# THE IN-VITRO EFFECT OF PROBING AND SCALING INSTRUMENTATION ON IMPLANT RESTORATIVE ABUTMENT SURFACES

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By

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// ABSTRACT

## Background

Dental implant abutments can be exposed to a variety of oral prophylaxis procedures. Instrumentation of restored dental implants could subject the apical collar of the implant restorative abutment to surface scratching. Scratched surfaces may pose a threat to the integrity of the soft-tissue seal around the apical portion of the abutment which eventually may compromise the alveolar support of the implant. The aim of this study was to objectively measure surface roughness on the apical collar of metal implant abutments induced by probing and scaling instruments.

## Materials and Methods

14 standard transmucosal 3 in 1, 4.5 mm diameter abutments made of titanium alloy (BioHorizons, Atlanta, GA) and 4 instruments, UNC-15 metal probe, Periowise plastic probe, McCall SM 17/18 metal scaler and universal plastic scaler were used to conduct the study. 4 abutments were used for non-treated measures and 10 abutments were used for instrumentation measures. All abutments were divided into four sections. Abutments used for instrumentation were treated with one of the four indicated instruments, one instrument per each section. Surface roughness of untreated and treated surfaces was assessed using a contact profilometer. Analysis of variance (ANOVA) was used to compare surface roughness between untreated and treated surfaces.

**Results**

ANOVA showed significant differences in surface roughness between the treated and untreated surfaces ($p< 0.0001$). Add hoc analysis using Tukey-Kramer HSD test showed no statistical differences between untreated measures and metal probe measures ($p>0.05$). On the other hand, statistical differences were noted between untreated measures with plastic probe measures ($p= 0.05$), plastic scaler measures ($p=0.05$) and metal scaler measures ($p=0.05$). The metal scaler measures were higher than plastic probe measures ($p=0.05$), and plastic scaler measures ($p=0.05$).

**Conclusions**

Probing around implant abutments with a metal probe seems to have no relevant effect on abutment surfaces. In contrast, instrumentation with scalers (both metal and plastic) and plastic probe may cause adverse surface changes. It is not known if these changes have clinical relevance.

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# CHAPTER 1 – INTRODUCTION

Dental implants currently are very popular in the field of dentistry and have gained wide acceptance as a viable treatment option for patients with missing teeth. This means that each day, more implants are treatment planned, placed and maintained. As with any dental procedure, home oral hygiene practices and professional maintenance are necessary if a successful outcome is to be expected. Implant survival depends on proper and timely monitoring (including probing evaluations) and maintenance.

Maintaining dental implants as skillfully as maintaining natural teeth is crucial to their long term success for the implant patient. In addition, instrumenting dental implants is different than instrumenting natural teeth. Since there is no periodontal attachment, care should be taken to avoid introducing bacteria and debris into the tissue around the implant collar. A wide variety of prophylaxis procedures have been recommended and used on implants to help with microbial plaque control and calculus removal (including use of hand scalers and specialized ultrasonic tips). Other available options include air polishing abrasive systems, rubber prophy cup with or without abrasives, toothbrushes with soft bristles, interdental brushes and plastic and metal scalers (Orton et al. 1989, Balshi 1986, Barnes et al. 1991). The dissimilar material composition and differing methods for use of these cleaning instruments may adversely affect the surface quality of the abutment and could increase plaque and calculus retention and accumulation (Thomson-Neal et al. 1989, Rapley et al. 1990).

Dental implants are usually placed in the jawbones with the implant fixture's coronal surface at the alveolar crest. The implant abutment interfaces with the implant fixture's coronal surface. The apical portion of the implant abutment, an exposed collar of metal, is usually coronal to the alveolar crest**.** The oral mucosal tissues surround this collar of metal and create a soft tissue seal around the implant-abutment interface. The function of this peri-implant seal is to maintain a barrier to outside contaminants. It does so by shielding the implant-abutment interface and the alveolar bone encompassing the implant.

Probing the sulcular depth around an endosteal dental implant is critical to judge the stability and maintainability of the implant. The benefit of probing the implant sulcus has been challenged in the literature because sound scientific criteria are lacking. The potential for damage to the fragile attachment and the implant surface exists during probing. Hence, conventional plastic periodontal probes are usually advocated for probing around dental implants (Misch 2008). Shallow sulcular depth indicates surrounding tissue stability whereas increased depths indicates loss of the protective seal around the implant and possible loss of alveolar bone support. Implant probing involves inserting the probe between the supra-alveolar component of the implant complex (implant-abutment interface region) and the oral mucosal tissues surrounding it. The probe's sides and tip do come in contact with the implant-abutment metal surfaces and rub against the metal collar at the apical third of the abutment (Figure 1). The probe rubbing against the implant-abutment metal surfaces may cause surface damage. A

damaged implant-abutment metal surface can act as a nidus for bacterial accumulation and infection around the implant, and may lead to implant failure.

Peri-implant probing depths appear to be most closely related to the thickness and type of mucosa circumscribing the abutment. Alveolar mucosa is generally associated with deeper probing depths, whereas a keratinized collar around the abutment is usually accompanied by more shallow depths (Van Steenberghe 1988). Investigators have debated the diagnostic and prognostic value of crevicular probing depth. Because the epithelial attachment adheres only weakly, some would consider probing to be invasive, allowing penetration of the probe close to the bony crest (Cranin et al. 1982). However, probing does provide a means of assessing clinical attachment loss over time, which may be an indicator of a failing implant. Thus, probing is an appropriate method to assess potential deleterious changes in the peri-implant environment as it reveals tissue consistency, bleeding and presence or absence of exudates.

Even though several studies have investigated the effect of prophylaxis/scaling instrumentation on implant-abutment metal surfaces, to the best of our knowledge, no studies have investigated if probing around dental implants can damage the implant-abutment metal surfaces and whether probes made of different materials have similar damaging effects. These are important gaps in knowledge that need to be addressed and resolved for better implant care.

Controversy exists as to the material from which the probe should be fabricated. It has been theorized that different metal types (stainless steel, titanium) should not come into contact because of a risk of contamination of the two metals and the resulting galvanic

corrosion that may develop and cause crestal bone loss (Misch 2008). Therefore, it is recommended that only titanium or plastic instruments be used to probe or scale the implant.

We hypothesized that probing around dental implants would alter and possibly damage the implant-abutment metal surfaces and we further hypothesized that different probe material would have a different surface-altering and possibly damaging effects on the implant-abutment surfaces. The main aim of this in-vitro study was to objectively assess the surface changes induced by probing on the apical metal collar of the implant abutment and to compare the differences (if any) in surface changes induced by probes made of different materials. An additional aim was to compare the surface changes induced by probing instruments with the surface changes induced by hand scalers made of different materials.

