

## Comparison of the thermal and surface changes of dental implant using rotary instruments and piezoelectric device after implantoplasty: an *in vitro* study

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### Abstract

**Objective:** Peri-implantitis is an irreversible inflammatory reaction in the soft and hard tissues around a functional implant. One of the treatment approaches of this disease include smoothing and polishing the rough surface and removing threads on the implants using rotary instruments, which is called implantoplasty. Clinicians should perform implantoplasty with caution because it may raise the temperature of the implant body as well as the surrounding bone. This study aimed to compare micromorphology and thermal changes obtained with different rotary instruments and piezoelectric device after implantoplasty.

**Methods:** In this *in vitro* study 48 Intra Lock fixture surfaces were processed in 60 seconds with six polishing procedures using 6,12 bladed carbide burs, 90, 30  $\mu\text{m}$  mean-particles-size diamond burs, and piezosurgery inserts OT1 (grain size= 91  $\mu\text{m}$ ) and OP5 (grain size= 30  $\mu\text{m}$ ). These instruments were applied in single or sequences procedures. Variations in temperature were recorded every 5 seconds. The roughness of treated surfaces was evaluated with a profilometer for Ra<sub>1</sub>, Rz<sub>1</sub> (single polish procedures), Ra<sub>2</sub>, and Rz<sub>2</sub> (sequence polish procedures) parameters. Also, surfaces were observed using a field emission scanning electron after each step of implantoplasty.

**Results:** The piezosurgery group showed statistically significant differences with the other two groups (maximum temperature 1.2°C). No statistically significant differences were observed between the carbide and diamond burs regarding the temperature changes and the temperature decreased from the start point in both groups. The mean Ra value in piezoelectric group (1.53 (0.23)) was significantly lower than diamond (2.45 (0.40),  $p<0.05$ ) and carbide (2.10 (0.28),  $p<0.05$ ) groups. Besides, this measure in the carbide group was significantly lower than that of the diamond group ( $p<0.05$ ). Rz<sub>1</sub> value was significantly greater in diamond and carbide groups compared to piezoelectric group. The results revealed significant differences among the three groups concerning Rz<sub>2</sub>. The minimum Rz<sub>2</sub> value was seen in piezoelectric group, while the diamond group showed the highest Rz<sub>2</sub> parameter.

**Conclusion:** This *in vitro* study showed that in suitable cooling conditions, implantoplasty with rotary and piezoelectric devices does not produce excessive heat increases which can damage the soft tissue or bone around the affected implant. The piezoelectric device produced smoother surfaces in single or sequence procedures compared to the burs and can be useful for implantoplasty.

**Key words:** Implantoplasty, Oral implant surface, Peri-implantitis, Piezoelectric device, Rotary instruments, Roughness, Thermal change.

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### Introduction:

Peri-implantitis surrounding oral implants refers

to an inflammatory process influencing the soft and hard tissues, which results in rapid loss of supporting bone and is accompanied with

bleeding and suppuration (1-3). Peri-implantitis is detected in 28-56% of the patients and 12-43% of the implants (4-6).

This disease can be caused by the status of the tissue surrounding the implant, implant design, degree of roughness, external morphology, and excessive mechanical load (7). The strains related to the periodontal disease are similar to those causing peri-implantitis (8, 9). The risk factors for peri-implantitis include history of periodontitis, genetics, smoking, alcohol consumption, diabetes, dental plaque, poor oral hygiene, and the depth of peri-implant pocket, implant prosthesis connection and the surface roughness of the transmucosal component of an implant (10-13). The factors which affect the bacteria's adhesion and composition of oral implant surfaces in both supra and subgingival environments include microbial population, salivary flow, salivary pellicle, and physical-chemical characteristics of the titanium surface, with morphology and roughness being the most important one (10, 14, 15).

