New in vitro technique for the evaluation of prostheses: Dynamic fatigue combined with crevice corrosion

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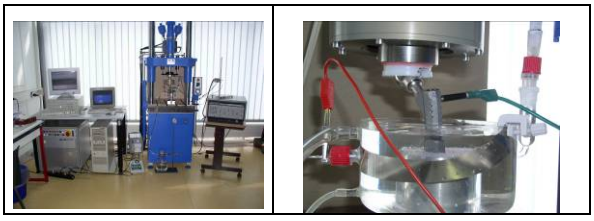
INTRODUCTION: An electrochemical study of the corrosion resistance of the articulation interface (distal / proximal module) of a prosthesis was performed in combination with a cyclic fatigue test. The complexity of the situation resides in the existence of interfaces between the distal part, the proximal part, and the dynamometric screw. A new technique for the evaluation of the resistance to cyclic dynamic corrosion with crevice stimulation of modular prostheses is presented. Two components of explanted modular prostheses of the same type after cyclic dynamic test with stimulation of crevice corrosion

METHODS: The test samples are complete modular prostheses. The distal module of the prosthesis was embedded in a reactive resin. The electrochemical cell was equipped with a Luggine capillary for the reference electrode (Fig.1 and 2)



The potentiostatic technique was adopted from the ASTM F746-97 standard. The test was conducted in steps of one million cycles for a total of 5 million fatigue cycles, and 200 potentiostatic (electrochemical) cycles were measured during the 5 million mechanical fatigue cycles. The procedure of a potentiostatic cycle consisted in stimulating at a potential of 800 mV SCE for 60 seconds and then recording the current at preselected potentials of 600 mV , 650 mV , 700 mV and 750 mV vs SCE for 36 minutes at each increment.

The test milieu was a solution of NaCl at a concentration of 9 g/l in ultra-pure water.

RESULTS: The integration of the potentiostatic curves gives the quantities of electrical charge (in microcoulombs) consumed in the fatigue process at each preselected potential. Fig. 3 displays the entirety of these results.

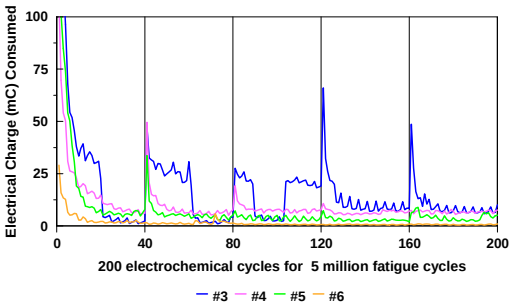


Fig 3 Behaviour of localised corrosion of prostheses #3, #4 and #5 (series1) during 5 million mechanical fatigue cycles.

DISCUSSION & CONCLUSIONS:

According to the results obtained, the evaluated electrochemical parameters and the visual observations reveal that :

1) The electrolyte penetrates into the interface of the distal/proximal modules during cyclic dynamic tests; this is not the case during static electrochemical tests.

2) The distal module undergoes cracking and corrosion in the interface region

A comparison of the explanted proximal parts with modular prostheses of the same type evaluated during the cyclic dynamic tests with stimulation of crevice corrosion, show significant similarities with regard to the phenomena of electrolyte diffusion, deposition of products and corrosion (Figs 4 and 5).

Fig.4 Proximal module explanted

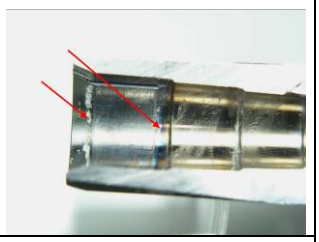


Fig.5 proximal module #4 evaluated in fatigue test

These observations motivate the use of comparative cyclic dynamic tests with stimulation of crevice corrosion in the design and evaluation stage of modular prostheses.