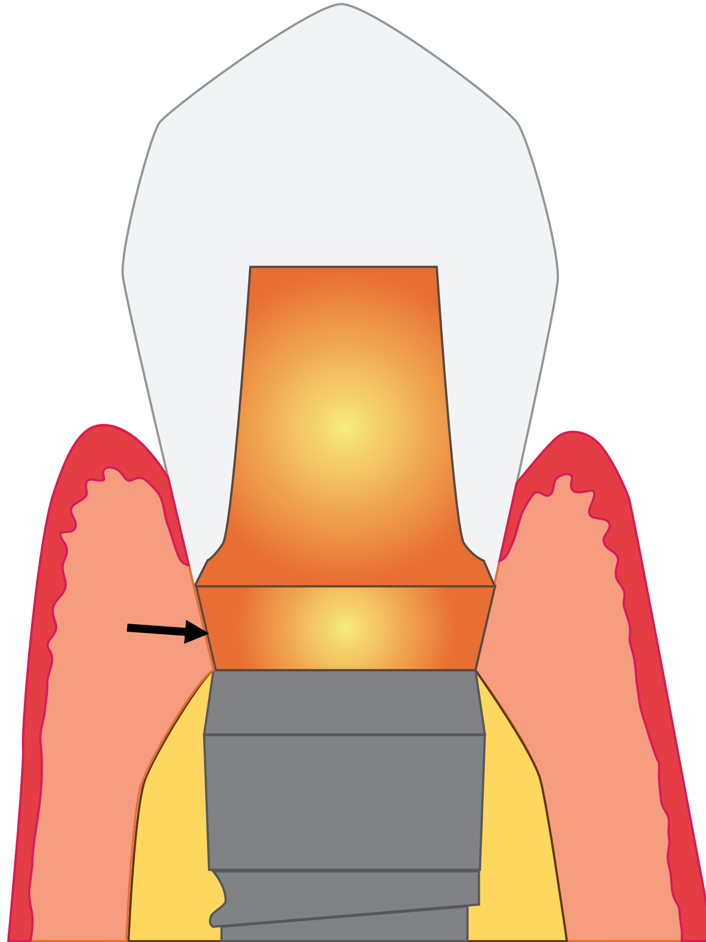


**Fig. 1.** The apical metal collar of the implant abutment. This area (as indicated by the arrow) is vulnerable to surface changes during instrumentation.

## CHAPTER 2- MATERIALS AND METHODS

A total of 14 standard transmucosal 3 in 1, 4.5 mm diameter abutments made of titanium alloy (BioHorizons, Atlanta, GA) were used in this study. Four abutments were used for untreated measures (control) and 10 abutments were used for treated measures (test). Each test abutment was treated in-vitro with 4 different instruments: UNC-15 metal probe (Hu-Friedy, Chicago, IL), Periowise plastic probe (Premier dental, Plymouth Meeting, PA) (Figure 2), metal scaler (McCall SM 17/18, Hu-Friedy, Chicago, IL) and plastic scaler (universal configuration, Hu-Friedy, Chicago, IL) (Figure 3). In preparing the abutments for the study procedures, the abutments were handled by the coronal portion, thus the portion of the titanium surface subjected to test conditions was otherwise untouched.

The coronal rim of each of the 14 abutments was divided into 4 equal sections. A highspeed hand piece and a 557 fissure bur were used to mark the sections in a cross fashion. Each of the 4 delineated sections of the abutment was then color-coded using a different color (black, red, blue and green) Sharpies marker. The abutment collar surface corresponding to the color-coded coronal rim was used for testing. Four of the abutments were randomly selected for baseline (untreated) measures. The remaining 10 abutments were used for instrumentation measures as follows: black dot (plastic probe, PP), red dot (metal probe, MP), blue dot (plastic scaler, PS), and green dot (metal scaler, MS).

To ensure stabilization while instrumenting the abutments, the test abutments were screwed into analogs that were embedded in a 2x2 inch plaster block. Test abutments used for instrumentation were treated with one of the four indicated instruments, one

instrument per each section. The surface of the apical collar corresponding to the marking of the coronal aspect received a standardized treatment of five strokes from the instrument assigned to it (Figure 4). All instrumentations were performed by a single examiner (BF). The instrumentation strokes were performed simulating normal clinical use. This would allow data gathered to have more clinical relevance.

Surface Roughness Measurements: The surface roughness of control and test surfaces was assessed by measuring the average surface roughness ($R_a$) using a contact profilometer. $R_a$ refers to "average surface roughness", which is defined as the arithmetic mean of the absolute values of the profile departures within the sample or evaluation length being measured. Surface roughness ($R_a$) values, (6-12 $R_a$ values per abutment specimen location; with no fewer than 5 separate abutments measured in this fashion for a total of 30-60 $R_a$ value), was measured using a Surfcorder SE 1700 profilometer (Kosaka Laboratory Ltd., Kosaka, Japan). Surface roughness was determined using this contact profilometer under a measuring stylus force of 0.7 mN using a sample length of 0.25 mm and tracing speed of 0.5 mm per second (Figure 5). As depicted in Figure 5, the abutment-analogue assembly was maintained in a fixed orientation with a laboratory vice-grip and fixture which insured a flat orientation of the abutment collar surface in the long (occlusal-gingival) axis or orientation of the assembly. The investigator (SJ) who performed the measurements was blinded in regard to test/control abutment status and was unaware of which instruments were used on which surfaces.

Light microscopy was carried out on several of the treated abutment surfaces at 50x magnification using an optical microscope (Nikon optical microscope interfaced with a UEye digital camera, version 3.1, Imaging Development Systems, Germany) to visualizes

surface irregularities or alterations caused by instrumentation.