Peri-implantitis does not respond effectively to nonsurgical therapy (16). Various surgical methods have been proposed for management of peri-implantitis with some success; however, no single method can be promoted based on the current evidence. Surgical procedures are categorized into two groups of regenerative and resective procedures (17, 18). Regenerative therapy aims to eliminate the bone defect around the implant by GBR-technique using bone and/or bone substitution. On the other hand, the goal of the respective therapy is "pocket elimination" by adapting the peri-implant soft tissue to the level of the bony defect (19, 20). Reduction of bacterial plaques ability to adhere to the implant surface should be taken into account, as well. This can be achieved through implantoplasty which is defined as smoothing and polishing the rough surfaces or eliminating the threads on the implants using rotary instruments (11). Clinicians should perform

implantoplasty with caution because it may raise the temperature of the implant body as well as the surrounding bone. The threshold temperature inducing cortical bone necrosis is 47°C for 1 minute (21). Only one study has investigated the thermal changes during implantoplasty. That study reported minimal thermal changes for diamond and carbide burs (11). Heat is also produced when preparing titanium abutments using tungsten burs eventually affect the surrounding bone (22). The generated heat can be influenced by bur type, working time, pressure, revolution per minute (rpm), and the turbine properties (11). In general, two types of dental burs are usually used; carbide and diamond (18).

On the other hand, piezoelectric device uses ultrasonic vibration and is beneficent since it prevents damage to the soft tissue and does not always need flap surgery. In addition, it requires much less force for a cut in comparison to the rotational burs. Moreover, because of the minimum heat produced while cutting, the vitality of the beside tissue is preserved (23, 24). Nevertheless, although the exposed surfaces have to be treated, little data is available about what thermal changes and surface modifications occur at the implant after implantoplasty. Also, no studies have been conducted on the use of a piezoelectric device in this procedure. Therefore, the present study aims to compare micromorphology and thermal changes obtained with different rotary instruments and piezoelectric device after implantoplasty.

## Methods:

In the present experimental, *in vitro* study, the researchers made use of 12 commercially available dental implants with a rough surface created by sandblasting and acid etching procedures (Intralock Implants Boca Raton, Florida USA). The surface of each implant was divided into 4 parts by thin vertical grooves

every 90 degrees and, consequently, 48 surfaces were obtained for implantoplasty.

Two diamond burs (SS White, New York, USA), round end tapered (grain size=90 µm and 30 µm), and two carbide burs (SS White, New York, USA), round end tapered (6 blades and 12 blades), were selected for the study. The Kavo turbine was powered at 20000 rpm (revolutions per minute) with a water flow of 25 ml/mm (KaVo, Germany) Piezosurgery device (Mectron, Italia) was at 24.000 Hz frequency and bone mode with delivery rate of the peristaltic pump 15-100 ml per min.

Piezosurgery inserts OT<sub>1</sub> (grain size= 91 micrometer) and OP<sub>5</sub> (grain size= 30 micrometer) were used in this study. Overall, 3 polishing procedures in two steps were considered and each method was applied on 16 surfaces. . Dental burs, piezosurgery tips, and the corresponding groups of polishing procedures are listed in Table 1. Temperature changes were measured using diamond bur, round end tapered (grain size= 90 µm), carbide bur, round end tapered (6 blades) and piezosurgery insert OT<sub>1</sub> (grain size= 91 micrometer).

**Table 1- Polishing procedures and their codes**

Polishing procedures			
Code	Specimens	Polishing procedures	Burs/piezo insert
1	Fixture	Single bur (first step)	Carbide/6blade
2	Fixture	Single bur (first step)	Diamond/90µm
3	Fixture	Single insert (first step)	OT1/90 µm
4	Fixture	Burs sequence (second step)	Carbide/6+12blad
5	Fixture	Burs sequence (second step)	Diamond/90+30 µm
6	Fixture	Inserts sequence (second step)	OT1/OP5/90+30 µm

Two vertical arms were fixed to a wooden plate and the turbine or piezosurgery was immobilized on one of the adjustable horizontal arms. An implant was also fixed to the other horizontal arm which allowed movement of the implant in

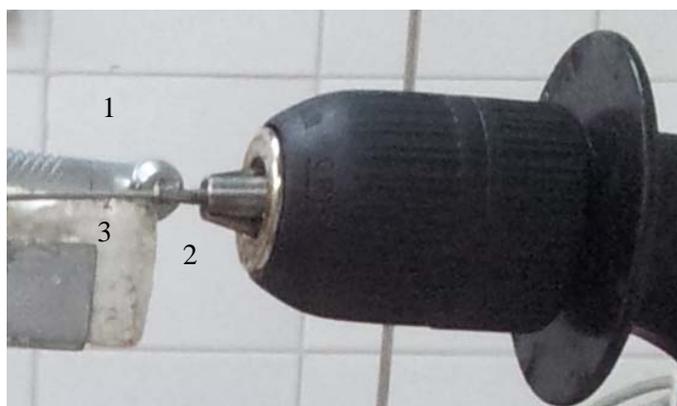
all directions. A 100 g weight was connected with dental floss close to the implant to exert a constant force on the dental bur during the drilling procedure (Figure 1).



