

Effects of Different Prophylaxis Procedures on Titanium Implant Fixture: A Scanning Electron Microscopy Study

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Abstract

This study aimed to describe the effects of different prophylaxis procedures on titanium implant fixture surfaces under Scanning Electron Microscopy (SEM).

Fifteen BEGO Semados® implant fixtures were mounted on stone stands and randomly divided into 3 groups which were Control (C) (n=5), Air Flow (AF) (n=5) and Rubber Cup with Pumice Powder (RC) respectively. After 2 minutes of prophylaxis procedures, all treated samples were irrigated with normal saline and fixed with 2.5% glutaraldehyde. They were air dried, wrapped and stored in individually labeled and sealed compartments. One fixture was randomly selected from each group and they were observed under SEM at x1000 and x2000 magnifications.

SEM showed that surfaces from C group displayed machine lines due to milling process with minimal pits and scratches. The surfaces from AF group had generalized micro pits and pores with the machine lines still observed. In RC group, the surfaces demonstrated homogeneous line of scratches that identical to the rotational movement of the RC. The machining marks and lines were also disappeared.

Based on the findings, the titanium implant fixture surfaces treated with RC revealed less invasive and more effective compared to AF.

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Introduction

The purpose of any dental treatment is to replace the damaged or lost part of the tooth structure with a suitable material to restore the function and aesthetic of the tooth. Many people replace missing teeth with dentures but attitudes towards them are less than favourable¹. In contrast, dental implants are generally viewed more favourably, in terms of aesthetics, functionality and stability and they are becoming increasingly available². Implant treatment is a common procedure in the replacement of missing teeth with a large number of implant systems are available and many are manufactured of commercially pure titanium. They are a costly investment and a good care should be taken to

avoid severe complications. In ensuring the longevity and lifespan of an implant, maintenance is crucial where proper instrumentation includes removing microbial deposits without altering the implant surfaces³.

Implants are susceptible to accumulation of bacterial plaque and calculus formation. In fact, because of decreased vascular supply around the implant and lack of connective fiber insertion, there may be greater susceptibility to plaque-induced inflammation and hence, leading to peri-implant diseases⁴. A dental implant fixture with a rough surface has a larger surface of contact with bone and more feasible to induce osseointegration while a smooth surface gives superior results in the reaction with soft tissue covering the bone⁵. Osseointegration is a direct connection between live bone and a functioning endosseous implant and the term functioning implying that the contact between the surface of the implant and live bone is sustained⁶. The first component of implant fixture to be exposed to the oral environment is the smooth surface of the fixture and if this surface is not clean, the bacterial plaque will accumulate thus leading to

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soft tissue inflammation which is known as peri-implant mucositis. Eventually, in the future, this will lead to peri-implantitis or failure of implant in the long term.

The therapies and instruments proposed for the prevention, control and management of peri-implant diseases appear to be based, to a large extent, on the available evidence regarding the treatment of periodontitis, such as plaque and calculus removal. Maintaining the surface integrity of the exposed fixture is crucial to avoid negatively affecting the soft tissue and surrounding bone. Surface roughness has been identified as an important parameter for implants and its capacity for being anchored in bone tissue. Surface roughness of implants does lead to increased colonization of bacteria and build-up of both supra and subgingival plaque⁷. Roughened surfaces can contribute to the bacterial plaque accumulation, allow re-colonization with pathogenic bacteria, and thus further deterioration of the integrity of the implant.

The plaque removal from implant surfaces can cause the possible damage to the implant surfaces and this is the main problem associated with. Any damage to the surface induces changes in the chemical oxide layer that may result in increasing corrosion. This process impairs the adhesion of fibroblasts and thus biocompatibility of the implant⁸. These results have led to a demand for plaque and calculus removal using instrument that cause little or no surface damage⁸. Therefore, it is crucial that the general dental practitioner have the knowledge of which instruments used for maintenance to remove plaque and calculus from the implant surface effectively and efficiently while causing minimal damage to its circumference.

Air Flow (AF) and also Rubber Cup with Pumice Powder (RC) are increasing in popularity to be used as the prophylaxis procedures to clean the titanium implant fixture. However, these procedures may disrupt the surface integrity of implant fixture. Thus the evaluation of these procedures may help in choosing the most non-invasive methods for implant maintenance in the future. Therefore, the objective of this study was to describe the effects of different prophylaxis procedures on titanium implant fixture surfaces with AF and RC by using Scanning Electron Microscope (SEM). The knowledge of these prophylaxis procedures used for implant cleaning could help the dentist in choosing the least

damaging method as well as to establish the best practice with respect to prevent from further peri-implant disease progression and subsequently to increase the survival rate of the dental implant.