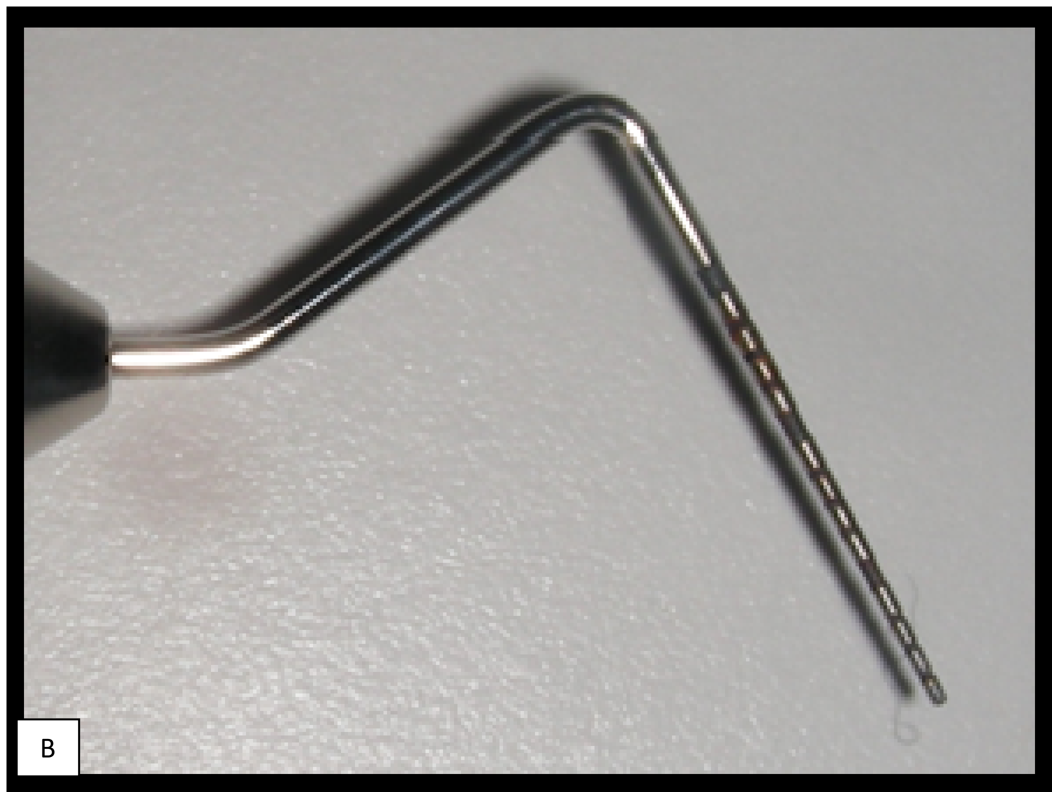



**Fig. 2.** Periowise plastic probe (A), UNC-15 metal probe (B).

**Fig. 3.** Universal plastic scaler (C), McCall SM 17/18 metal scaler (D).

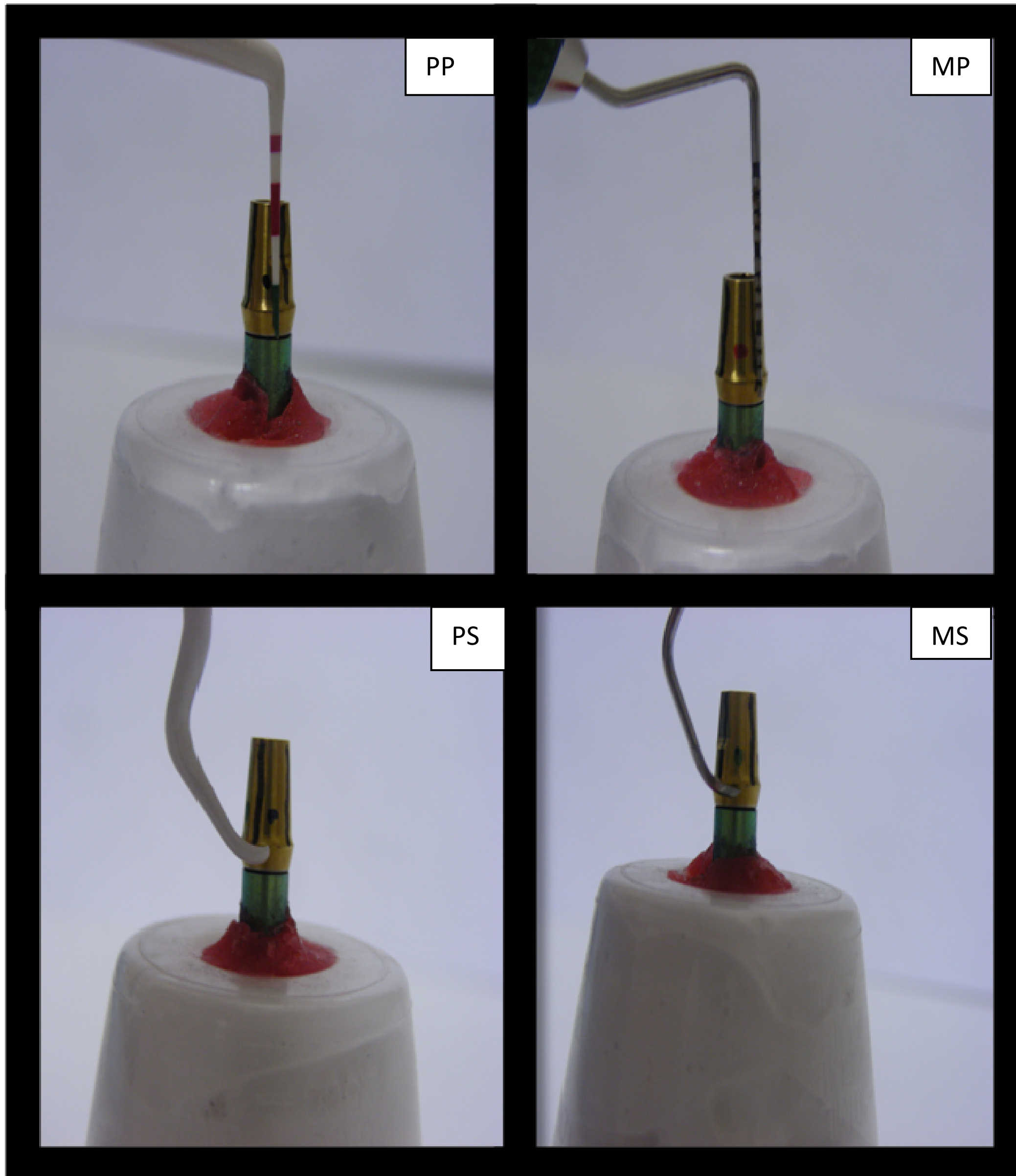
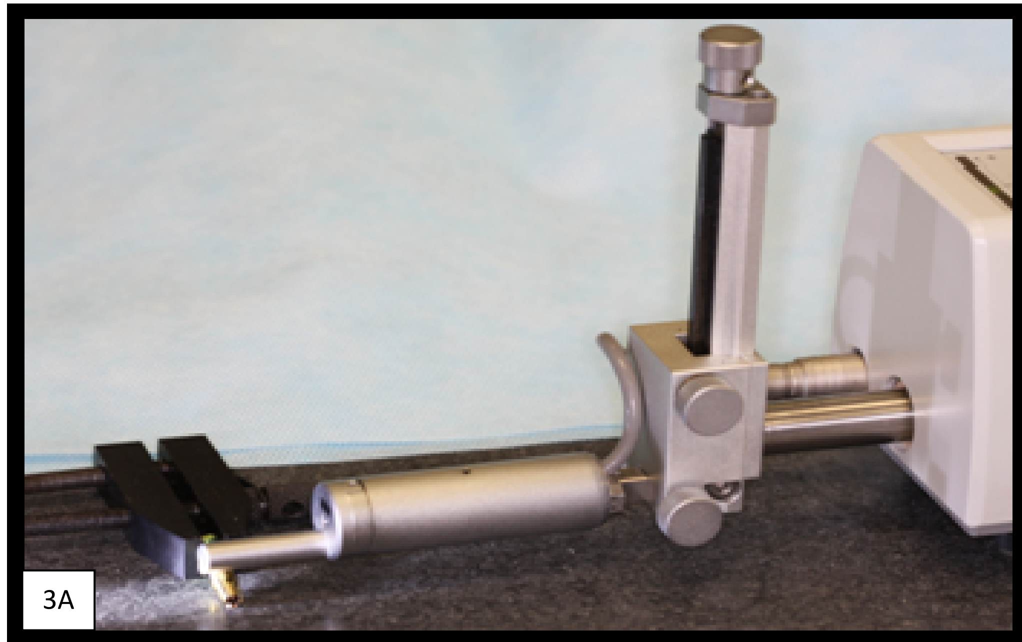



**Fig. 4.** Treatment of abutment surfaces with plastic probe (PP), metal probe (MP), plastic scaler (PS) and metal scaler (MS).



