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In-vitro replication, measurement and characterisation of fretting wear for development of total hip replacement prostheses

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## Aim

The study aims to replicate and measure the common wearing mechanism on prosthetic femoral stems, fretting wear. The wore particles from fretting wear transferred to articulating surfaces and jeopardise the lifespan and stability of total hip arthroplasty (THA).

## Objectives

- ✓ To determine the loading force in POP
- ✓ To conduct a pin-on-plate experiment (POP)
- ✓ To determine the changes in surface conditions of the plates



## Background

- ✓ Total hip arthroplasty (THA) is usually the last and only resort for completely curing and improving patients' quality of lives who suffer from osteoarthritis, rheumatoid arthritis and etc.
- ✓ Various ways to perform a THA including different types of prostheses including modular/ mono blocks joint and matt/ highly polished surface (Figure 1). Hence, different wear phenomena occur.



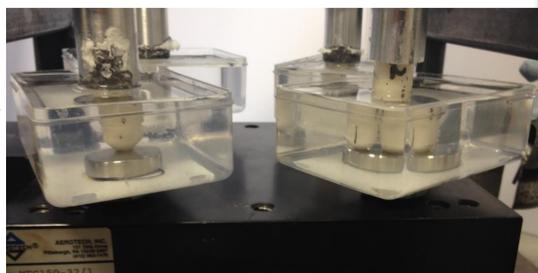
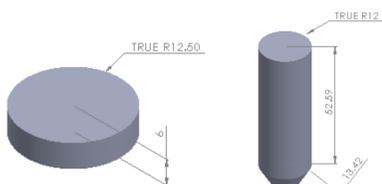
Figure 1 Different types of prosthetic joints

- ✓ Fretting wear is one of the common wear phenomenon occurs at the stem-cement interface resulting from repeated micromotions. It creates deep valleys on the surface and generates oxides which adhere to the surface.
- ✓ One of the visual evidence from fretting wear is the presence of fretting corrosion appearing as deep red oxide.
- ✓ Areal surface characterisation techniques were adopted to quantify the wear which enabled to quantify and visualise the severity of fretting wear generated in the POP experiment.
- ✓ The establishment of a repeatable measurement methods gives a useful tool for material screening in development of replacement prostheses.

## Methodology and Experimental Details

### Designs of the Pins and Plates

- ✓ Relative movement between plates and pins is 60  $\mu\text{m}$  [5]
- ✓ Equivalent force of 0.201 BW is applied on each pin
- ✓ Movement frequency is 3Hz [5]
- ✓ 3 Millions cycles are conducted
- ✓ Pins and plates are immersed in Ringers' Solution



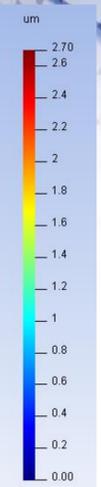
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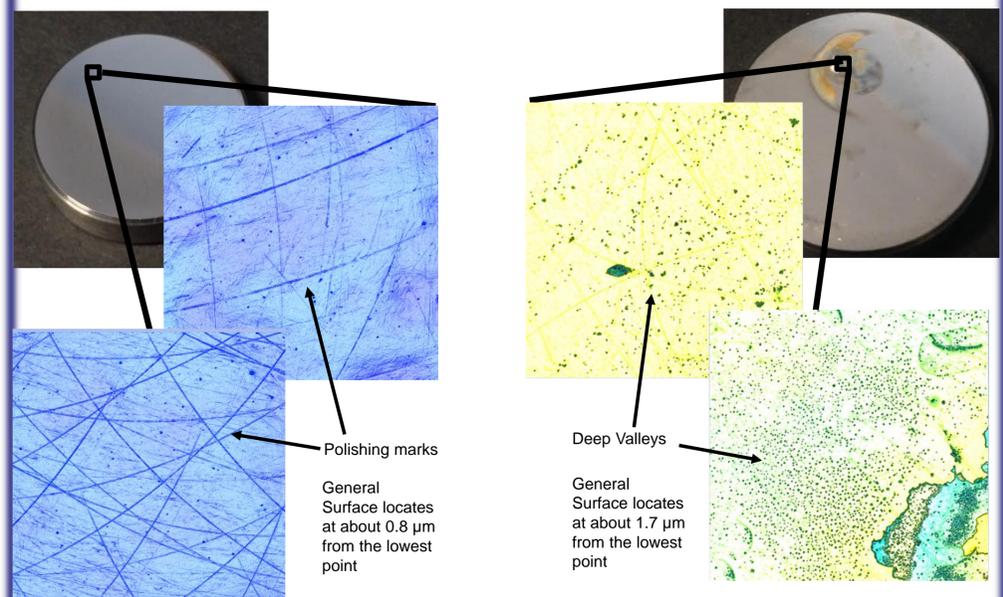
## 3. Measurement and Results of Pins & Plates

