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A Comparison of Heat Generated Between Carbide and Diamond Bur during Implantoplasty

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A Comparison of Heat Generated Between Carbide and Diamond Bur during Implantoplasty

by

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Each person whose signature appears below certifies that this thesis in his/her opinion is adequate, in scope and quality, as a thesis for the degree Master of Science.

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ABSTRACT

Purpose: This study was conducted to evaluate heat generated during the implantoplasty procedure by comparing the heat generated using either a carbide or diamond round bur. . **Materials and Methods:** Bovine ribs were selected as the osseous model for this study. Changes in temperature were measured using a digital thermometer (Extech SDL200 four channel thermometer, Extech instruments, Melrose MA). Ther k-thermocouples were positioned within the implant screw access, apex of the implant, and crestal bone adjacent to the implant and ambient air. 5 bovine rib bone blocks were prepared by place 5 cylindrical titanium grade 5 alloy large grit sand blasted acid etch (SLA) non-self tapping implants (Sydent Astral 4.2x10mm) into the prepared osteotomies with an insertion torque of 30Ncm. Implants were placed in a final position of 6mm depth leaving 4mm of surface treated implant threads exposed above the crest of bone. A total of 25 implants were placed in 5 bone models. Implantoplasty was performed using an electric high-speed rotary handpiece (Bien Air, 200,000rpm) with a carbide and diamond round bur (Brassler 8 FG surg carbide and Brassler FG surg course diamond). Each implant was divided in half along its long axis. On one half of the implant, group 1, the implantoplasty was performed with a new carbide round bur using constant irrigation of 23°C. In group 2, implantoplasty was performed on the remaining half of the implant using a new course grit diamond bur. Implantoplasty was considered complete once all the exposed implant threads and SLA treated surface was removed. Using IBM SPS 26 (Armonk, New York, United states), descriptive statistics including mean and standard deviation were calculated. A paired t-test and one-way ANOVA test was used evaluate results. **Results:** In group 1, a mean change of temperature inside the screw access of

2.06°C with a standard deviation (SD) of ± 8.71°C, crestal bone adjacent to the implant had a mean change of -6.10 ± 3.19°C SD, and the apex of the implant had a mean change of -0.67 ± 0.34°C. For group 2, implantoplasty resulted in a mean change in temperature inside the screw access of 19.06 ± 11.38°C, crestal bone adjacent to the implant had a mean change of -3.56 ± 2.61°C, and the apex of the implant had a mean change of -0.55 ± 0.66°C. Mean difference between group 1 and group 2 of 16.99 ± 14.09°C inside the screw access, a mean difference 2.53 ± 4.25°C in the crestal bone adjacent to the implant, and a mean difference of 0.12 ± 0.68°C SD at the apex of the implant. A statistically significant increase in temperature was observed in the crestal bone adjacent to the implant and within the screw implant when implantoplasty was performed using a diamond round bur at a p-value < 0.01. No statistically significant difference was found at the apex of the implant in either carbide or diamond group with p-value = 0.38. Temperature was highest within the implant during implantoplasty. The peak temperature within the implant of both groups are illustrated in figure 3. In the carbide group, the mean peak temperature difference -3.04 ± 5.74°C while in the diamond group the mean was 4.91 ± 10.02°C (table 2). The temperature increase within the implant was statistically significantly greater in the diamond group with a mean of 8.32 ± 11.91°C at p-value <0.0. The time to reach peak temperature was measured within the implant screw access. The mean time to peak temperature was 20.48± 8.36 seconds for the diamond group and 19.96± 5.25 seconds for the carbide group. There was no statistical significant difference between groups for time to peak temperature within the implant screw access. **Conclusion:** A statistical significant increase in temperature was observed within the implant screw access and crestal bone adjacent to the implant when implantoplasty was performed with a diamond bur. No significant change in temperature was observed at the apex of the implant in either the carbide or diamond group. From this study, it was concluded that implantoplasty is performed using constant irrigation results in minimal increase in bone temperature. The cooling effect of constant irrigation is adequate to prevent the transfer of heat into the bone that could raise bone temperature to a critical level resulting in bone necrosis. When diamond burs were used to perform implantoplasty there was significantly more heat produced than carbide burs but neither resulted in a critical increase in bone temperature. It is concluded that when implantoplasty is best performed using constant irrigation and a carbide round bur to minimize heat production and reduce risk to the adjacent peri-implant bone.