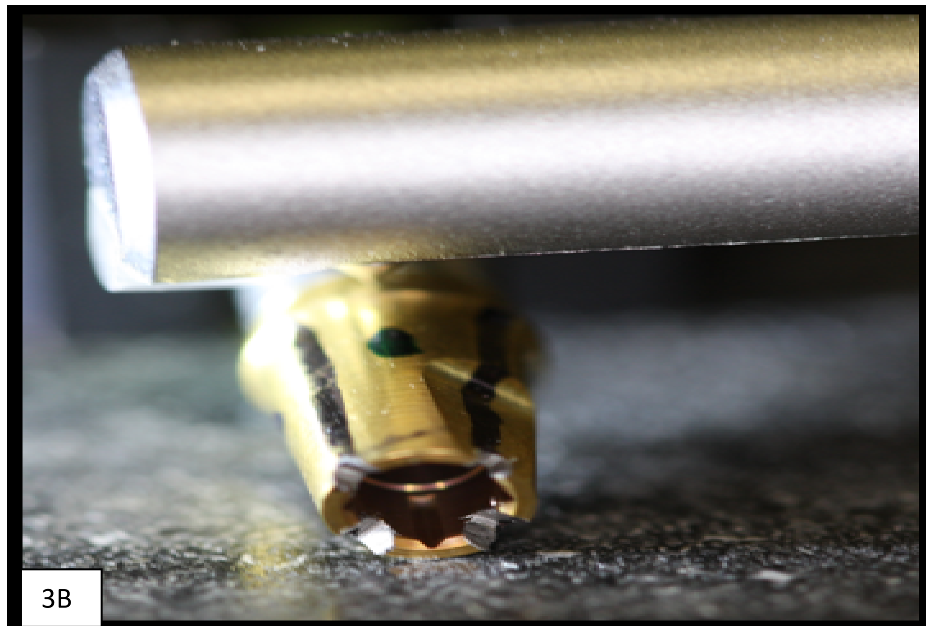




**Fig. 5.** Surfcorder SE 1700 profilometer (3A). Surface roughness was determined using this contact profilometer under a measuring stylus force of 0.7 mN (3B).

### *Statistical Analysis*

Collected data were entered into a personal computer and mean section scores were computed. The unit of analysis used was the computed section scores. JMP statistical package, version 8.0.1 (SAS-INSTITUTE, Cary, NC) was used for the analysis. Analysis of variance (ANOVA) was utilized to compare the differences between the groups. Tukey-Kramer HSD test was used for follow up mean comparisons.

# CHAPTER 3- RESULTS

For test abutments, a total of 10 abutment sections (10 measurements per section) were measured for each instrument used (plastic probe, metal probe, plastic scaler, metal scaler) representing a total of 100 measurements per instrument. For control abutments, a total of 16 untreated abutment sections (10 measurements per section) were measured, representing a total of 160 untreated measurements. For all evaluated sections (test and control), the average of the 10 measurements per section was calculated and used as the section score. Data are summarized in Table 1.

Section scores were used for comparison analysis. ANOVA showed significant differences in surface roughness between the untreated and treated surfaces ($p < 0.0001$) (Figure 6). Add hoc analysis using Tukey-Kramer HSD test showed no statistical differences between untreated measures and metal probe measures. On the other hand, statistical differences were noted between untreated measures with plastic probe measures ($p = 0.05$), plastic scaler measures ($p=0.05$) and metal scaler measures ($p=0.05$). The metal scaler measurements were higher than plastic probe measures ($p=0.05$), and plastic scaler measures ($p=0.05$).

**Table 1.** Average surface roughness (Ra) as determined by the profilometer.

Data presented as the average of 10 measurements per section. The last row presents the total average of measurements for all samples combined.

| Samples | MP | MS | PP | PS | UT |
|---|---|---|---|---|---|
| 1 | 0.6267 | 3.2858 | 1.8016 | 3.2844 | 1.5475 |
| 2 | 0.9809 | 3.1127 | 3.1814 | 1.8431 | 1.1379 |
| 3 | 0.9351 | 4.1604 | 2.1903 | 1.3681 | 0.9316 |
| 4 | 1.1962 | 2.5155 | 2.7858 | 3.3119 | 1.1 |
| 5 | 1.1479 | 2.7351 | 2.4791 | 2.7044 | 1.6445 |
| 6 | 1.0825 | 3.5115 | 1.984 | 2.3941 | 1.5183 |
| 7 | 0.9591 | 2.0753 | 3.1785 | 1.88 | 1.1881 |
| 8 | 0.9306 | 3.5131 | 1.8915 | 1.3494 | 1.1577 |
| 9 | 0.8683 | 4.2713 | 1.201 | 1.1396 | 1.6003 |
| 10 | 1.0312 | 3.1162 | 1.7221 | 2.2476 | 0.95391 |
| 11 | | | | | 1.0797 |
| 12 | | | | | 1.2252 |
| 13 | | | | | 0.95362 |
| 14 | | | | | 1.1851 |
| 15 | | | | | 1.1527 |
| 16 | | | | | 0.54863 |
| Total Average (SD) | 0.97585 (0.15) | 3.22969 (0.68) | 2.24153 (0.65) | 2.15226 (0.77) | 1.18280 (0.28) |

MP- metal probe; MS- metal scaler; PP- plastic probe; PS- plastic scaler; UT- untreated.