Materials and methods

Study design

The study done was an experimental laboratory study. The instrumentations were performed at School of Dental Sciences, Universiti Sains Malaysia. The samples then were scanned with Scanning Electron Microscope (SEM) at School of Health Sciences, Universiti Sains Malaysia.

Brand of fixture

There were many brands of fixtures available and used in Malaysia. However, for this exploratory study, we chose Bego Semados® RI Implant Fixture as this brand was among the commonly used in Universiti Sains Malaysia. A typical dental implant fixture has both smooth surface and rough surface, and the level of embedment may differ in different brand of fixture. For Bego Semados® RI Implant Fixture, both smooth and rough surfaces were fully submerged into the bone.

Titanium implant fixture

Fifteen Bego implant fixtures were used in this study. The fixture-analog unit was mounted into the 2cm x 2cm x 4cm box shaped block stand which functioned as the working model.

Sampling methods

All fifteen titanium implant fixtures were randomly selected for three different groups of prophylaxis procedures.

Hygiene instruments and methods

All samples were randomly divided into one of the following groups and all methods used for every group were standardized for each fixture to obtain optimal results:-

Group 1: C (n = 5)

Samples were irrigated with normal saline and fixed with 2.5% glutaraldehyde. These samples were untreated and selected as a C group.

Group 2: AF (n = 5)

Samples were treated with an AF (Air Flow® Masters, EMS, Munich, Germany) using amino acid glycine powder (Air-Flow® Powder Perio, EMS). The application was accomplished using a specially designed nozzle, consisting of a metal tube that was fitted with three orthogonally

orientated holes at 01, 1201 and 2401 to the long axis of the tube. This specific design was associated with a horizontal exit of the air powder mixture and a reduced pressure of 1 bar, thus preventing emphysema formation in the adjacent tissue⁹.

The handpiece (Air Flow® EL-308/A, EMS) was held in 30° angulation and guided in a circular motion from coronal to apical parallel to the abutment surface in a non-contact mode (0.5 - 1 cm from the surface)¹⁰. The instrumentation time for each aspect (mesial, distal, buccal and lingual) was total up to 2 minutes as recommended by the manufacturer⁹.

Group 3: RC (n=5)

The selected samples were polished using rubber cup polishing kit with the pumice mixed with normal saline and were polished perpendicularly onto the abutment surfaces while moving with a gentle touch. The rubber cup was rotated with contra-angle slow speed handpiece at approximate 2,500 rpm for 2 minutes duration on all¹¹. The pumice powder granules used was ultra-fine (0 - 40 µm) in size mixed with normal saline as lubricant¹².

All samples were treated for 2 minutes each. The treated fixture were then irrigated with normal saline and fixed with 2.5% glutaraldehyde. The samples were air dried, wrapped in sterile 2cm x 2cm dry gauze and stored in individually labeled and sealed compartments prior to mounting and scanning procedures.

Scanning Electron Microscopy (SEM)

Out of fifteen titanium implant fixtures, one fixture was randomly selected from each groups and observed by using SEM. As for standardization, the flat surface of the prepared potion was faced the stub and the convex surface was selected for scanning procedures. The specimens were sprayed with gold powder for coating effect prior to scanning procedure by using Leica Sputter Machine for clearer images. Then, they were mounted onto specimen stub and viewed by using high resolution SEM. The magnifications selected were at x1000 and x2000 thoroughly over the selected area and was compared with the C group.

The captured images were viewed and edited by using software (XT microscope control) in a computer system attached to the SEM machine.

Results

Descriptive statistic was applied in this study on fifteen Bego Semados® RI Fixtures. Throughout an experiment, a topography of surface changes was observed and confirmed by SEM images. The magnifications at x1000 and x2000 were used for this evaluation. Only one sample from each group was randomly selected for scanning.

