

A New Micro-Fretting- Corrosion (μ FC) Test System to Study Dental Implant Degradation Processes

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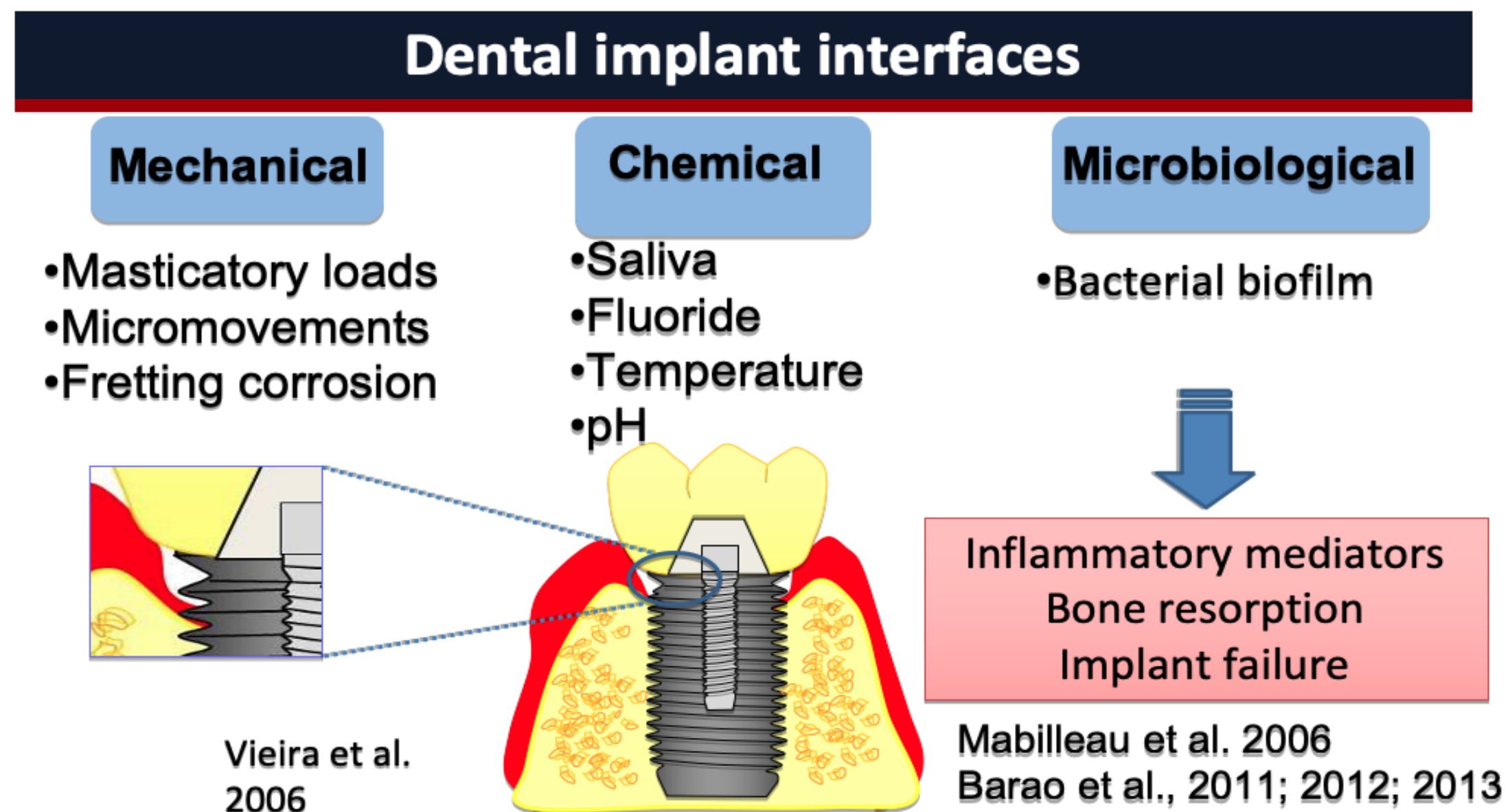