CHAPTER 1

Introduction and Literature review

Dental implants are a predictable and reliable method of restoring edentulous and partially edentulous ridges to improve patient comfort, esthetics, and function. It has been shown, the prevalence of peri-implantitis to be as high as 22%(1). Peri-implantitis is a destructive inflammatory condition that affects the connective tissue surrounding dental implants and results in progressive loss of the supporting bone. The onset of disease can occur at anytime, while its progression occurs in a non-linear and accelerating pattern. Clinically, peri-implantitis show signs of inflammation and increasing pocket depths >6mm when compared to baseline. The tissue destruction from peri-implantitis often results in a circumferential pattern of crestal bone-loss around the affected dental implant (2). Strong evidence shows that patients with a history of severe periodontitis, poor plaque control, and the absence of regular maintenance care following implant therapy are risks factors for development of peri-implantitis. Other potential risk factors with limited or inconclusive supporting evidence include diabetes, smoking, residual cement, lack of keratinized tissue, overloading of implant, titanium particles, bone compression necrosis, overheating, micromotion, and biocorrosion (3).

The goal of treating peri-implantitis is to eliminate infection and maintain healthy hard and soft peri-implant tissues. Surgical treatment of peri-implantitis includes removal of infected tissue, decontamination of the implant surface, and resective or regenerative osseous procedures (4). Implantoplasty is performed by removing threads and smoothening the exposed rough implant surfaces. The smoothed implant surfaces are less prone to plaque accumulation.

Heat generated during osteotomy for implant placement can devitalize the adjacent bone resulting in a necrotic zone of bone around osteotomy sites (5). An in vitro rabbit study showed that elevating the bone temperature to 47°C for 1 minute resulted in heat induced cortical bone tissue necrosis (6). A major reason for early implant failure has been attributed to surgical trauma and excessive heat production during implant site preparation (7). To prevent elevating bone to critical temperature, cooling is provided by irrigation with chilled saline during implant site preparation (8). When no irrigation is used, heat generated during bone drilling results in an increase in bone temperature to above the critical temperature for bone resulting in irreversible bone damage (9).

The physical properties of titanium and titanium alloy used for dental implants and implant components are thermal conductive. Heat conduction has been observed in dental implants after exposure to hot beverages (10)(11), abutment preparation (12)(13), and when autopolymerizing acrylic resins are applied directly to an implant (14). These studies showed that a change in temperature could be observed in all portions of the implant but the greatest change in temperature occurred at the cervical portion of the implant. Depending on the temperature of the beverage and length of exposure, the increase in temperature can exceed the critical bone temperature. During titanium abutment preparation, an increase in implant temperature has been observed (15). The type of cutting instrument can also affect the amount of heat generated. Diamond burs have been shown to produce less heat during titanium abutment preparation when compared to tungsten carbide burs (19).

Heat generated during the implantoplasty procedure may increase the temperature of bone adjacent to the implant. Minimizing the amount of heat generated during implantoplasty is necessary to reduce the risk of elevating bone temperature beyond its critical temperature that would result in damage to the adjacent bone. The aim of this study was to compare heat generated during the implantoplasty procedure using either a carbide or diamond round bur. The null hypotheses were that there is no significant change in temperature when performing implantoplasty and that there is no significant change in temperature between carbide or diamond round bur.

