Addressing Taper Corrosion Issues

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Fretting and Corrosion

• Recently identified as clinically significant in MOM THA’s (Langton et al, 2011)
  – Analysis initially focused on the modular head-stem interface

• Concern has expanded to M-PE bearings (Cooper et al 2012, Plummer 2016)

• Are there any solutions for taper corrosion?
Taper Corrosion is Not New

• Retrieval analyses from the late 1980’s revealed corrosive attack of modular interfaces
  – Proposed mechanism: mechanically assisted crevice corrosion (Gilbert et al, 1993)
  – Complex, multifactorial problem
Are Ceramics Heads a Solution to Taper Corrosion?

Ceramic-Metal Modular Junction

Metal-Metal Modular Junction
1st Study: Taper Damage (2013)

Do Ceramic Femoral Heads Reduce Taper Fretting Corrosion in Hip Arthroplasty? A Retrieval Study

Steven M. Kurtz PhD, Sevi B. Kocagöz BS, Josa A. Hanzlik MS, Richard J. Underwood PhD, Jeremy L. Gilbert PhD, Daniel W. MacDonald MS, Gwo-Chin Lee MD, Michael A. Mont MD, Matthew J. Kraay MD, Gregg R. Klein MD, Javad Parvizi MD, Clare M. Rimnac PhD

www.orthoceramics.org
Ceramic Heads Decrease Metal Release Caused by Head-taper Fretting and Corrosion

Sevi B. Kocagoz BS, Richard J. Underwood PhD, Daniel W. MacDonald MS, Jeremy L. Gilbert PhD, Steven M. Kurtz PhD

www.orthoceramics.org
2nd Study: Material Loss (2016)

To compare taper corrosion and material loss between ceramic and CoCr head-stem tapers in retrievals using a matched cohort study design.
Matched Cohort Study Design

Ceramic Head Cohort (N = 50 pairs)

Metal Head Cohort (N = 50 pairs)
Drexel University Implant Repository Clinical Partners
• 15 Participating Clinical Centers
Cohort Matching Criteria

1) Implantation time (most important)
2) Stem flexural rigidity
3) Lateral offset
4) Head size

- Goldberg et al., CORR, 2002
- Higgs et al., AAHKS, 2012

Flexural Rigidity = $E \cdot I = E \cdot \frac{(ND)^4}{64}$
Total Material Loss Rate

Total Volumetric Material Loss Rate

Ceramic
Head Taper (Ceramic)

Score: 1

Score: 2

Score: 3

Score: 4
Head Size (Ceramic Cohort Heads)

\[
\text{Volumetric Material Gain Rate (mm}^3/\text{year})
\]

\[
\begin{align*}
\text{Femoral Head Size (mm)} & \quad \text{Rho} = -0.014; \ p = 0.93
\end{align*}
\]
Total Material Loss Rate

p < 0.0001

Total Volumetric Material Loss Rate (mm$^3$/yr)

Ceramic

Metal
Material Loss (Metal Cohort)

Total Volumetric Material Loss Rate (mm³/yr)

\[ p < 0.0001 \]
Head Size (Metal Cohort)

Volumetric Material Loss Rate $\text{mm}^3/\text{yr}$

Femoral Head Size (mm)

Rho = 0.28; p = 0.047
Alloy Combination (Metal Cohort)

Total Volumetric Material Loss Rate (mm³/yr)

- Dissimilar (n = 42)
- Similar (n = 8)

p = 0.03
The Bearing Makes A Difference!

- Total material loss is less in ceramic head modular junctions than in metal head junctions
  - Ceramic head size (≤ 36 mm) not associated with material loss
- CoCr heads generate >90% of the material loss in modular tapers
- Ceramic heads are a solution for reducing taper corrosion
Fretting and Corrosion Damage in Taper Adapter Sleeves: A Retrieval Study

2016 SICOT: Thursday Morning Hip Free Papers

MacDonald DW, Chen A, Lee GC, Klein GR, Cates H, Mont MA, Rimnac CM, and Kurtz SM
Taper Adapter Sleeves

- How to replace CoCr femoral head during revision for ALTR and taper corrosion?
- Revise using CoCr or Ceramic head?
- What to do when the taper is damaged?
Research Questions

1. What is the prevalence mechanically assisted crevice corrosion in retrieved taper adapters used in THA?

2. What implant and patient factors influence the fretting corrosion behavior of titanium taper sleeves?
Patient Demographics

- In vivo $0.7 \pm 0.9$ years
  - Range: $0 - 3.2$ years
- 49% Female (18/37)
- Age: $58 \pm 9$ years
- UCLA Activity Score = 5
- 53% (19/37) were implanted in primary surgery.
Exemplar Fretting Corrosion Scores
Fretting Corrosion Scores

- Internal Sleeve
- External Sleeve
- Stem Trunnion

*\( p = 0.0002 \)
*\( p = 0.001 \)

- Minimal (Score = 1)
- Mild (Score = 2)
- Moderate (Score = 3)
- Severe (Score = 4)
Discussion

• Limited revision options when faced with revision surgery involving a corroded, damaged taper:
  – Ceramic head + Ti sleeve
  – CoCr head
  – Revise stem

• Sleeves are Ti alloy
  – Ti corrosion products are considered to be less cytotoxic than Co and Cr
Welcome to the Medical Ceramics Encyclopedia

Our goals are to provide an online reference and education about the peer-reviewed literature for ceramic biomaterials used in total joint replacements and to stimulate hypothesis-driven research in applications of ceramic biomaterials. The focus of the site is to summarize the clinical performance of medical grade ceramic and ceramic implants.

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