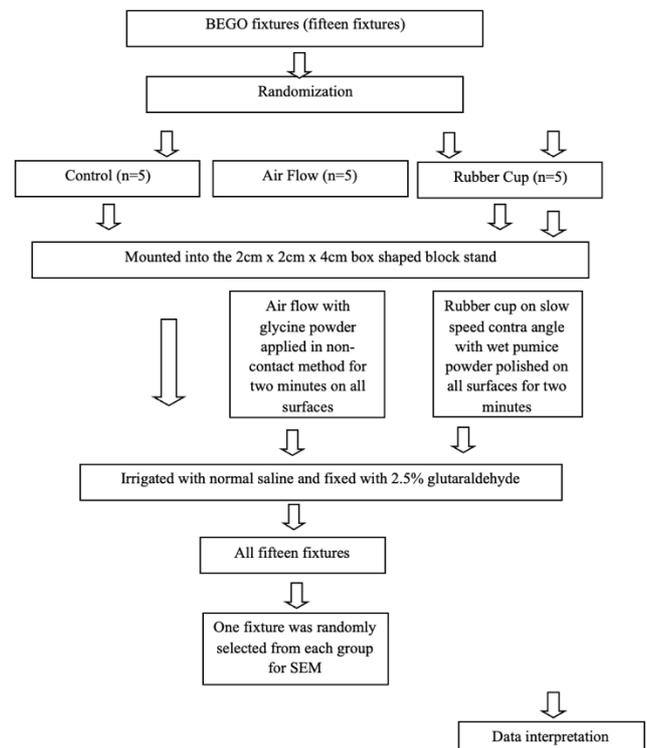


Figure 1. Flowchart of the methodology protocol.

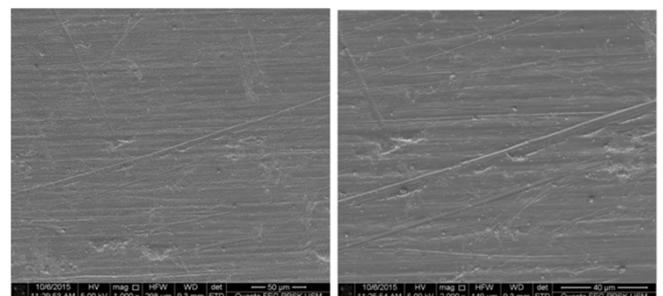


Figure 2. SEM images of titanium-implant fixture surface topography in C group at x1000(Left) and x2000(Right) magnification respectively.

At x1000 magnification, in C group, the surface was not undergone any prophylaxis procedure. There were machining marks observed running in uniform horizontal lines. Scratches and pits were observed on the implant

surfaces as they were removed from the manufacturer's packaging. In AF group, the machining marks were also observed as those seen in the C group with patchy appearance surface and remnant of amino acid glycine. In RC group, the implant surface showed prominent surface alteration where irregular shaped defects on implant surface was noted.

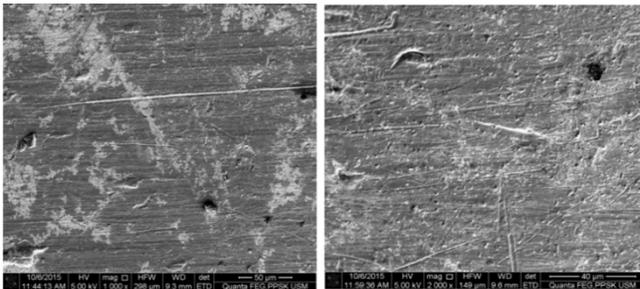


Figure 3. SEM images of titanium-implant fixture surface topography in AF group at x1000(Left) and x2000(Right) magnification respectively.

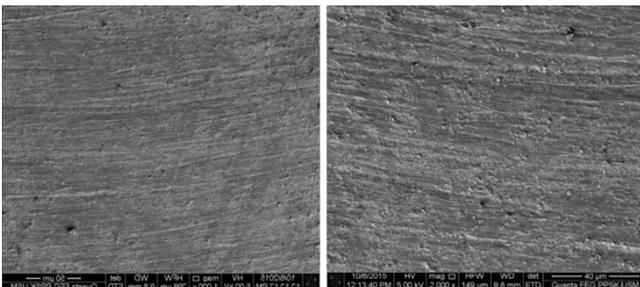


Figure 4. SEM images of titanium-implant fixture surface topography in RC group at x1000(Left) and x2000(Right) magnification respectively.

At x2000 magnification, in C group, the surfaces exhibited pronounced circumferential machining marks with minimal pits and scratches. In AF group, the surface created was dramatically altered, more irregular topography with the presence of multiple micro pores and pits and also fine debris. In RC group demonstrated homogeneous line of scratches that identical to the rotational movement of the rubber cup with pumice. The machining marks and lines were also disappeared (Fig, 1, 2, 3, 4).

Discussion

Implant loss can occur up to a year after implant placement - "early implant loss" and a year after implantation - "delayed implant loss", which is primarily associated with the development of a pronounced inflammatory

reaction in the tissues surrounding the osteointegrated implant¹³. Maintaining healthy tissues around implants is considered a critical factor for their long term success¹⁴. More plaque seem to accumulate on implants and implant components than natural teeth⁷. In case of peri-implant disease, the implant fixture surface to be exposed first would be the smooth surface. It has been reported that even on relatively smooth implant surfaces, plaque accumulates faster when compared with natural teeth. To prevent the implant fixture from further plaque accumulation and bone loss, the smooth surfaces need to be cleaned with hygiene instrument that would not create roughness for plaque accumulation.