**Figure 1- Experimental design: (1) plate: (2) piezoelectric handpiece secured to arm: (3) manageable arm holding the implant: (4) 100 g pressure weight**

In fact, this specific weight was selected since it is known as the average pressure exerted clinically on a tooth, measured at the bur tip (11). The bars were adjusted such a way that the active part of the drill contacted the implant during the tests. The thermo coupler electrode (testo 645, Germany) was put in the coronal dental implant canal and isolated by a piece of composite material (Figure 2). A thermo coupler is a sensor for measuring temperature. It consists of two dissimilar metals, joined at one end. When the junction of the two metals is heated or cooled, a voltage is produced that can be

correlated back to the temperature. Unit of temperature measurement was Celsius. The turbine or piezosurgery was placed in an idle status. In addition, the thermocouple was set on until the temperature reading was stabilized (starting point). Immediately after that, every section of the implants was drilled for 60 seconds under abundant water cooling and applying brushing-like crossing (coronoapically) movements and the temperature was determined by the thermocouple every 5 seconds. Also, bur or piezosurgery insert was changed every two minutes.



**Figure 2- Experimental design: (1) turbine secured to the fixed arm; (2) implant connected to a manageable arm; and (3) thermocouple electrode wired to the implant**

After polishing, the implants were removed from the holder and analyzed for roughness and morphology. For each section, two linear parallel roughness measurements at a distance of 2.00 mm were performed with a profilometer (Hommel Werke, Schweningen, Germany).  $R_a$ , which refers to the arithmetic mean of the departure of the profile from the mean line, and  $R_z$ , defined as the average of all peak-to-valley heights in the assessment length, roughness parameters were recorded. It should be mentioned that  $R_a$  is the most common parameter for roughness measurement. The mean of the 2 linear parallel roughness measurements were calculated and these values were used for statistical analysis.  $R_{a1}$  and  $R_{z1}$  parameters were used to measure the roughness

of the first step (for single polishing method). Then, the implants were placed on aluminum foil by a carbon adhesive tape and observed using a field emission scanning electron microscope (FESEM) (S4160, Hitachi, Japan) at 20 KV through a secondary electron detection mode. Afterwards, the implants were fixed on the bar and the surfaces were re-treated using bur sequences. Measurement of  $R_{a2}$  and  $R_{z2}$  (for sequence polishing method) and FESEM observations were carried out in this step.

Average roughness and temperature changes between the three groups over time were analyzed using Repeated Measures ANOVA. Then, Post Hoc Tukey Test was used in order to determine the intergroup differences. Besides,  $p < 0.05$  was considered as statistically

significant.

**Results:**

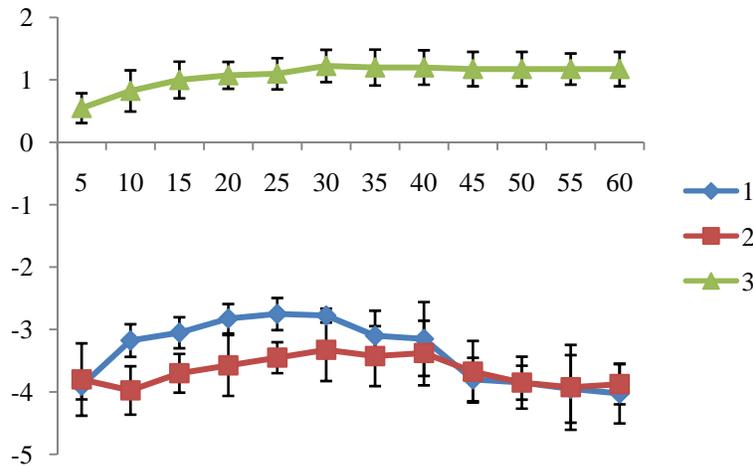
At first the temperature was measured and then, temperature changes were calculated at any time relative to the initial reference. Based on the results of Repeated Measures ANOVA, the temperature trends were similar in three groups; in other words no significant interaction effect was observed between the three groups over time ( $p=0.072$ ). On the other hands a significant difference was found between the three groups regarding the overall mean temperature changes relative to the base line which is called the group effect ( $p=0.001$ ). Regardless of the three methods, a significant difference was detected between the three groups concerning the average temperature changes over time which is the time effect ( $p=0.006$ ).