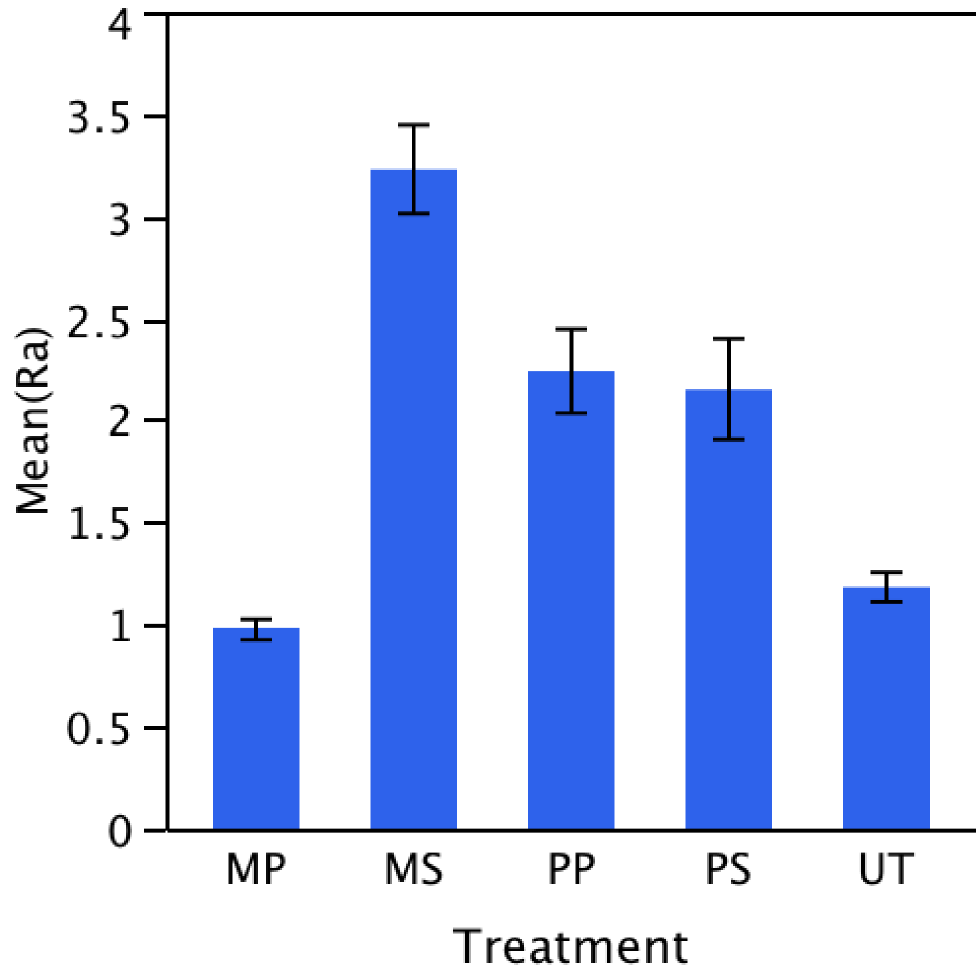



**Fig. 6.** A chart showing average surface roughness (Ra) by treatment; metal probe (MP), metal scaler (MS), plastic probe (PP), plastic scaler (PS) and untreated surfaces (UT). The bars represent average surface roughness (Ra) and the whiskers indicate standard error of the mean. ANOVA showed significant differences between the groups ($p<0.0001$). Follow-up analysis with the Tukey-Kramer HSD test showed no difference in surface roughness between MP and UT, surface roughness of PP and PS were comparable and higher than MP and UT ($p=0.05$), and surface roughness of MS was higher than all other groups ($p=0.05$).

Under the optical microscope (50x magnification), it was evident that the surfaces of untreated abutments were not smooth. Definite machined grooves could be seen circumferentially. It should be mentioned that the track of the profilometer stylus was parallel to the orientation of the grooves resulting from the machining of the abutment. Therefore, the grooves, themselves, had little, if any, contribution to the average surface roughness measures of the abutment surface. Only scratches or surface alterations perpendicular to the grooves and the stylus track would significantly alter or increase the average surface roughness measures, insuring valid measurement of actual hand instrument effects. For the treated samples, those surfaces treated by the metal scaler displayed scratches and surface irregularities after instrumentation (Figure 11). The plastic probe and plastic scaler did not appear to significantly affect the abutment surface although residue created by the instrumentation could be seen on the treated surfaces (Figures 8 and 10, respectively). On the other hand, the metal probe seems to have had limited or no effect on the abutment surface (Figure 9).

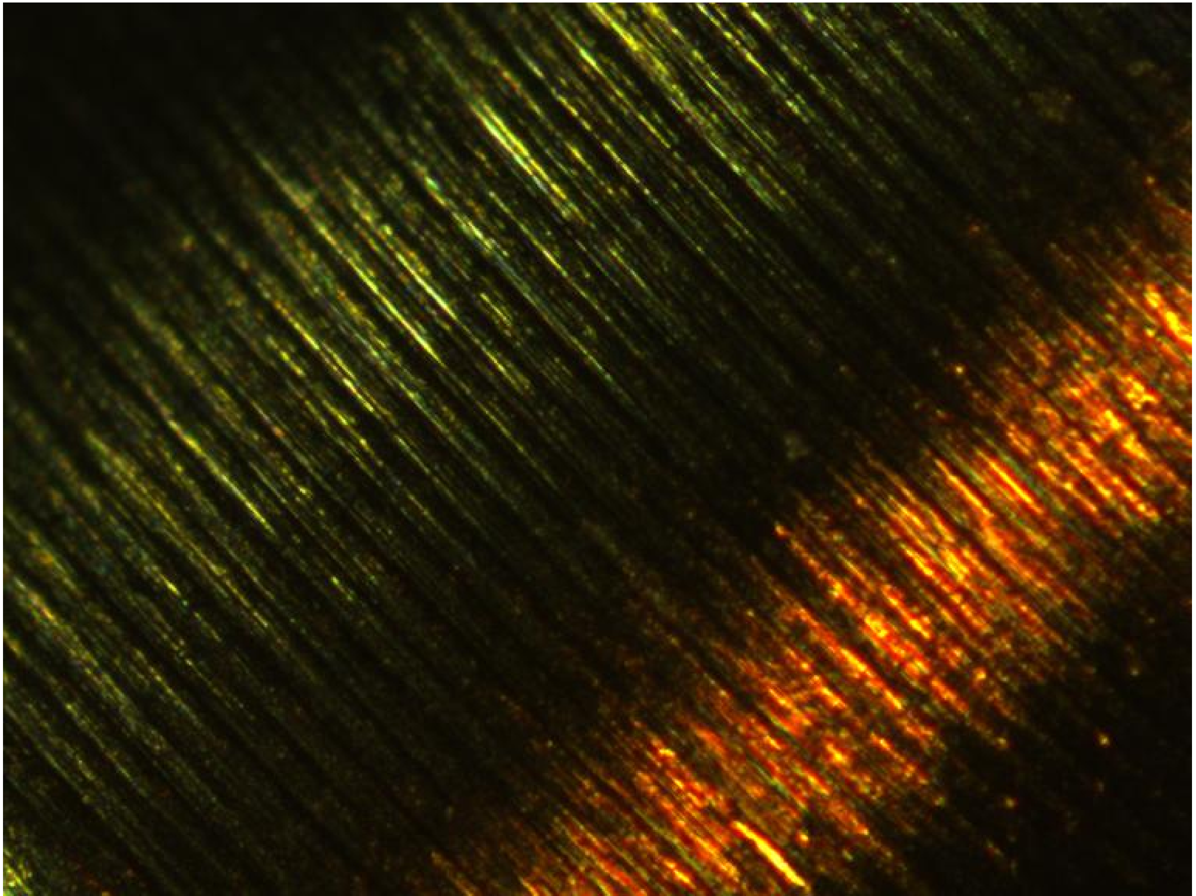


**Fig. 7.** Example of untreated abutment surface (50x magnification). Machined grooves on abutment surfaces are evident.