At the moment, there are no clear protocols for the treatment of peri-implantitis, and there are no data in the literature devoted to the study of the effect of mechanical treatment on the implant surface, depending on its type, and as a result, the prognosis for the treatment of peri-implantitis¹⁵. Up till this day, literature clearly shows the lack of a cleaning and polishing treatment for oral implants that may be universally applied and does not damage implant surfaces^{16, 17}. Various methods have been advocated, with no definitive gold standard (e.g., plastic instruments, air abrasives, polishing rubber cups)¹⁴. According to an in vitro study done on effect of prophylaxis procedures on titanium abutments, they have come to a conclusion that the rubber cup with tin oxide and the air abrasive system seemed to produce the most significant polishing effect¹⁸.

Therefore in this study, we had narrowed it down to the evaluation of the effect of air flow and rubber cup with pumice powder on smooth surface of titanium implant fixture. Air flow with glycine powder and rubber cup with pumice are increasingly known as the promising new solution for hygiene procedure of oral implants with regards to treatment and prevention of peri-implant mucositis¹⁹.

The smooth surface of titanium implant fixtures in the control group, as supplied by the manufacturer, was not entirely smooth when viewed under both x1000 and x2000 magnification of SEM. The surface clearly showed visible machine lines across its surface. These findings were also demonstrated similar to Lima et al. who studied a few types of implant discs²⁰.

At x1000 magnification, air flow group showed generalized micro pores and pits across the entire surfaces. As for the rubber cup group, there were generalized scratch lines all across the surface but minimal pits and pores. At x2000 magnification, the surface created by the air flow was dramatically altered, with presence of generalized micro pores and pits with fine debris on its surface. Rubber cup group demonstrated surface irregularities with obvious scratch lines and minimal pits. Air flow group showed more prominent machine lines compared to rubber cup group.

According to previous studies, treatment with air flow resulted in no change²¹ or in slight increase of the surface roughness²². Although they were found to cause little or no damage to the smooth surfaces, air flow appeared to leave powder deposits on the surface. Whether such residues influence healing events was still unknown. It should be noted that different variables such as water flow, exposure time, size and hardness of the particles, air pressure and nozzle-target distance may affect the abrasive capacity of these systems and thus their effects on the titanium surfaces. Augthun et al. evaluated the effects of instrumentation on smooth titanium fixtures. Again, both plastic instruments and air abrasives were found to cause almost no damage to the surfaces²³.

However, according to some previous studies, the use of rubber cups both with or without paste, appeared to leave the surfaces unaltered. The treatment of smooth surfaces with rubber cups and paste resulted in a smoothing of the surfaces^{22, 24}. SEM observations were limited to subjective interpretations and also qualitative results.

SEM images in this study also revealed different surface topographies according to different treatments. The machining mark with irregular scratches and small pits resulting from machining could be clearly seen on the C abutment; however, it was reduced on the RC treated surfaces suggesting a smoothing effect. Studies had found that RC resulted in lesser roughness, obliterated surface asperities and scratches¹¹ and reports also suggested that the use of RC polishing did not increase surface roughness²⁵.

Inversely, they were enhanced on AF treated surfaces, suggesting a roughening effect. It was concluded that surfaces treated with AF

created the roughest surface, while the RC created a smoother surfaces by obliterating the original milling marks¹¹. This was similar to Duarte et al. who found that AF gave some sand-blasting effects and irregular crater-like defects²¹. In addition, AF treatment significantly increased the surface roughness of the titanium surface though it was still considered safe²⁶.

The surface alteration still occurred even though the amino-acid-glycine powder used in AF was the softest available powder for subgingival use that should not affect the root surface and soft tissue even more in harder surfaces such as titanium¹¹. Furthermore, it was found that AF that used three different abrasive materials, such as glycine based powder, soft powder and erythritol powder, gave an insignificantly rougher surface compared to non-treated surfaces viewed under SEM²⁷. The roughness effect could be obvious on laser profilometry as its measurements are more sensitive compared to SEM²⁸.

Conclusions

Based on the findings, we would suggest that the titanium implant fixture surfaces treated with RC revealed less invasive and more effective compared to surfaces treated with AF under present test condition. However further study has to be conducted for conclusive findings.

Acknowledgements

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Declaration of Interest

The authors report no conflict of interest.

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