When using diamond and carbide burs, first, a

temperature decrease of 3.9 °C from the baseline was observed and the temperature remained below the baseline value throughout the 60-second test period. After a few seconds, the temperature began to rise and after 45 seconds, a decrease was seen and the temperature remained negative and stable until the end of the polishing. (Diagram 1).

During piezoelectric device application, the temperature increased from the baseline. In the 30<sup>th</sup> second, increase of temperature reached 1.2 °C and remained stable and positive until the end of the polishing (Diagram 1).

Based on multiple comparison Tukey test, a statistically significant difference was found between the piezoelectric group and carbide ( $p=0.003$ ) and diamond ( $p=0.002$ ) groups; however no significant differences were observed between diamond and carbide groups at all times points.



**Diagram1- Temperature changes for the different instruments tested, (1: Diamond- mean, 2: Carbide- mean, 3: Piezoelectric- mean)**

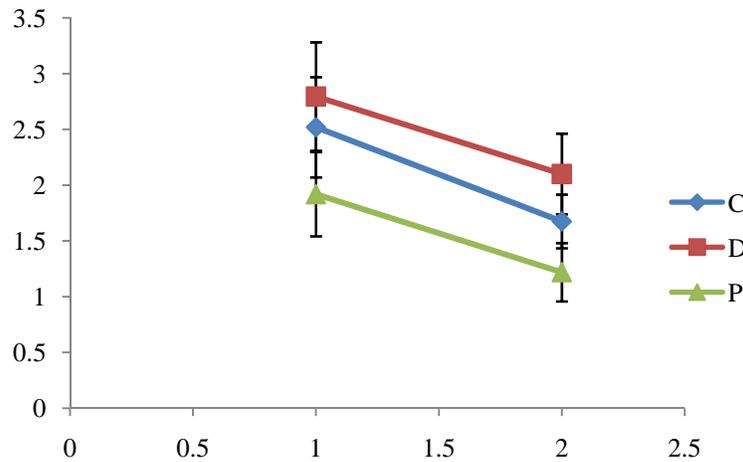
Considering Ra, no interaction was found between the methods and groups. In other words, the average changes of Ra after polishing were similar in the three groups ( $p=0.494$ ) (Diagram2)

Overall, the polishing procedures effectively reduced the average roughness parameter (Ra) in

the three study groups. Mean Ra<sub>1</sub> (2.41 (0.57)) of the total sample was significantly higher than the mean Ra<sub>2</sub> (1.66 (0.46)) ( $p<0.001$ ).

Furthermore, the study results revealed a significant difference among the three groups regarding the mean of Ra ( $p<0.001$ ). The results of Tukey's test also showed that the mean value

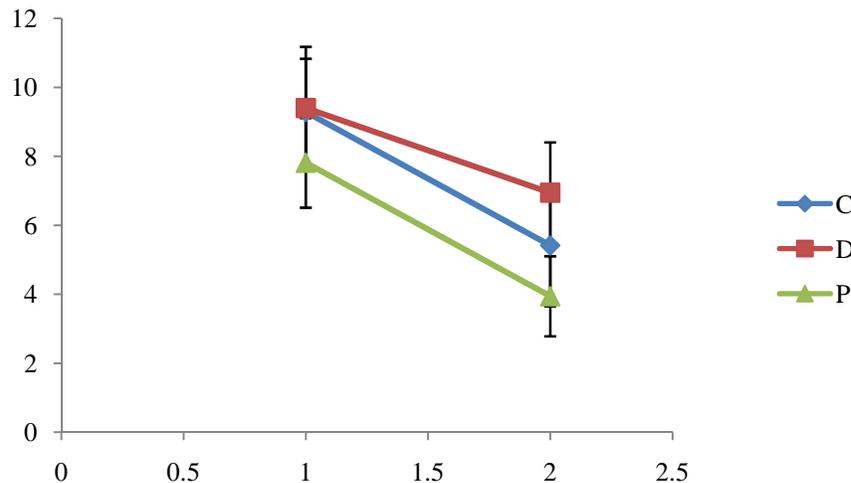
in the piezoelectric group (1.53 (0.23)) was significantly lower than that of the diamond (2.45 (0.40),  $p<0.001$ ) and carbide (2.10 (0.28),  $p<0.001$ ) groups.