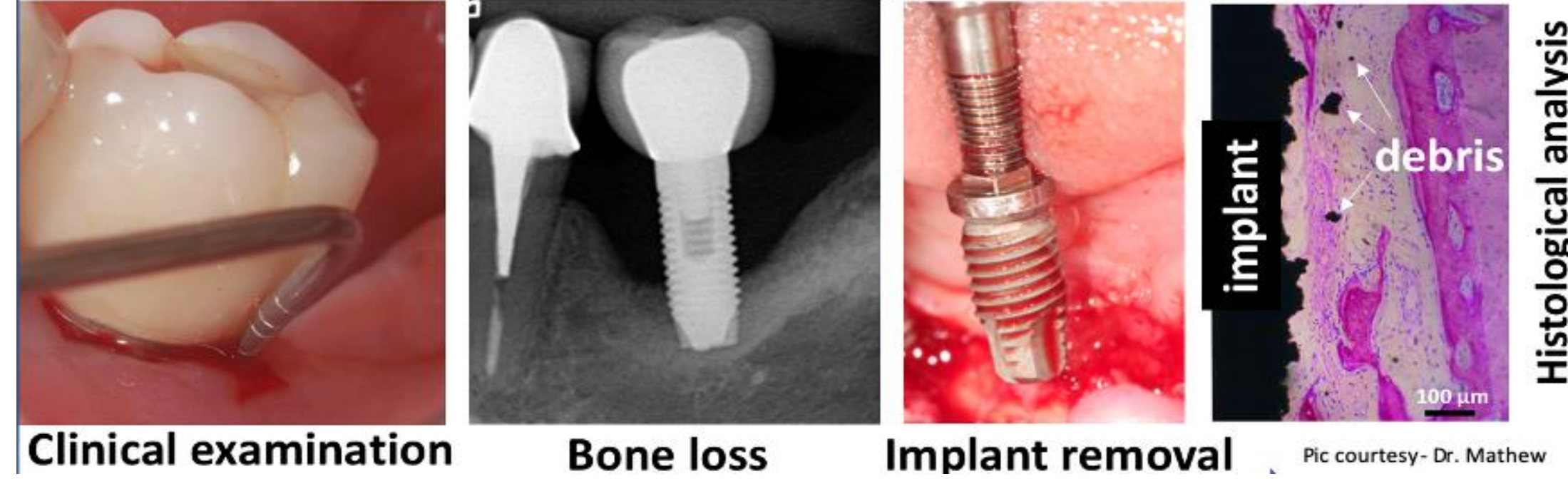
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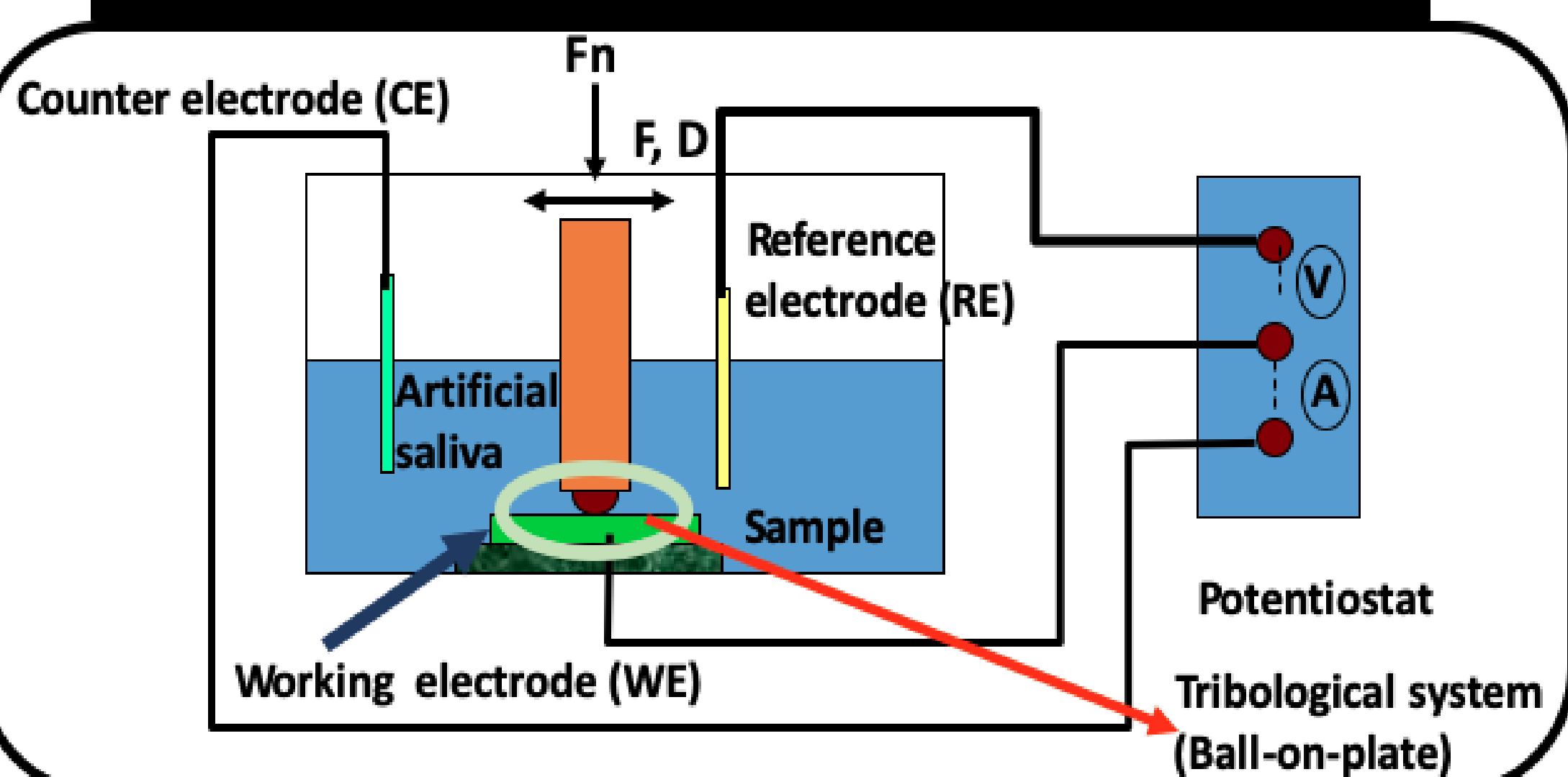
Objective

