“In vitro Comparison of Head-Neck Taper Junction vs. Bone-Stem Interface Fretting Corrosion in a Total Hip Arthroplasty Model”

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Motivation

- Fretting
- Corrosion

Cyclic loading
Small amplitude movements (1-100µm)

Synovial fluid

DEGRADATION of the material

- Release of metal ions and wear debris
- Inflammation
- Osteolysis
- Crack initiation
- Loosening of the implant
Motivation

Modular Junctions (Head-Neck interface)

Bone-Stem interface

Pelvis
Acetabular cup
Femoral head
Femoral neck
Femur
Femoral stem
Marrow cavity
Micro-movements

Load applied

[Diagram showing anatomical parts of the hip, including the acetabular cup, femoral head, femoral neck, femur, femoral stem, and marrow cavity.]
**Motivation**

**Hypothesis**: The amount of fretting-corrosion that occurs at the Bone-Stem interface is greater than at the Head-Neck taper junction*.

**Goal**: Measure the OCP voltage drops associated with low and high loads at the bone-stem (Ti6Al4V alloy) interface.

* Based on previous studies from the group (not published).
Experimental details

Bone-stem fretting systems:

- Cut epiphysis
- Drill a hole in the marrow cavity (Ø:18.5 mm)
Experimental details

Bone-stem fretting systems:

- **Insertion test:**
  - Rate of 10mm/min up to 2cm press fit
  - 8800 Instron test frame

- **Cyclic loading test:**
  - **Stage (1):** low load (100N-500N)
  - **Stage (2):** higher loads (500-2000N)

- **Electrochemical measurements:**
  - Open circuit potential (OCP)
  - WE - Ti6Al4V rod
  - RE - SCE
Results

Evolution of potential:

Potential (voltage) drop induces fretting corrosion

OCP drop 215mV
Results

Potential drop: head-neck* vs. bone-stem

Fretting-corrosion at the Bone-Stem interface was significantly greater than at the Head-Neck taper junction.

* Based on previous studies from the group (not published).
Summary

• **Hypothesis** supported.

• **Press-fit into femoral bone**: free potential behavior is strongly dependent on the unique morphology of the bulk bone and the unique contact areas of Ti6Al4V stem.

• Amount of fretting-corrosion at the bone-stem interface is higher than that previously reported for metal-on-metal taper junction [1].

• The identification of fretting-corrosion behavior at two locations of hip implants may indicate critical instability of the electrochemical system, where the **synergistic interaction** of fretting and corrosion may accelerate degradation mechanisms in some patients.

Future Work

- Fretting-corrosion in sawbones (polyurethane foam with properties similar to trabecular bone)
- Perform EIS tests
- Perform potentiostatic tests (applied potential)
- Synergism between corrosion and wear mechanisms.
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Questions?