Evaluation of loading conditions on fatigue-failed dental implants by fracture surface analysis

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Abstract

PURPOSE: The goal of this study was to determine the relationship between fracture surface morphology and applied stress level for dental abutment screws loaded in cyclic fatigue. If a correlation between fracture surface and load level can be determined, then the fracture surface analysis could be used as a tool to assess the mechanism by which a screw failed and the magnitude of the load at which it failed. MATERIALS AND METHODS: Test implants were loaded with static and cyclic forces. In the cyclic test, the load versus the number of cycles was plotted as a curve for biomechanical analysis. The fracture surfaces of the failed screws were observed and recorded using scanning electron microscopy (SEM). RESULTS: Two fracture phases, a smooth region and a rough region, were observed on the fracture surface. After identifying the boundary between the 2 regions, the smooth region ratio (SRR), the ratio of the smooth phase area to the area of the whole fracture surface, was measured using digitized SEM images. The mean SRRs were 0.60 +/- 0.03, 0.66 +/- 0.03, and 0.75 +/- 0.03 when the tested implants were subjected to dynamic loading of 60%, 55%, and 50% ultimate failure loading (UFL), respectively. Linear relationships were found between the SRR values and loading magnitude and between SSR and number of cycles. DISCUSSION: The smooth area on the fracture surface can be used to assess the load conditions and internal stress of fatigue-fractured implants. CONCLUSIONS: These results demonstrate that fracture surface analysis of fractured implants has the potential to become a useful indicator for assessing implant fracture mechanisms.