**Diagram 2- Mean Ra changes during sequence polish procedures (C= Carbide group, D= Diamond group, P= Piezoelectric group, 1=Ra<sub>1</sub>, 2=Ra<sub>2</sub>).**

Besides, this measure was significantly lower in the carbide group compared to the diamond group ( $p=0.008$ ). Comparison of the mean of Rz in the three groups and the two polishing procedures

revealed an interaction effect between the methods and groups ( $p=0.005$ ). This means that the mean differences of Rz<sub>2</sub> were not similar in the three groups. Thus, subgroup analysis was used for comparison (Diagram 3).



**Diagram3- Mean Rz changes during sequence polish procedures (C=Carbide group, D=Diamond group, P=Piezoelectric group, 1=Ra<sub>1</sub>, 2=Ra<sub>2</sub>).**

No significant differences were found between carbide and diamond groups regarding Rz<sub>1</sub>

( $p=0.977$ ). However, this value was significantly greater in diamond and carbide groups in

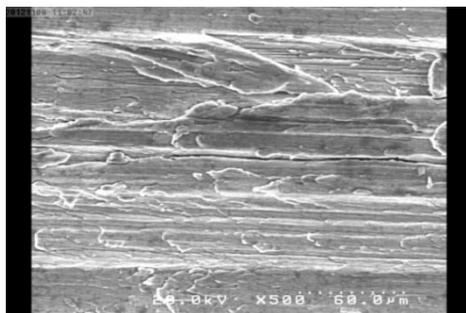
comparison to the piezoelectric group ( $p=0.016$ ,  $p=0.027$ , respectively). On the other hand, significant differences were observed among the three groups concerning  $Rz_2$ . The minimum  $Rz_2$  value was seen in the piezoelectric group, while the diamond group showed the highest  $Rz_2$  parameter.

Table 2 shows mean and standard deviation of  $Ra_1$  and  $Rz_1$  roughness parameters obtained from single bur or piezosurgery insert treated surfaces. Figures 3a, 4a, and 5a show the intended aspect of the surfaces.

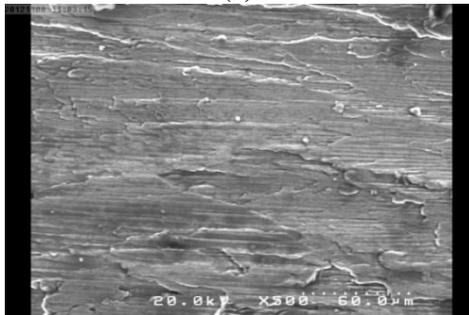
Table 3 shows mean and standard deviation of  $Ra_2$  and  $Rz_2$  obtained from the surfaces treated with instruments sequences. Figures 3b, 4b, and 5b show the aspect of the surfaces polished with the sequence of the instruments.

**Table 2- Roughness parameters in single polish procedures**

Code	$Ra_1$ (SD)	$Rz_1$ (SD)
1	2.519 (0.4490)	9.288 (1.5444)
2	2.794 (0.4864)	9.400 (1.7780)
3	1.919 (0.3781)	7.813 (1.2997)

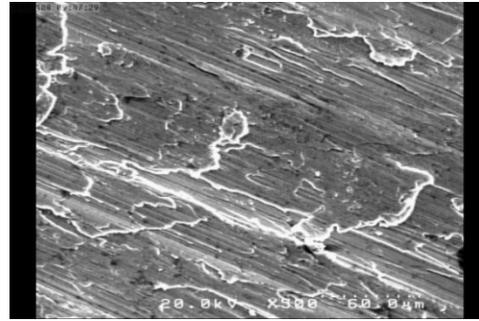


(a)

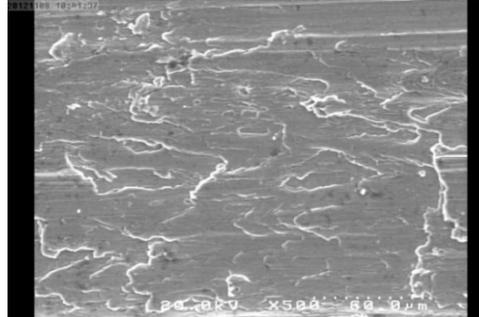


(b)

**Figure 3- Sequence of polishing with carbide burs. (a) 6 blades Carbide bur; (b) 6 blades+12 blades burs. Original magnification X500.**



(a)