Chapter 2

Materials and Methods

Bone model

Bovine ribs were selected as the osseous model for this study. The thermoconductivity of bovine cortical bone has been shown to be similar to the human mandibular jaw bone (16). They were obtained from the local butcher shop and cut into eight-inch long segments. Five bovine rib segments with a cortical layer thickness of 2mm-3mm were then selected as the bone model for the study. After preparation, the bone models were kept in Ringers solution and stored at 4.0°C to maintain the thermosphysical properties.

Temperature measurement system

The bone temperature was measured using a digital thermometer and four K-thermocouple sensors. The thermometer measures a temperature ranging -30°C to 300°C with a resolution of 0.1°C allowing constant real-time temperature readings (Extech SDL200 four-channel thermometer, Extech instruments, Melrose MA). Temperature measurements were taken at four locations: within implant screw access, crestal bone adjacent to the implant, apex of the implant, and ambient air. Temperature was recorded at the initial, peak, and final temperatures. In addition, the time to reach peak temperature was recorded using a digital stopwatch to the hundredth second.

Experimental System

The bovine bone model was secured to the work stand using adhesive tape. A conventional dental implant motor osteotomy preparation with constant irrigation was used to prepare 5 osteotomies in each bone model according to the manufacturers recommendation. The final distance between implants was 10mm in every bone model. Five cylindrical titanium with grade 5 alloy large grit sand blasted acid etch (SLA) implants were then placed into the prepared osteotomies with an insertion torque of 30Ncm (Astral 4.2x10mm, Sydent Implants, Binyamina, Israel). The dental implant was placed at a final position of 6mm depth leaving 4mm of implant threads exposed above the crest of bone. A total of 25 implants was placed in 5 bone models. The bone models with implants were then kept in the Ringers solution and stored at 4.0°C.

For the implantoplasty, bone models were submerged in a 38.0°C water bath (Fischer Scientific Isotemp 202S, Pittsburgh, PA) for 4 hours until internal temperature of bone reached 38.0°C ± 1.0°C. Then the bone model was placed on the work stand where the thermocouples were secured into position. Implantoplasty was initiated once the internal temperature of the bone model reached 36.0°C. This experiment was done in each bone model individually.

Treatment

Implantoplasty was performed using an electric high-speed rotary hand piece (Bien Air, 200,000 rpm) with a carbide round bur and diamond round bur (Brassler 8 FG Surg carbide and Brassler FG surg course diamond). Each implant was divided in half along its long axis. On one half of the implant, group 1, the implantoplasty was performed with a carbide round bur using constant irrigation of 23°C. Implantoplasty was considered complete once all the exposed implant threads and SLA treated surface was removed.

After each implantoplasty the implants were returned to the 38.0°C water bath until internal temperature returned to baseline. For group 2, the treatment was then repeated for the remaining half of the implant using a course grit diamond round bur under constant irrigation of 23°C. A brand new bur was used for implantoplasty on each implant surfaces.

Statistical analysis

Descriptive statistics including mean and standard deviation were used. A paired t-test was used to compare differences within groups. One-way ANOVA test was used to compare the change in temperature between implant location. All statistical analyses were done using IBM SPSS 26 (Armonk, New York, United States)

CHAPTER 3

Results

The change in temperature in the screw access, crestal bone adjacent to the implant, apex of the implant, and ambient air was measured during each implantoplasty procedure in 25 implants. Temperature was measured at each location using a digital thermometer and 4 K-thermocouple sensors.

In the group 1, the carbide group, a mean change of temperature in the screw access, crestal bone adjacent to the implant and the apex of the implant were 2.06°C with a standard deviation (SD) of ± 8.71°C, -6.10 ± 3.19°C SD, and -0.67 ± 0.34°C respectively. For the group 2, the diamond group, implantoplasty resulted in a mean change in temperature inside the screw access of 19.06 ± 11.38°C, at crestal bone adjacent to the implant 3.56 ± 2.61°C, and the apex of the implant of -0.55 ± 0.66°C (table 1, fig. 5,6).