Recent studies showed that the degradation of dental implants due to the combined effect of masticatory forces and fluid (e.g., saliva) leads to wear (fretting) and corrosion (called tribocorrosion) at implant component interfaces [1-3]. This may lead to bone resorption and implant failure [4].



Although several fretting-corrosion studies were reported, until now, there were no systematic studies with a micromotion of 5 μ m that had been reported. This is mainly due to the technical difficulties in producing a micromotion fretting test system [3,5]. Therefore, the **main objective** of this study was to develop a **micro fretting-corrosion (μ FC) test system** to simulate the dental implant interface (Ti6Al4V-Ti6Al4V interface) and report the initial results.

In-vitro Tribocorrosion test simulating oral conditions



Materials and Experiments

The newly developed fretting apparatus was interfaced with a Gamry made potentiostat (Interface 1000) as shown in **Fig.1**. The moving stage with micromotion capability was supplied by Thorlabs Inc (West coast, USA) and load cell was supplied by Load star Inc (CA,USA). The tribological components consisted of a pin-on-disc contact, immersed in a double-walled corrosion chamber. In this study, a Ti6Al4V pin (3mm dia) in contact with a Ti6Al4V disc (11 x 7 mm) was used to simulate the Ti-Ti dental implant interface as the working electrode. Both specimen surfaces were polished with a standard metallography protocol (Surface roughness-50 μ m). The load applied was 233N with an amplitude of $\pm 5\mu$ m in artificial saliva (pH=6.5) for 10 cycles. The Pt wire was the reference electrode and a 3mm graphite rod was a counter electrode. To validate the test system the fretting test under free potential mode was conducted, the evolution of open circuit potential and dissipated friction energy was monitored.