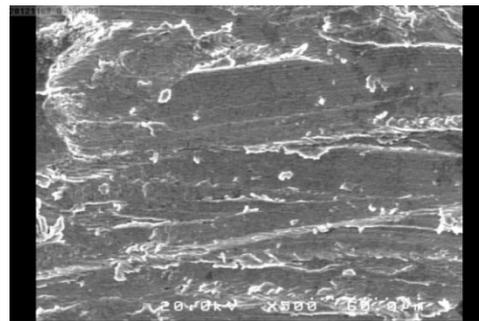
(b)

**Figure 4- Sequence of polishing with diamond burs. (a) 90 micrometer particle size diamond bur; (b) 90+30 particle size burs. Original magnification X500.**

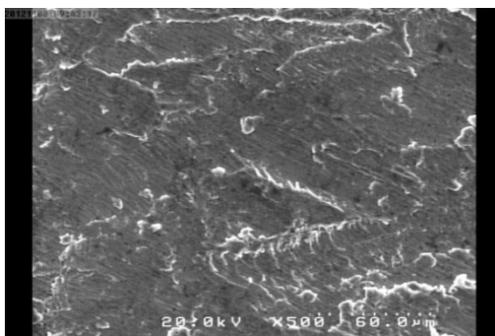
**Table 3- Final roughness parameters in sequence polish procedures**

Code	$Ra_2$ (SD)	$Rz_2$ (SD)
4	1.675 (0.2408)	5.413 (1.7561)
5	2.100 (0.3615)	6.944 (1.4633)
6	1.219 (0.2613)	3.944 (1.1627)

In the FESEM overview image (500-magnification), the single burs produced surfaces which were affected by waviness (Fig.3a and 4a). However, the effect of the waves was decreased by using bur sequences (Fig.3b and 4b).



(a)



(b)

**Figure 5- Sequence of polishing with piezoelectric inserts. (a) 90 micrometer particle size (b) 90+30 particle size. Original magnification X500**

### Discussion:

In the present study, no statistically significant differences were observed between the carbide and diamond burs. In the beginning, due to water pressure and air of the turbine, a considerable decrease was detected in the temperature in both groups. During the experiment, because of the drill contact while smoothing the threads, the temperature increased (carbide burs and diamond burs: 0.4°C and 1.2°C, respectively). At the end of polishing, however, because the surface had become smooth, temperature dropped.

The piezosurgery group showed statistically significant differences with the other two groups and its maximum temperature rise was 1.2°C which remained stable until the end of the process. This is due to the nature of the ultrasonic device and the lack of air pressure. One of the major benefits of using piezoelectric device in this treatment is no need to flap.

Implantoplasty is a clinical challenge due to it may raise the temperature. Heat may possibly have a negative impact on the bone and tissue nearby the implant. Heat shock at 42°C made temporary changes in osteoblasts (25).

Nevertheless, only one study has examined temperature variations during plastic implantoplasty.

Sharon *et al.* demonstrated efficiency and

thermal changes during implantoplasty in relation to the bur type) carbide and diamond) and concluded that selecting a proper bur could reduce the working time. That study also showed that implantoplasty under appropriate water spray conditions resulted in only minor thermal changes (1.5°C) and could be considered as a safe procedure (11).

Ormianer *et al.* showed that during the setting of the autopolymerizing acrylic resins applied directly to an implant abutment, a mean maximum temperature increase of 4 to 5 °C was detected in the implant-bone interface (26). One study also showed an abutment reduction with medium grain diamonds was raise interface-temperature (1°C) (22). It was found that the temperature of the dental implant and the surrounding bone could be affected by a change in mouth temperature due to hot food or drinks (27). Therefore, according to the mentioned studies, there is a relationship between the temperature in the coronal part of and the bone surrounding the implant.

Due to technical problems in this study, the thermocouple was placed in the coronal canal of the implant. Yet for further simulation of oral conditions, future studies are recommended to measure the temperature changes in the implant bone interface.

When pre-implantitis occurs, the titanium surface is exposed in the oral cavity and is covered by bacterial plaque. Therefore, polishing of the exposed surface in the oral cavity is recommended in the treatment of periimplant disease for avoiding re-infection and facilitating oral hygiene procedures. Microbial adhesion to biomaterials is related to factors, such as surface-free energy, chemical composition, and material surface irregularities. Moreover, the effect of surface roughness on plaque accumulation is more important in comparison to surface-free energy. Bacterial adhesion cannot be further decreased below the accepted roughness threshold; i.e., 200 nm (10,

28).