Mean temperature difference between group 1 and 2of 16.99 ± 14.09°C in the screw access, a mean difference of 2.53 ± 4.25°C in the crestal bone adjacent to the implant, and a mean difference of 0.12 ± 0.68°C at the apex of the implant. A statistically significant increase in temperature was observed in the crestal bone adjacent to the implant and screw access when implantoplasty was performed using a diamond round bur at a p-value < 0.01. No statistically significant temperature change was found at the apex of the implant in either group 1 or group 2 with p-value = 0.38 (table 1).

Temperature was the highest in the screw access during implantoplasty. The peak temperature within the screw access of both groups is illustrated in figure 3. In group 1, the mean peak temperature difference -3.04 ± 5.74°C while in group 2 the mean was 4.91 ± 10.02°C (table 2). The temperature increase in the screw access was greater in group 2 with a mean of 8.32 ± 11.91°C with a statistical significant p-value <0.01 (table 2).

CHAPTER 4

Discussion

Heat generated during implantoplasty procedures may cause adverse effects on the peri-implant tissues if the temperature of the peri-implant tissues increases beyond its critical temperature threshold. Necrosis in the cortical bone occurs when bone temperature is increased to 47°C for 1 minute. (6) In this study, implantoplasty with constant irrigation did not cause a significant increase in bone temperature and never reached the critical threshold of 47°C. The selection of round bur did result in a significant difference in heat generated during the procedure. More heat was produced with the diamond round bur compared to the carbide round bur. The results agree with a previous invitro study that reported greater heat production with diamond burs when compared to carbide burs. This same study reported minimal 0.9°C to 1.5°C change in temperature of the adjacent crestal bone (19).

An important observation of this study was that constant irrigation during implantoplasty provides adequate cooling of the implant and bone to prevent an increase in bone temperature. For the current study, constant room temperature irrigation at 23°C was provided by the dental unit electric hand piece. In both group 1 and 2, the bone temperature never reached the critical temperature of 47°C. From the limits of this study, 30 seconds application of the high-speed rotary instrument with constant irrigation was able to maintain a large temperature safety margin during the implantoplasty procedure.

Selection of instrumentation is important to maximize efficiency and minimize heat production during implantoplasty. In this study, carbide round burs were more favorable for the implantoplasty procedures resulting in less heat production than the diamond round burs. A previous study comparing a premium diamond bur, carbide bur, and regular diamond found that the carbide bur was more efficient than the regular diamond but less than the "premium" diamond bur when used for implantoplasty. (17) It was also previously reported that diamond burs produced more heat during implantoplasty than carbide burs. (19)

Another observation was the initial increase in temperature within the screw assess started between 9 to 11 seconds for most of the implantoplasty procedures in both group 1 and group 2. However the temperature within the screw access did not increase gradually from baseline. Instead, the temperature would increase and decrease very quickly multiple times during implantoplasty around the implant. These quick periods of increase and decrease in temperature observed throughout the implantoplasty may be caused the variation in handpiece angulation and pressure that is applied to the implant while performing the procedure.

Another observation during the study was the large amount of titanium particles created during implantoplasty. Previous studies have discussed how the presence of titanium particles can contribute to a chronic inflammatory response. Titanium particles surround by inflammatory cells have been observed in tissue biopsies of diseased implants. Titanium particles may act as a foreign body resulting in a chronic inflammatory response and contributing to peri-implantitis. (18) The complete isolation of the surgical site and retrieval of the titanium particles would be extremely difficult or impossible in a clinical setting. The benefit of implantoplasty must be carefully considered against the risk of iatrogenic release of titanium particles into the surrounding implant tissues.