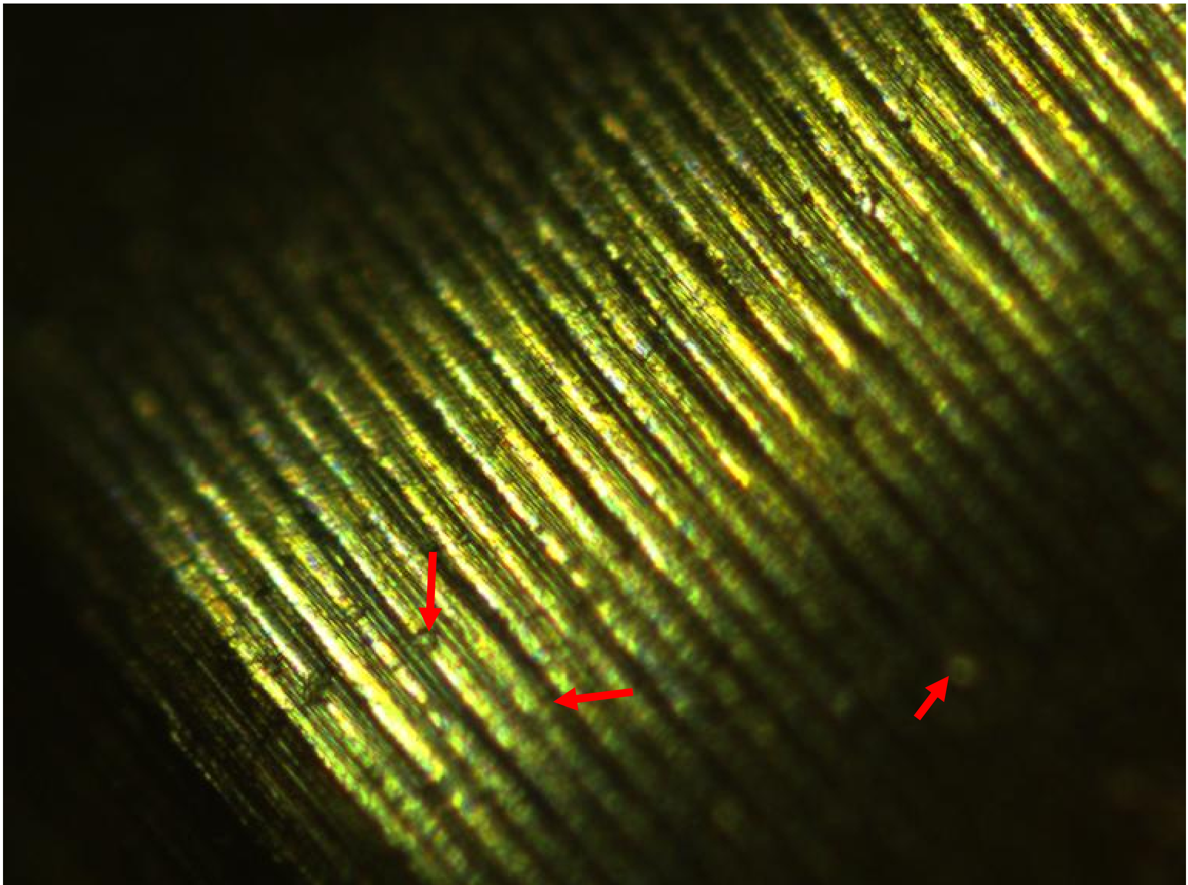


**Fig. 8.** Abutment surface after treatment with plastic probe (50x magnification). Possible residues from plastic probe are evident as indicated by the arrows.

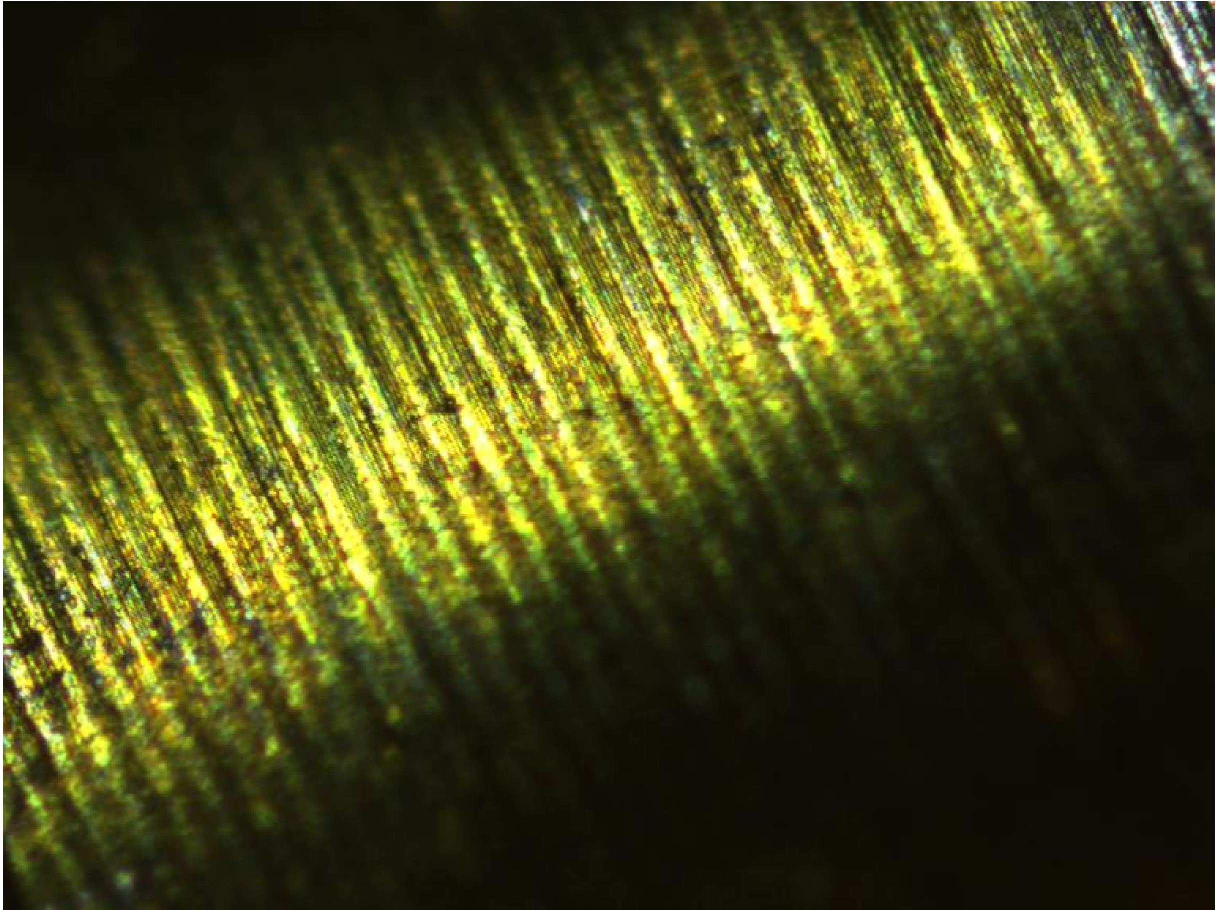


**Fig. 9.** Abutment surface after treatment with metal probe (50x magnification). No apparent surface alteration with the metal probe is noticed.

