Evaluation of the effect of early bacterial colonizers on the surface of retrieved dental healing abutments

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Statement of Purpose: Healing abutments (HA) are titanium caps screwed temporarily on dental implants for the initial healing period, which is of approximately 3 months. HA avoid functional loading of dental implants facilitating osseointegration and aiding in soft tissue management [1]. Inflammation of soft tissues due to bacteria/bacteria biofilm has been associated with early failure of dental implants [2]. A recent study demonstrated the ability of early colonizers to acidify the growing environment and electro-chemically attacking the surface of dental implants [3]. HA are highly exposed to bacterial colonization in the oral environment. Primary colonizers of bacterial biofilm, which are aerobic/facultative anerobes, access the surface of implants. These microorganisms create an acidic environment facilitating an anaerobic microenvironment for biofilm growth. This study hypothesizes that early bacterial colonization may lead to surface deterioration due to this acidic oral environment. In this study, HA were retrieved from patients and evaluated with microscopy and spectroscopy techniques.

Methods: Two groups of HA retrievals were received. Group 1 was composed of one Straumann regular neck (RN) straight walled healing abutment (height = 4.5 mm) for tissue-level dental implants. Group 2 was composed of five Straumann regular connection (RC) conical healing abutment (5 x 6 mm) for bone level dental implants. Each group had an unused control HA for comparison. The retrieved abutments were subjected to optical microscopy (Keyence VHX-2000, Itasca, IL). Areas of interest were further investigated with scanning electron microscope (SEM, JEOL JSM-6010, Peabody, MA). X-ray photo-electron spectroscopy (XPS) was performed to evaluate the elemental composition, oxidation state as well as chemical environment of atoms on the surface. In order to understand the effect of bacteria, HA retrievals were compared with two sand blasted, large grit, acid etched (SLA) dental implants. One of the implants was immersed in an *in-vitro* medium containing early colonizing bacteria, *Streptococcus mutans* monoculture for a period of 60 days simulating the initial healing period. The other implant was a packaged and un-used implant which served as a control.

Results: Microscopic evaluation showed minor surface etching with yellow and blue discoloration (Figure 1b) in group 1 abutment. Mechanical wear such as scratches and cracks were observed on both groups (Figure 1c and 1f). SEM corroborated scratches, cracks and discoloration observed in the optical microscopy. Both optical microscopy and SEM confirmed a defect free surface of the control abutment in each group. In the XPS analysis, the dental implant immersed in *S.mutans* showed lower concentration of oxygen bound to titanium. The most important observation was the prominent presence of the element Iron on the surface. The control dental implant showed only the presence of titanium with higher concentration of oxygen molecules bound to it. XPS analysis of retrieved HA showed equivalent concentration of oxygen bound to titanium compared to their respective controls. But there was no prominent presence of Iron on the surface of HA as observed on the rough surface of the dental implant evaluated with this technique.

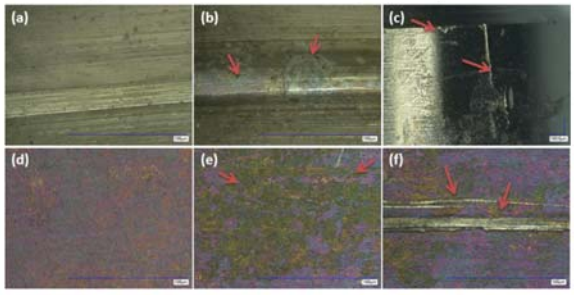

Figure 1 (a-c) Group 1 HA; (a) Control; (b) Retrieval with discoloration; (c) Retrieval with mechanical scratches; (d-f) Group 2 HA; (d) Control; (e) Retrieval with discoloration; (f) Retrieval with mechanical cracks.

Conclusions: Figure 1b showed a characteristic surface discoloration in group 1. The characteristic yellow and blue discoloration observed with the implants in group 1 can be associated with oxidation of titanium to Ti^{3+}/Ti^{4+}. This feature could be attributed to the electrochemical attack on the surface due to the acidic oral environment created by the early colonizing bacteria. In group 2, color coding of HA made it difficult to characterize discoloration. Mechanical wear observed on HA may be due to the insertion/removal of HA during surgery as HA are not exposed to functional loading. The XPS data of dental implant immersed in *S. mutans* clearly showed the breakdown of oxide layer and exposure of the bulk. The ability of bacteria to adhere to the surface and release metabolic products was further confirmed with the presence of Iron which is one the main metabolic constituents of *S.mutans*. In the XPS analysis of retrieved HA, no destruction of the surface passivity was observed. This may be due to the smooth surface of HA which is inhospitable for bacterial colonization and multiplication compared to the rough surface. Thus, HA have lower susceptibility for bacterial colonization and experience minimal damage on the surface. Dental implants are typically rough and composed of modular parts in comparison to HA. Therefore, it is important to understand how bacteria adhere and proliferate on the surface and interfaces of these implants..

[1] http://genieoss.com/manufacturer/straumannhealing.html
[2] Pontoriero R, Tonetti MP, Carnevale G, Mombelli A,Nyman SR, Lang NP. Clin Oral Implants Res 1994;5:254-259; [3] Rodrigues DC et al., Materials 6(11):5258-5274; 2013;