This study has some inherent limitations as an invitro animal model study. The bovine rib bone model that was selected for this study is similar to the human mandible but not identical. The dimensions of the bovine rib is much larger than the human mandible which increases the amount of surface area for heat dissipation. Also, no periosteum or tissue was left covering the bone sample which may allow more heat to the environment the the invitro setting. The cortical bone thickness of the sample was between 3mm-4mm which resulted in most of the implant being placed within the cortical bone. Peri-implantitis results in loss of the crestal bone around the implant which can cause a decrease in the thickness of the cortical bone around the implant. In addition, limitations in the experimental set up made maintaining a constant bone temperature once the bone was removed from the water bath difficult. More in vivo studies are needed on the heat generated during implantoplasty procedures and its affect if any on the adjacent bone and soft tissues. Lastly, implantoplasty was standardized by using a single operator to perform all implantoplasty procedures. However, variation in hand piece angulation and pressure applied to the implant would have occurred during implantoplasty. This may account for the range of temperature standard deviation that was recorded in the results of this study.

Chapter 5

Conclusion

Implantoplasty is used to remove plaque retentive features of implants affected by peri-implantitis. From this study, it was concluded that the production of heat occurs with implantoplasty. However, when implantoplasty is performed using constant irrigation there is no increase in bone temperature. The cooling effect of constant irrigation is adequate to prevent the transfer of heat into the bone that could raise bone temperature to a critical level resulting in bone necrosis. When diamond burs were used to perform implantoplasty there was significantly more heat produced than carbide burs but neither resulted in a critical increase in bone temperature. It is concluded that when implantoplasty is best performed using constant irrigation and a carbide round bur to minimize heat production and reduce risk to the adjacent peri-implant bone.

Fig 1: Cylindrical titanium grade 5 alloy large grit sand blasted acid etch (SLA) non-self taping implants