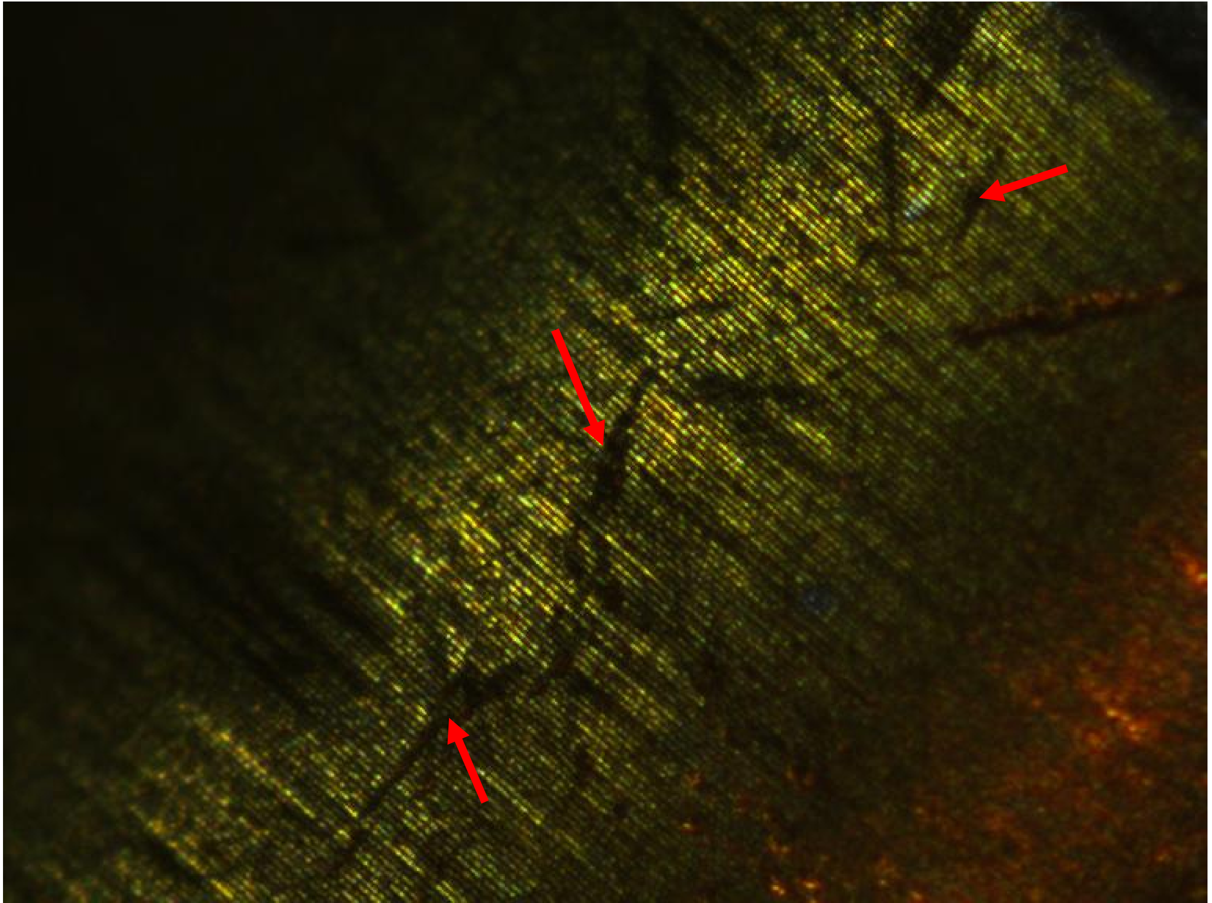


**Fig. 10.** Abutment surface after treatment with plastic scaler (50x magnification). Possible residue and debris from plastic scaler could be seen as indicated by the arrows.

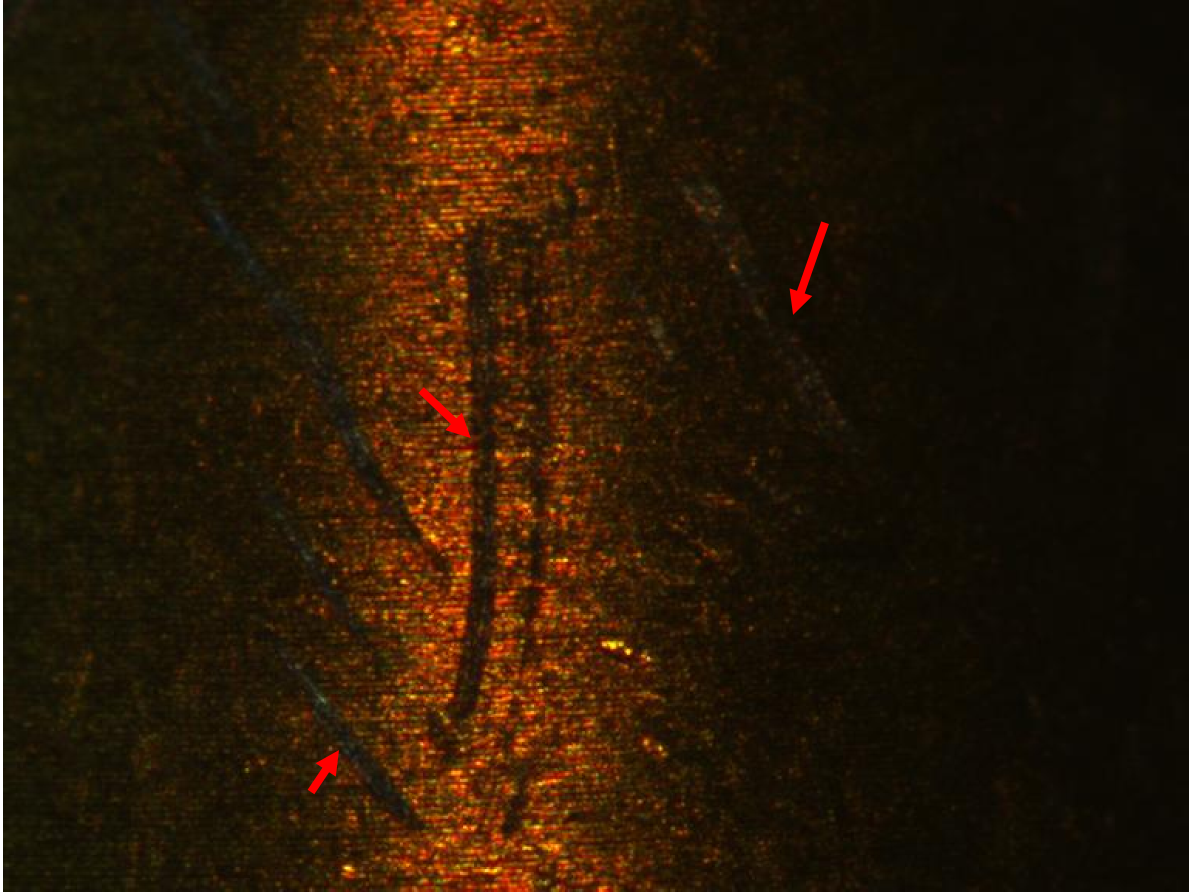


**Fig. 11.** Abutment surface after treatment with metal scaler (50x magnification). Probable surface gouging noticed by the metal scaler as indicated by the arrows.

## SECTION 4- DISCUSSION

Monitoring and maintaining dental implants is essential for long-term implant success. Monitoring dental implants involves periodic probing to assess the integrity of the soft-tissue seal around the implant abutment and the stability of implant-mucosal junction. Maintaining dental implants involves periodic prophylaxis and scaling with various instruments. It is well documented that ailing/failing implants lose the integrity of the mucosal seal, develop increased probing depth and show signs of mucosal tissue inflammation such as swelling and bleeding (Miyasato et al. 1982). It is also well documented that transmucosal implant surfaces build plaque and calculus that potentially would induce tissue inflammation and loss of the mucosal seal integrity around the implant (Lekholm et al. 1986). Thus probing and scaling of dental implants are important for implant maintenance. Unfortunately probing and scaling of dental implants is potentially associated with implant surface damage and the risk of microbial infections and implant failure.

In this study we evaluated in-vitro the effect of probing and scaling instruments on implant abutment surfaces. We also compared the implant abutment surface changes induced by probes and scalers made of different materials. We showed that metal probes had no relevant damaging effect on the abutment surfaces. Both plastic probes and plastic scalers equally induced roughness on the abutment surfaces. Metal scalers induced the most damaging effect and highest surface roughness on the abutment surfaces.

These results may possibly be explained mechanistically based on the following: Clearly the metal scaler, with its sharp, cutting metal blade action, aggressively gouges and

abrades the surface of the metal abutment leaving the abutment surface with deep and broad gouges and scratches (Figure 10). This change in surface morphology caused by the aggressive action of the metal scaler creates a significantly increased surface roughness on the abutment, with an approximate 300% increase in surface and almost twice that of the next more aggressive surface treatment.