The compounds used for decontamination of the implant surface include 10% hydrogen peroxide, Teflon or titanium coated curettes, abrasive sodium carbonate air-powder, surgical gauzes soaked in saline, metronidazole gel, tetracycline hydrochloride solution, air-powder abrasive alone or in combination with CO<sub>2</sub> laser irradiation, ultrasonic instruments, and rotating rubber cup under chlorhexidine irrigation (24).

The present study investigated the micromorphology of the implant surface after polishing of the titanium surface of Intra Lock implants. The study demonstrated that it is possible to polish the implant surface using burs and piezoelectric inserts during a clinical procedure. However, implantoplasty with piezoelectric device produced more homogeneous surfaces with lower roughness. In general, polishing depends on many factors, such as time, pressure, design, size, and number of the blades, and grit size as well as the sequence of the burs (14). In this study, a wavy effect was observed on the surfaces polished by the carbide and diamond burs, which might be due to the burs' ability to cut large pieces of titanium. These waves are probably the cause of the greater dispersion of Ra and Rz data in these groups.

Spherical burs work on a minimal surface in the region of the apex due to their geometric property. On the other hand, tapered shape burs maintain a contact surface to the implant, which explains their better cutting action. Such burs are also able to plane the surfaces even in the presence of narrow inter space.

Romeo *et al.* Showed that the respective therapy accompanied by implantoplasty positively affected the implant survival as well as the clinical parameters of preimplantitis, including probing depth, sulcus bleeding, and suppuration (1). Another study reported two cases in which the implants developed localized peri-implantitis lesions. In order to remove the surface

contamination, implantoplasty followed by topical tetracycline was used together with guided bone regeneration. In both cases, the procedures were successful in arresting the disease and rebuilding the bone defect (30). In a randomized controlled trial, implantoplasty was used in addition to regenerative surgical procedures. However, the method of surface debridement and decontamination (ER: YAG laser versus plastic curettes+ cotton pellets+ sterile saline) had no significant effects on the clinical outcomes six months and two years after the treatment (31, 32).

Rimondini *et al.* (2000) evaluated, *in vitro*, the effectiveness of diamond and carbide burs, and bur sequences to remove the plasma-sprayed titanium coating from fixture surfaces. A roughening effect of the 8 µm mean-grit diamond bur and 30 bladed burs were noted. The most effective titanium plasma sprayed removal were obtained by 30 µm and 15 µm mean-particle-size diamond burs, and carbide 12 plus 16 bladed burs used in sequence (14). Blade number and diamond particle size of burs were different with our study and the procedure was done manually that all of them impact on the results.

Unursaikhan *et al.* (2012) compared roughness of titanium surfaces treated by different hygiene instruments. The equipment included a piezoelectric ultrasonic scaler with a newly developed metallic tip (NS group), a piezoelectric ultrasonic scaler with a conventional tip (CS group), a piezoelectric root planer ultrasonic scaler with a conventional tip (PR group), and a plastic hand curette (PH group). Scanning electron microscopy analysis showed no significant changes in the titanium surfaces in the NS and PH groups. All CS and PR sites lost their original texture and showed irregular surfaces. The roughness values (Ra and Rz) of the titanium surfaces increased in all, except the PH and NS groups (33).

Meier *et al* compared different rotary

instruments for their effectiveness and efficiency to smoothen micro-rough implant surfaces. Irrespective of the drill design (spherical or conical) all rotary instruments showed obvious variations in processing times as well as significant differences of Ra and Rz values. The processing time required did not correlate with the roughness values. Compared to spherical carbide cutters with transversal grooves, the conical cutters had the lowest mean roughness values (<1 micron) (19). Carbide rotary burs used in this study were spherical or conical with special blades design that was different from our study.

One of the implantoplasty disadvantages is that it can produce small granules and create a tattoo-like side effect. Moreover, the granules may contribute to aerosol formation with potentially harmful effects.

### **Conclusion:**

This *in vitro* study showed in suitable cooling conditions, implantoplasty with rotary and piezoelectric devices does not produce excessive heat increases which can damage the soft tissue or bone around the

affected implant. Also when carbide and diamond burs were applied in sequence procedures during implantoplasty, they could create implant surfaces with acceptable roughness. On the other hand, piezoelectric device produced smoother surfaces in single or sequence procedures in comparison to the burs.

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### **Conflict of Interest: “None Declared”**

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