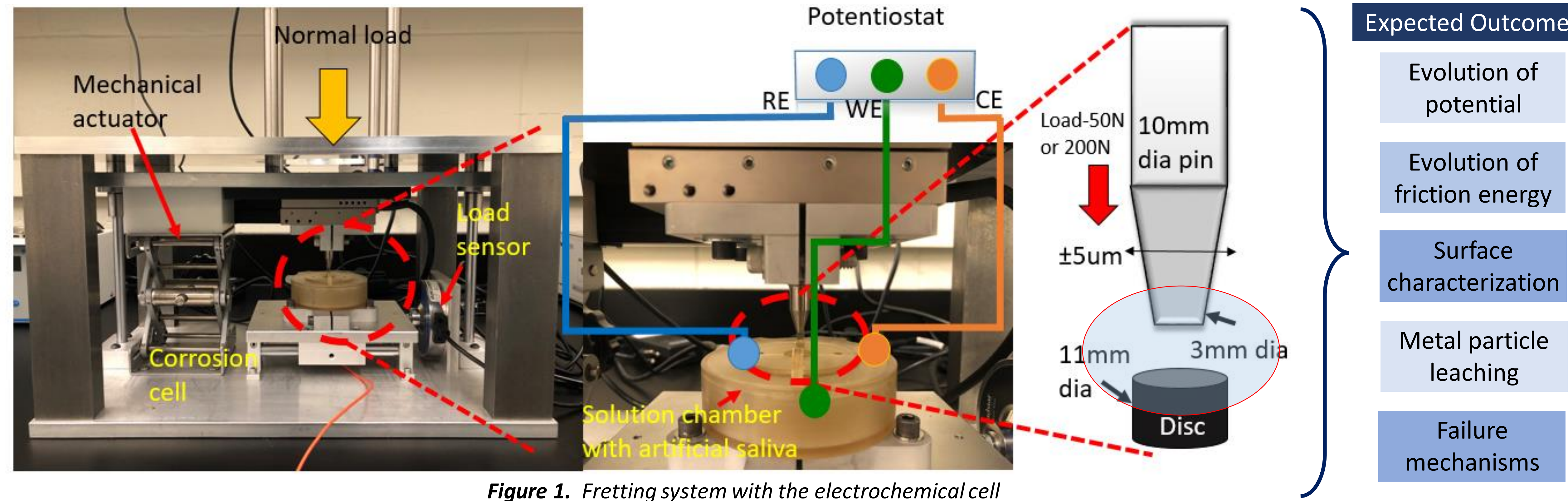


Figure 1. Fretting system with the electrochemical cell

Conclusions

- In this work, a new fretting apparatus was built and utilized to study tribocorrosion properties of a dental implant material under micromotions ($\leq 5\mu$ m).
- The preliminary experiment was conducted with a Ti6Al4V-Ti6Al4V interface, artificial saliva, with $\pm 5\mu$ m for 10 cycles.
- The fluctuations of open circuit potential (OCP) were monitored, and friction loops were generated. The dissipation energy was estimated as 0.01389 Joules.
- Therefore, the new micro-fretting-corrosion test system was validated. The importance of the role of electrochemical and mechanical factors on dental implant degradation was demonstrated.
- New understanding of the degradation mechanisms due to the synergistic interaction of wear and corrosion will assist in mitigating the early failure of dental implants.

Future work

- ❖ The preliminary experiment was conducted for 10 cycles, the system may be further developed to monitor the tangential force, as well as the electrochemical response from the fretting process for long-term experiments.
- ❖ Further characterization such as SEM and 3D profilometry to analyze the wear scar and wear loss.