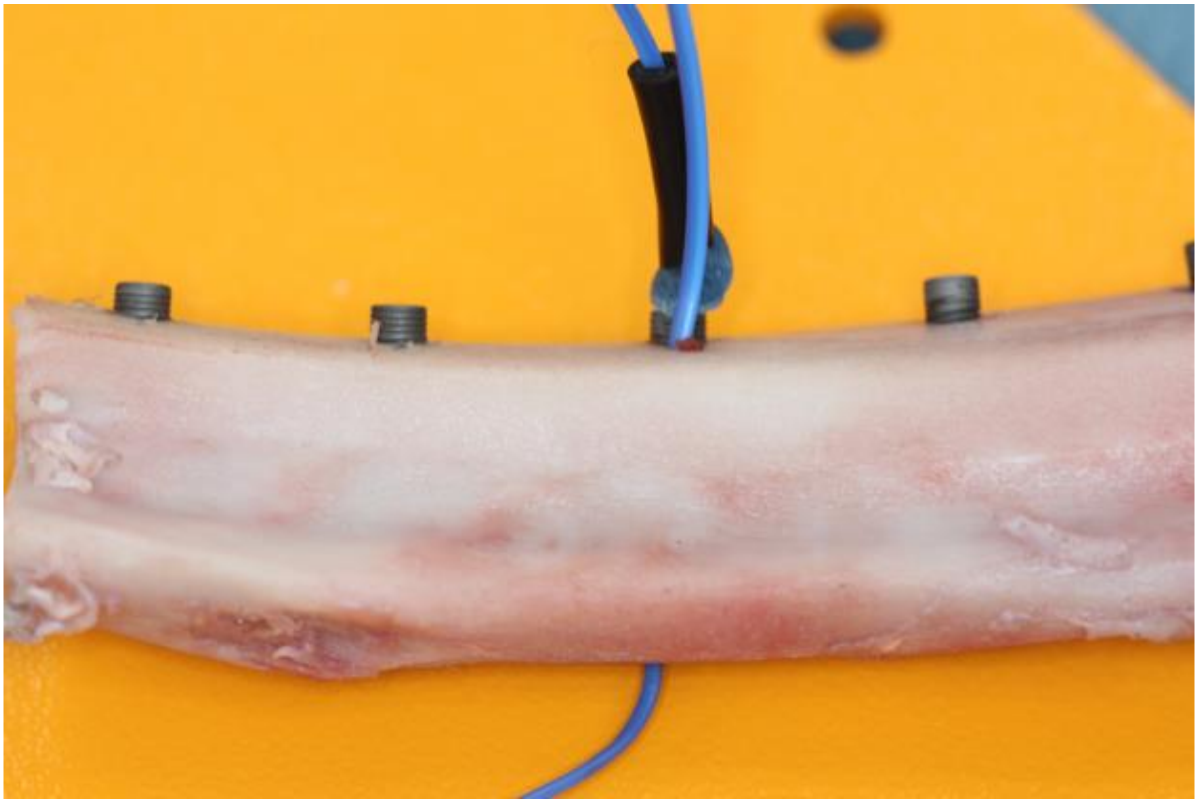

Fig 2: Thermocouples positioned in the implant screw access, apex of the implant, and crestal bone adjacent to the implant.

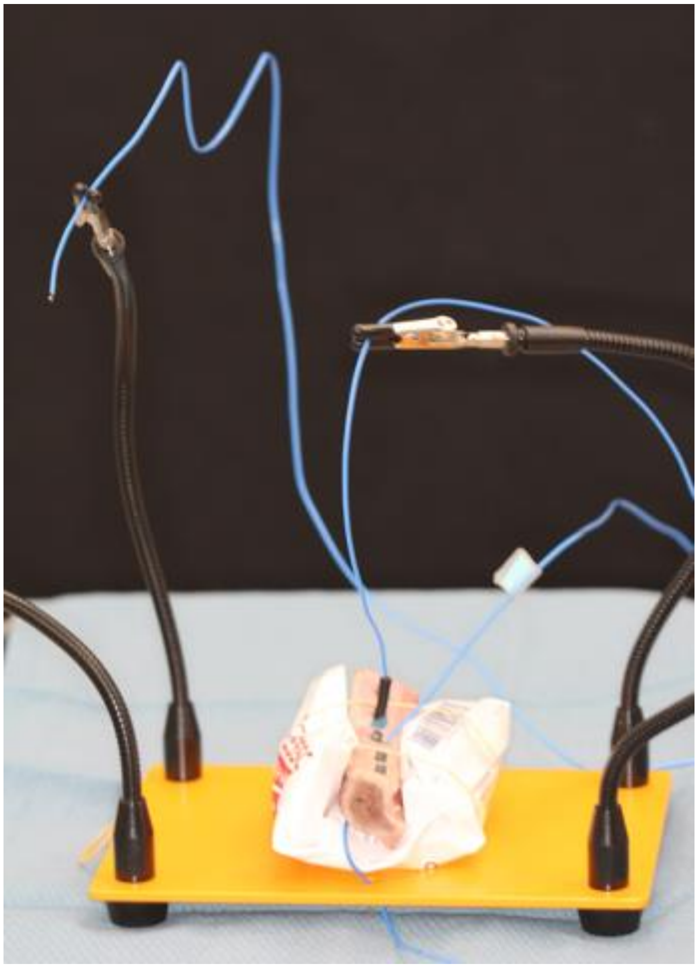

Fig 3. Experimental design. Bovine bone model is wrapped in instant hot pack to prevent heat loss to ambient air. Thermocouples are placed at various points around the implant.

Fig 4. Wax used to seal openings around thermocouples to isolate thermocouples from irrigation during implantoplasty.

Fig 5: Box plot: Illustrating mean change in temperature change from baseline to final of diamond and carbide burs.