The approximate numerical and near-statistical significance of the values for the metal probe treated surface to the untreated surface (Figure 7) may be evidence of the limited action of the blunt and rounded end surface of the metal periodontal probe on the abutment surface. Comparison of the similarity of the magnitudes of the standard deviations between these two groups (and the dissimilarity of these values to the other two treatment groups) lends further support to their statistical equivalence. It may be possible that the rounded point of the metal periodontal probe burnishes the machining grooves on the abutment, thus slightly reducing the surface roughness on the implant abutment surface (Figure 9).

The surprising action of the plastic scaler and plastic probe, by increasing the surface roughness of the abutment significantly above the untreated surface mean roughness values, is somewhat explained by the light microscopy of the surfaces. It appears that the plastic instruments deposit a significant amount of attached plastic particles and debris on the surface of the abutment (Figures 8 and 10). This debris may be firmly attached to the surface of the abutment through both mechanical attachment to the machining grooves on the abutment, but also through electrostatic forces based on charge differences between

the plastic particles and the metal surface. This debris then creates large “positive” artifacts on the surface, thus contributing significantly to surface roughness.

Previously several studies evaluated the effect of prophylaxis and scaling instruments on implant and abutment surfaces. In vitro studies have shown that instruments used to clean teeth caused varying degrees of damage to implant surfaces (Bain et al. 1993, Bain 1998). One study evaluated the effects of scaling a titanium implant surface with metal and plastic instruments in vitro. They reported that plastic instruments produced an insignificant alteration of the titanium implant surface following instrumentation, while metal instruments significantly altered the titanium surface (Fox et al. 1990).

In another study, the surface characteristics produced by various oral hygiene instruments and materials on titanium implant abutments were studied. A total of nine oral hygiene instrumentation methods were used on 10 Branemark titanium abutment cylinders. The authors concluded that the rubber cup with flour of pumice created a smoother surface than the control. In addition, the interdental brush, soft nylon toothbrush, plastic scaler, Eva plastic tip, rubber cup, and Cavi-jet left a surface comparable to the control, whereas the metal scalers and the cavitron created a severely roughened surface (Rapley et al. 1990).

In addition to the studies mentioned earlier, other investigators studied the effects of various hygiene instruments using an electron microscope. The results showed that stainless steel instrument had a gouging effect on the titanium surface, creating a much rougher texture whereas the use of plastic scalers, rubber cup with and without a tin oxide polishing agent, and an air-powder abrasive system all seemed to produce a somewhat

smoother abutment surface. The authors concluded that prophylactic procedures differ markedly in their effect on the titanium abutment surface (Homiak et al. 1992).

Previous studies have also shown that Sonic and ultrasonic scalers with metal tips caused fairly substantial changes to implant surfaces (Stefani et al. 1988). Furthermore, it has been demonstrated that scalers with Teflon-coated, plastic, or carbon tips caused minimal damage to implant surfaces (Ruhling et al. 1994). Such findings from the study confirm previous reports on the damage caused by metal scalers used to debride implant surfaces free of plaque and calculus that accumulate on the surface of the implant which can damage the implant and lead to pocket formation around the implant.

In an SEM study, the cleaning potential of various hygiene instruments were tested on titanium abutments. A total of 25 abutments were subjected to one of the following treatment methods: scaling with metal, plastic, ultrasonic instruments, air-polishing, weekly rubber cup polishing or daily brushing with a conventional toothbrush. The authors were able to show that regular rubber cup polishing and regular brushing resulted in the highest surface cleanliness, while the air-polishing procedure showed the lowest cleanliness score. Hence, it was concluded that taken the present findings and those of other studies concerning the effects of scaling on the surface roughness and biocompatibility into consideration, that plastic scalers may be the instruments of choice for debridement of titanium implant surfaces (Speelman et al. 1992).

**Table 2.** Provides a summary of previous studies discussed and highlights major findings

| **Author** | **Type** | **Instruments** | **Method** | **Findings** |
| --- | --- | --- | --- | --- |
| Fox et al. (1990) | In-vitro | Titanium-alloy tipped curette, curette of stainless steel, plastic curette | Helium neon (HeNe) laser, SEM | Greater roughness was observed for surfaces treated by metal curettes compared to either untreated control surfaces ($p<0.01$) or surfaces treated by plastic curette ($p<0.01$). |
| Rapley et al. (1990) | In-vitro | Rubber cup with flour of pumice, interdental brush, soft nylon toothbrush, plastic scaler, Eva plastic tip, Cavi-jet, metal scalers, cavitron | SEM, Polaroid photomicrographs | Rubber cup with flour of pumice created a smoother surface than control. The interdental brush, soft nylon toothbrush, plastic scaler, Eva plastic tip, rubber cup, and Cavi-jet left a surface comparable to the control. The metal scalers and the cavitron created a severely roughened surface. |
| Homiak et al. (1992) | In-vitro | Stainless steel scaler, plastic scaler, rubber cup, tin oxide slurry, air-powder abrasive | SEM, Light microscopy | Stainless steel had a gouging effect on titanium surface, whereas plastic scalers, rubber cup with and without a tin oxide polishing agent and an air-powder abrasive produced smoother surface. |
| Ruhling et al. (1994) | In-vitro | Ultrasonic scaler (Teflon-coated, stainless steel), sonic scaler (Teflon-coated, stainless steel), light-curette | SEM, Stereomicroscope, Surface profilometry | No discernible damage was caused by Teflon-coated sonic and ultrasonic scalers or implant curettes made of plastic on |

| | | (plastic), Implacare plastic curette, Implarette metal curette, Gracey 7/8 metal curette | | smooth titanium surfaces. |
|---|---|---|---|---|
| Speelman et al. (1992) | Animal study | Metal scaler, plastic scaler, ultrasonic instruments, air-polishing, weekly rubber cup polishing, daily brushing with conventional toothbrush | SEM, Photomicrographs | Regular rubber cup polishing and regular brushing resulted in the highest surface cleanliness, while the air-polishing procedure showed the lowest cleanliness score. |

Our findings support and corroborate the previously reported damaging effect of metal scalers on abutment surfaces. However, our findings conflict with the benignancy of plastic scalers. This may be explained by the different methodologies used for evaluating surface roughness. In our study we used contact profilometry. Most previous studies used SEM and the images were judged for surface roughness by calibrated evaluators. Another possible explanation is the type of implant surface tested. In our study the abutments used had a machined surface. The surface grooves of a machined surface provide resistance when the plastic instrument rubs against them and the generated plastic debris collects in between the grooves. Previous studies may have used implants/abutments with polished surfaces that would eliminate the friction between the plastic material and the metal surface.

# CHAPTER 5- CONCLUSIONS

In conclusion, instrumentations used to check the health of an implant and during its maintenance may produce severe surface damages on the titanium abutment. Probing around implant abutments with a metal probe seems to have no relevant effect on abutment surfaces. In contrast, probing with plastic probes and instrumentation with scalers, particularly metal scalers, may cause adverse surface changes. It is not known if these surface changes have clinical relevance. In other words, the effects such surface irregularities may have clinically on soft and hard tissues are not known. Therefore, further in-vivo studies are needed to investigate these aspects.

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