Reference

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Results and Discussion

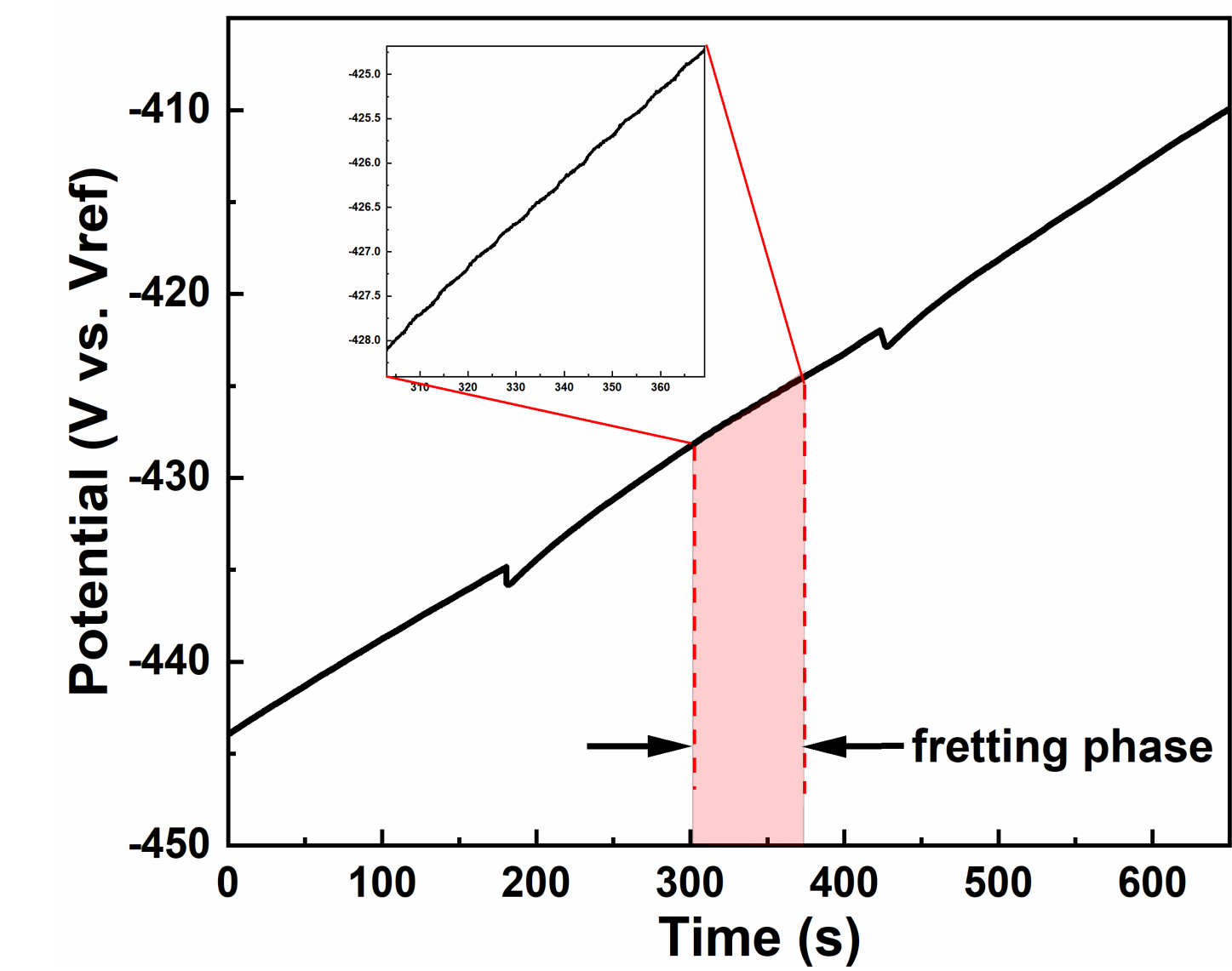


Figure 2. 10 cycles open circuit potential test in artificial saliva

Fig. 2 shows the open-circuit potential (OCP) results for 10 cycle fretting movements in artificial saliva (pH=6.5). The fretting phase started at 300s and ended at 370s. The enlarged curve clearly indicates the electrochemical change induced by the fretting process.