|                      | Values   | Parameters                       | Values            |
|----------------------|----------|----------------------------------|-------------------|
| Sq ( $\mu\text{m}$ ) | 0.0209   | Sds ( $1/\text{mm}^2$ )          | 44199             |
| Ssk                  | -0.5357  | Vmp( $\text{um}^3/\text{mm}^2$ ) | 782.649           |
| Sku                  | 317.2405 | Vmc( $\text{um}^3/\text{mm}^2$ ) | 18435.1           |
| Sp ( $\mu\text{m}$ ) | 0.5843   | Vvc( $\text{um}^3/\text{mm}^2$ ) | 23318.8           |
| Sv ( $\mu\text{m}$ ) | 0.6563   | Vvv( $\text{um}^3/\text{mm}^2$ ) | 2473.2813         |
| Sz ( $\mu\text{m}$ ) | 1.2406   |                                  | (Pre- experiment) |

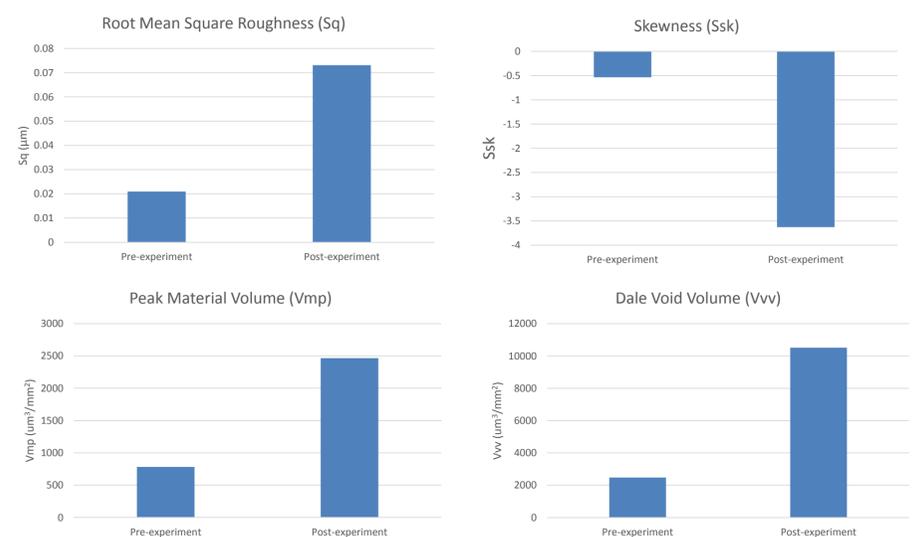
|                      | Values   | Parameters                       | Values             |
|----------------------|----------|----------------------------------|--------------------|
| Sq ( $\mu\text{m}$ ) | 0.0731   | Sds ( $1/\text{mm}^2$ )          | 273252.5           |
| Ssk                  | -3.6280  | Vmp( $\text{um}^3/\text{mm}^2$ ) | 2465.5986          |
| Sku                  | 333.1529 | Vmc( $\text{um}^3/\text{mm}^2$ ) | 39181.825          |
| Sp ( $\mu\text{m}$ ) | 1.687    | Vvc( $\text{um}^3/\text{mm}^2$ ) | 41271.5            |
| Sv ( $\mu\text{m}$ ) | 1.5673   | Vvv( $\text{um}^3/\text{mm}^2$ ) | 10510.475          |
| Sz ( $\mu\text{m}$ ) | 3.2545   |                                  | (Post- experiment) |



- ✓ 3D surface characterisation parameters adopted in this study were with reference to the Green Book, the output from project "Surfstand" lead by Prof. L Blunt in "SurfStand" project in 2001.
- ✓ Out of all the parameters, Skewness (Ssk) is the most important in one in the current study. This parameters shows the features dominating at the surfaces. Positive and negative values of Skewness represent peak and valleys dominant respectively .



## 5. Discussion & Conclusion



1. Fretting wear occurred on all plates
2. Deep fretting valleys were created during the POP supported by numerical data and visual evidences
3. Surface become more dominated by valleys or pits as demonstrated by a shift in skewness to negative values.
4. Areal surface characterisation techniques quantify and qualify the severity of fretting wear with high standard