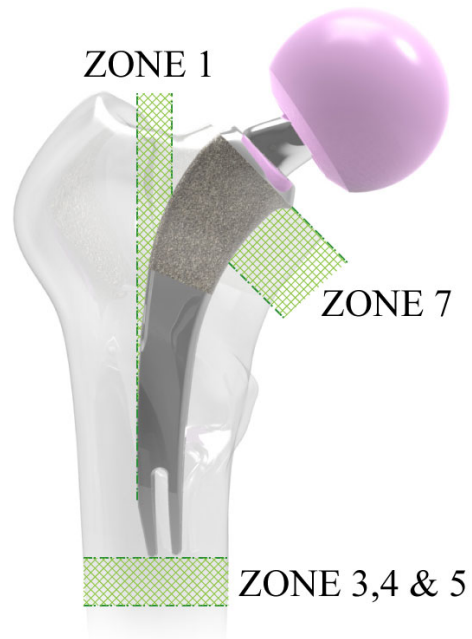


Fig. 1: Specimen tested-group 1.

Fig. 2: Specimen tested-group 2.

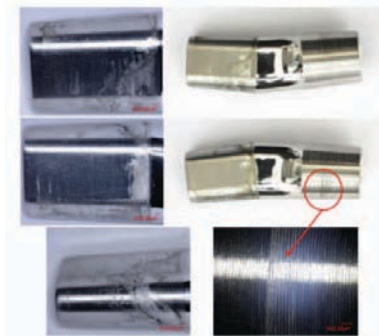
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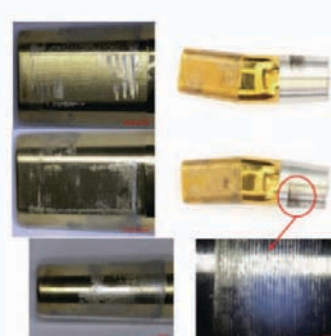
Beyond Compliance

Specimen	Mean initial weight [g]	Mean post-fatigue weight [g]	Weight loss [mg]
1.1	37.6202	37.5408	79.4
1.2	37.5002	37.6172	-117.0 ¹
1.3	37.5419	37.4981	43.9
2.1	37.6659	37.6649	1.0
2.2	37.5203	37.5191	1.2
2.3	37.5404	37.5390	1.4

Specimen 1.



Specimen 2.



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The fretting wear for both types of systems is illustrated. Significant reduction in Tin coated.

The TiN coated necks showed significantly less fretting wear when tested under the same load conditions.

A second series of TiN coated samples were tested these were fully TiN coated necks to include the head / neck junction.



Specimen	Mean initial weight [g]	Mean post-fatigue weight [g]	Weight loss [mg]
1.1	37.6409	37.6393	1.6
1.2	37.5937	37.5923	1.3
1.3	37.6591	37.6577	1.4



Fig. 8: Representative photograph of the surfaces of the neck post fatigue – specimen 1.1

CONCLUSION: TIN COATING NECKS SIGNIFICANTLY REDUCES WEAR COMPARED TO UNCOATED. THERE WAS NO SIGNIFICANT DIFFERENCE FOUND BETWEEN FULLY TIN COATED NECKS AND PARTIALLY COATED NECKS.

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Significant advantage in reducing wear of C.C modular neck interfacing with titanium stem.



Group 2 (n=3)



Increased taper engagement reduces stress thus reducing corrosion / debris generation.

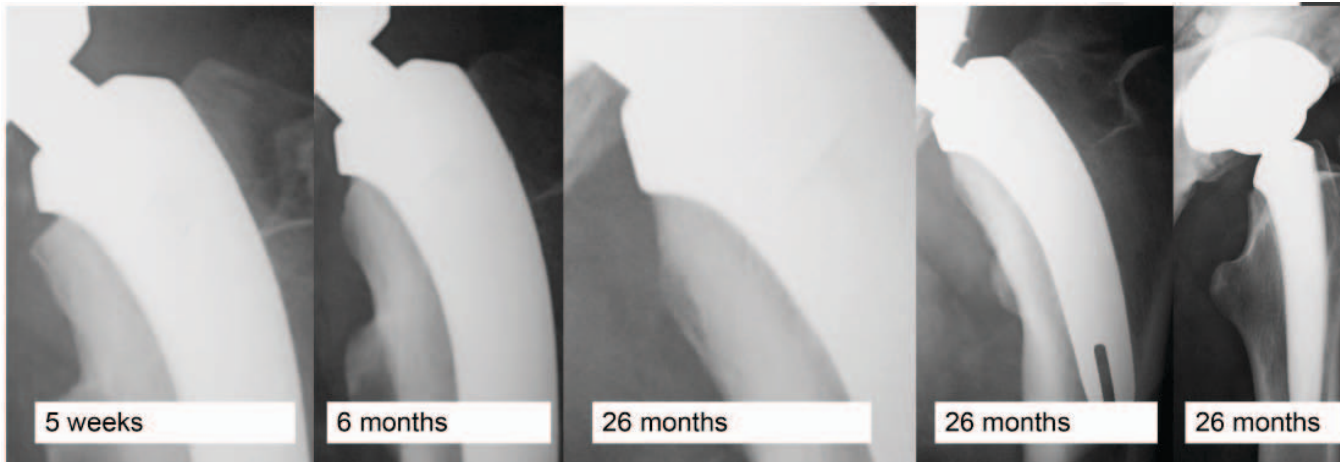
Neck Retention design results in lower stress due to combined shorter offset with larger taper engagement. Tin coating of modular C.C. necks in a titanium stem reduces wear compared to uncoated necks.

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SUMMARY

CLINICAL EXPERIENCE



Positive bone remodeling increased calcar density
2,825 USA / ARC™ Stems implanted since April 2010
98.6% survival

2 reported pseudo tumors both w / MoM bearings (1 AU & 1 USA)

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Short Curved Neck Preserving Stem

Modular Junctions

Not all taper junctions are designed or function equally

Know your design

Know required technique

Know design & material limits

Demand beyond compliance testing

Sound engineering principals work

Incremental advancement in technology works

Modularity can be designed and fabricated safely

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CONCLUSION

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