Understanding the effects of tooth brushing using an abrasive dentifrice on the wear of enamel

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What is Tribology?

• The study of friction, wear and lubrication.

• The science of interacting surfaces in relative motion.

• The UK economy loses £24 billion every year because of problems with friction, wear and lubrication.

• Tribology looks at ways of reducing this damage in transport, manufacturing and healthcare sciences.
Introduction

• Most common method to clean teeth is using a toothbrush with a dentifrice
• Toothpastes contain abrasive particles that are harmful to the delicate tissues of the teeth
• During tooth brushing, these hard particles can cause the tooth surface to wear

Previous studies

• Dentine wear (1,2)
• Reciprocating rig
• Calcite and perlite abrasive particles (3)

Proposed study

• Enamel wear
• Novel head design of rig
• Alumina and silica abrasive particles

Aim

Obtain an understanding of the **tribology** behind the interface of the tooth and toothbrush lubricated by toothpaste slurry.
Methodology

Test Materials

- Bovine teeth
- GSK mounted in epoxy resin
- Polished
- Hydrated

Toothbrush

- Tek Pro® firm
- Bristle diameter – 110 µm

Angular abrasive particles

- **Alumina** (HV = 2500)
  Mean particle size alumina - 9µm

- **Silica** (HV = 1200)
  Mean particle size silica – 19µm
## Reciprocating rig

<table>
<thead>
<tr>
<th>Test conditions</th>
<th>Quantities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load (N)</td>
<td>5</td>
</tr>
<tr>
<td>Frequency (Hertz)</td>
<td>4</td>
</tr>
<tr>
<td>Stroke length (mm)</td>
<td>4.9</td>
</tr>
<tr>
<td>Slurry concentration (g/cm³)</td>
<td>0.5% CMC + 10% Glycerine (base) + 20% abrasive</td>
</tr>
<tr>
<td>BS EN ISO 11609:2010 Dentistry — Dentifrices — Requirements, test methods and marking</td>
<td>0.5% CMC + 10% Glycerine (base) + 20% abrasive</td>
</tr>
<tr>
<td>Counterface material</td>
<td>Enamel disk</td>
</tr>
</tbody>
</table>

### Diagram

- **Slurry feed**
- **Novel TE-77 head**
- **Load**
- **Reciprocating arm**
- **Translation arm**
- **Cam housing**
- **Sample bath**
- **Bovine disk**
- **Toothbrush**
- **Friction transducer**
- **Enamel disk**
- **Epoxy resin**

- Stroke length 4.9 mm
Friction results

Mean friction = 0.071
stdev ±0.0054

Mean friction = 0.066
stdev ±0.0030

Mean friction = 0.078
stdev ±0.0042

- Nylon alone cannot damage enamel
- Particles embedded on the nylon bristle roughen the enamel.
- Friction between wet nylon and enamel = high
- Friction between particle and enamel = low
Talysurf profiles

Saliva

Alumina

0 hours

2 hours

4 hours

6 hours
Wear process

Stage 1

2 - body grooving
Material removal

$V_1 = \text{wear volume}$

Stage 2
Overall roughening effect
Increase in roughness

$V_1$
Bovine disk: Wear analysis

1. Particle pressed against enamel by the deflected bristle

2. Loaded particle acts in a 2-body way

3. Bristles with entrained abrasives are causing 2-body abrasion
   - Large grooves = bristles
   - Smaller grooves = individual particles

4. Results in a rough surface and change of profile
Summary

- Alumina generates more wear on enamel compared to silica
- Both particles roughen the teeth overtime
- A significant difference in friction between the particle and control slurry group
- Future work will explore lower loads of 1N and 2N on the multi-station rig
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