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Influence of load cycling in wet environment on the bending strength of 3Y-TZP three unit FPDs processed via CAD-CAM

F.T Silva(1)

(1) Associate Professor Programa de Engenharia Metalúrgica e de Materiais, PEMM-COPPE/UFRJ, Cidade Universitária, Ilha do Fundão, Centro de Tecnologia, Bloco-F sala F-210, flatesi@metalmat.ufrj.br

Abstract – The aim of this study was to evaluate in vitro the influence of mastication on the bending strength of three unit FPDs of 3Y-TZP processed via CAD-CAM. Those frameworks were submitted to load cycles in wet environment (450N, 1Hz) for different number of load cycles (5,000 to 1,000,000). From Kruskal-Wallis test the decrease in strength with the number of load cycles was considered statistically significant. From XPS analysis of Y_2O_3 it was observed two small Y-OH peaks which indicates that tetragonal-monoclinic transformation due to grinding and load cycling in wet environment may promote some ageing on 3Y-TZP FPDs.

There are some indications in the literature [1] correlating the ageing of 3Y-TZP at room temperature with wet environment. Chung et al. [2] suggested a thermal treatment at higher temperature and inert atmosphere (1600 or 1700^{0}C) in inert atmosphere in order to avoid this aging. Ruiz and Redley [3] have shown that sintered 3Y-TZP at high temperature (1450-1550^{0}C), has two main phases: an yttrium rich cubic zirconia and an yttrium depleted tetragonal zirconia. After load cycling in wet environment (450N,1Hz) it was observed that no FPD fractured by fatigue. This result agrees with Jung,et al. [4] which indicates that the threshold load to fracture by fatigue should be higher than 500N. In order to evaluate the influence of the number of load cycles on its residual load, the non-fractured FPDs were submitted to a three point flexural test with the axial load applied at the pontic center. Figure 1 shows a slight decrease in residual strength with an increase in the number of load cycles. Figure 2 shows a FPD, where cracks are nucleated at the maximum tension stress at the connector and propagating obliquely to the region of the maximum compressive stress at the pontic center. A possible cause for this fracture could be related to tetragonal-monoclinic reverse transformation mainly at the surface of the connector due to grinding and to the cyclic fatigue in wet environment. X-ray diffraction and X-ray photoelectron spectroscopy (XPS) were used to investigate the phase transformations and the possible interactions among zirconia, yttria and water molecules. It was shown from XPS spectra that ZrO_2 has no interaction with water molecules; otherwise, Y_2O_3 have shown some interaction, which was observed by the two major peaks related to Y-O and two minor peaks related to Y-OH. It was also observed in the same region an increase in Y content after sintering in relation to the same region before sintering. These results agrees with recent published data [5].

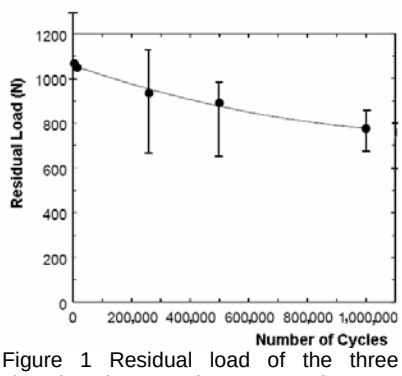

Figure 1 Residual load of the three zirconia three unit FPD unit FPD previously submitted to different number of load cycles

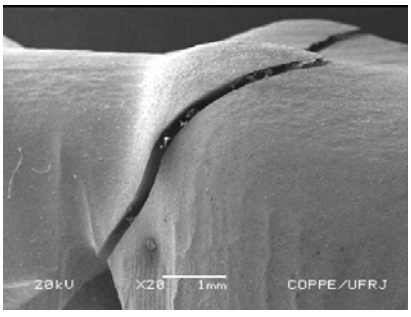

Figure 2 – Fracture mode of the dense zirconia three unit FPD (500,000 cycles (450N, 1Hz) in wet environment

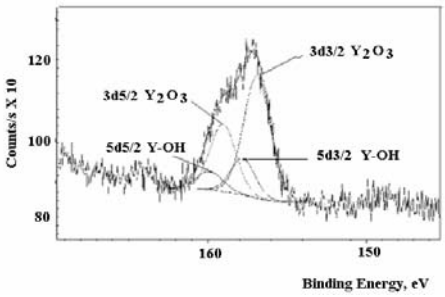

Figure 3 – XPS of Y species on fractured 3Y-TZP in wet environment

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2 - Chung,T., Song,H., Kim,G., and Kim,D., "Microstructure and phase stability of yttria-doped tetragonal zirconia polycrystals heat treated in nitrogen atmosphere," *J. Am. Ceram. Soc.*, 80 (1997) 2607-2612
3 – Ruiz,L., Readey,M.J., Effect of heat treatment on grain size phase assemblage and mechanical properties of 3Y-TZP, *J Am. Ceram. Soc.*, 79 (1996) 2331-2340.
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