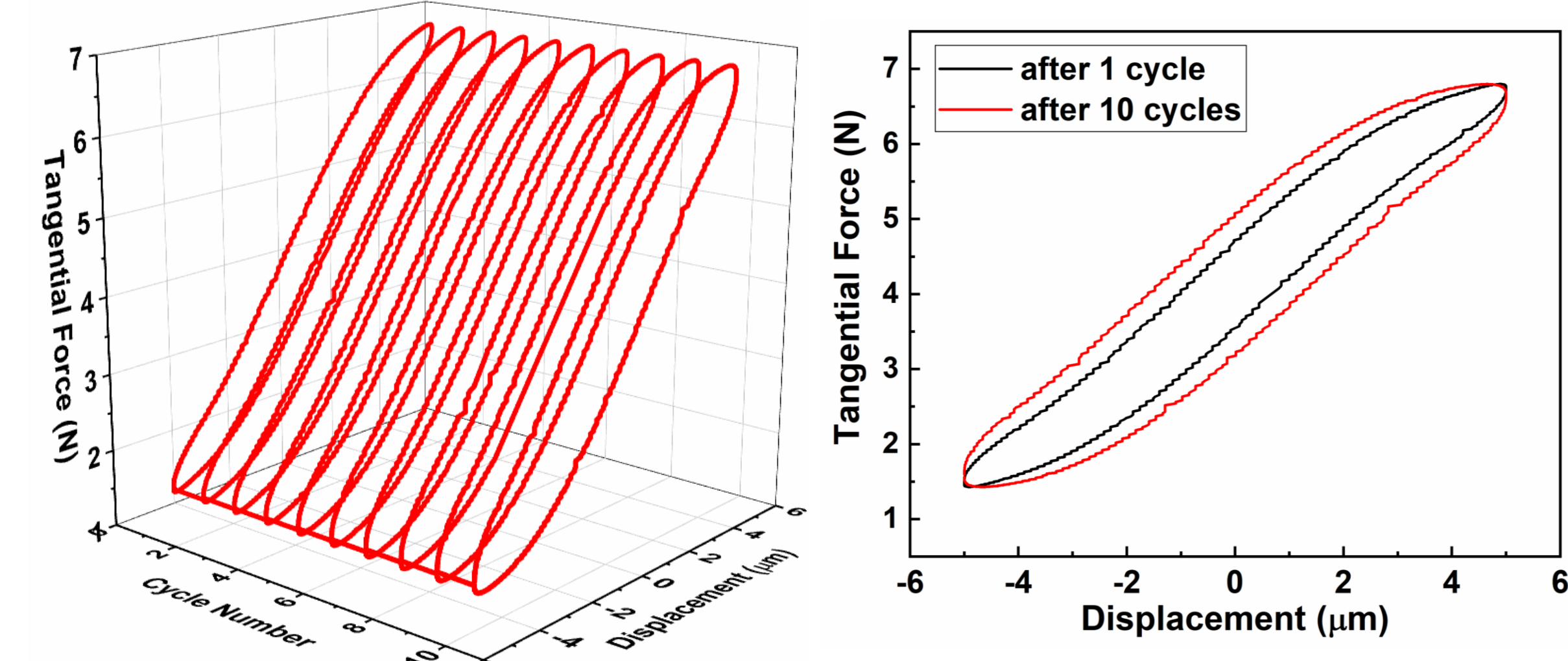


Figure 3. Evolution of Fretting loops throughout 10 cycles

Figure 4. Fretting loops for the 1st cycle and the 10th cycle

Fig. 3 & 4. The Fretting loops were generated as a function of displacement and tangential force. **Fig. 3** presents the evolution of the fretting loops throughout the whole fretting process (10 cycles), and **Fig. 4** displays the fretting loops of the 1st cycle and the 10th cycle, respectively. Furthermore, the energy dissipated during the fretting movements can be estimated based on the area of fretting loops. According to our analysis, the area of the 1st fretting loop is 8.632, meaning the dissipation energy from the 1st cycle is 0.00863 J. The same analysis was conducted for the 10th cycle, the dissipation energy after 10 cycles was 0.01389 J.

Acknowledgements

We thank Dr. McNallan (Dept. of Civil and Materials Engineering, UIC) for the support, UIC Mechanical workshop for the assistance, Blazer foundation (Rockford) for the financial assistance.