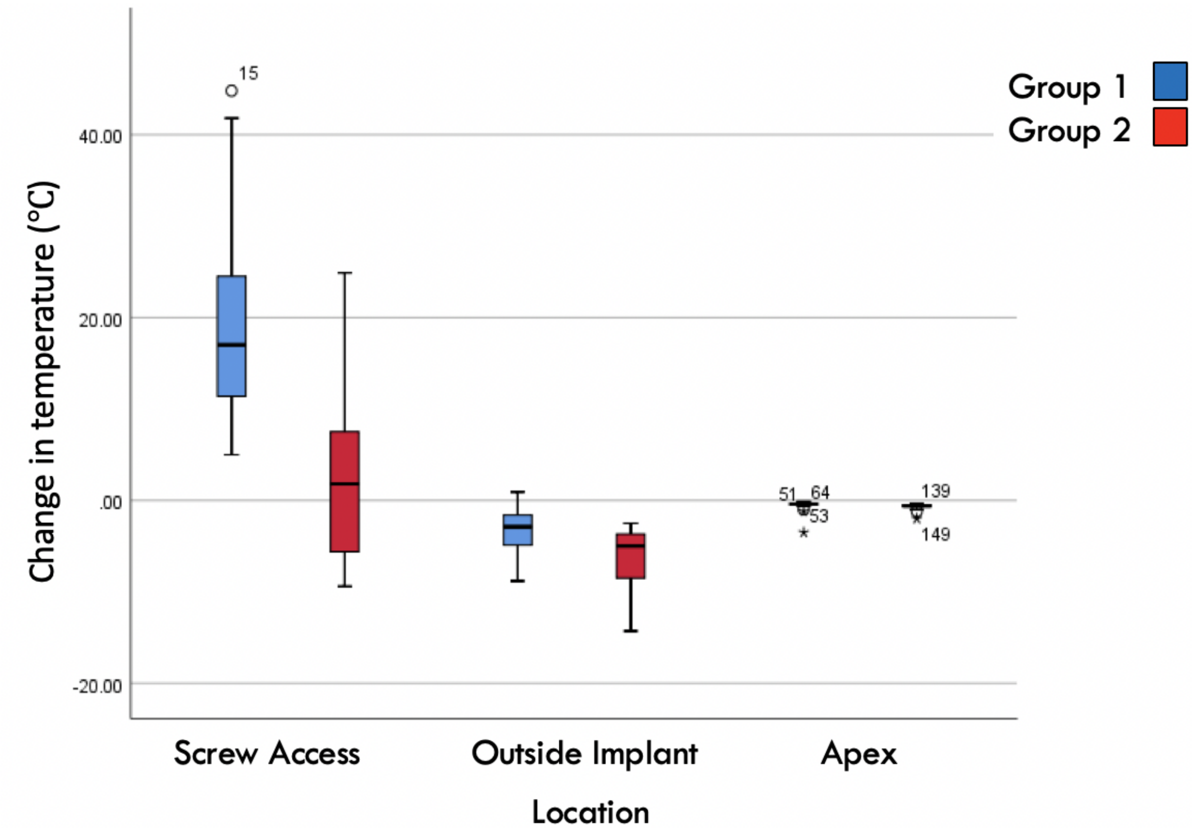

Table 1: Mean change in temperature from baseline to final by group.

Location	N	Group	Mean (°C)	Std. Deviation	Minimum	Maximum	Mean Difference (SD)	P-value
Screw Access	25	Group 2	19.06	11.38683	5.00	44.80	16.99(14.09)	0.0001
	25	Group 1	2.06	8.71578	-9.40	24.90		
Outside Implant	25	Group 2	-3.56	2.61580	-8.80	.90	2.54 (4.25)	0.007
	25	Group 1	-6.10	3.19113	-14.30	-2.50		
Apex	25	Group 2	-0.55	.66277	-3.50	-.10	0.12 (0.68)	0.388
	25	Group 1	-0.67	.34943	-2.00	-.30		

Table 2: Mean difference of peak temperature in diamond and carbide groups

	Mean (°C)	N	Std. Deviation	Mean Difference	P
Group 2	4.91	25	10.02	8.32	0.002
Group 1	-3.40	25	5.74		

Table 3: Mean time to peak temperature inside implant

	Mean (Seconds)	Std. Deviation	df	P
Group 2	19.96	5.25	24	0.8082
Group 1	20.48	8.36		

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