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"COMPARATIVE EVALUATION OF HEAT TRANSFER DURING REMOVAL OF METAL CERAMIC AND ZIRCONIA CROWNS "

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Abstract:

The direct bone-to-titanium contact is defined as osseointegration. Bone tissue injury from heat above 470C is harmful to osseointegration. The Complication associated with osseointegration is not the only side effects noted in implant dentistry. Besides this, prosthetic complications, which include screw loosening, fracture, ceramic fracture and gingival inflammation or proliferation are also common. All of these prosthetic complications may necessitate the removal of the implant prosthesis for replacement, maintenance or repair. For a cement-retained prosthesis, removal may not be straightforward. If the adhesive bond of the cement can be broken, the restoration is easily removed. If not, prosthesis must be removed by drilling through the restoration channel or sectioning the restoration with a high speed dental handpiece. The purpose of this study was to measure the amount of heat transferred to the implant-bone interface when a ceramic-veneered crown and a zirconia crown is sectioned with tungsten carbide burs using irrigation.

Key words: Osseointegration, K type thermocouple, Ceramic-veneered crown, Zirconia crown, Tungsten carbide bur,

Introduction:

Surgical trauma during implant placement interferes with tissue integration which is one of the major reasons for early implant failures. During drilling, the local temperature in bone may exceed 1000c, depending on factors such as irrigation for cooling, bone properties, drill type, and drilling force and speed. However, not only surgical trauma but also prosthetic procedures during the initial integration phase might interfere with the delicate tissues around oral implants. There are also other several implant prosthetic procedures that could carry a risk of heat transfer to the bone-implant interface such as intraoral preparation of implant abutments or shortening its occlusal height, subgingival preparation of abutment margins, preparation of abutment grooves for resistance and retention of the final crown, shortening of impression coping screws, or occlusal adjustment of metal or porcelain restorations.

Abutment preparation sometimes may be required to allow temporization after insertion of immediate loaded implants. Burs such as diamond and tungsten in a high speed dental turbine hand piece generate excessive heat generation at the implant bone-interface and can delay bone healing. The effect of overheating the implant-bone interface may result in bone necrosis and soft tissue encapsulation leading to implant failure .Heat- induced tissue necrosis not only inhibits microcirculation of the bone and jeopardizes its regenerative capacity, but also dangers primary healing and osseointegration due to reduced initial implant stability. Thus the threshold level of causing irreversible damage to the bone tissue is 470 C.

Metals such as titanium and titanium alloy are excellent thermal conductors, therefore the impact of secondary heat generation on peri-implant bone is a clinical concern. The temperature generated varies according to rotary instrument type, duration of the grinding procedure, and the presence of external coolant. The different cooling systems provide maintenance of an appropriate temperature and prevent tissue overheating during an exothermic dental implant insertion procedure.

Heat is also produced when preparing a titanium abutment with tungsten burs which is composed of carbon alloy that can affect the surrounding bone. Diamond burs which are also used in daily practise differ from each other by design, carrier material. Coating, and degree of roughness which may affect the efficacy of the bur and the amount of heat produced. Other factors that can affect heat generation are working time, pressure produced, resolution per minute(rpm), and the turbine properties (torque).

Healing following bone surgery may be delayed or even prevented if the bone cells are severely injured by the frictional heat generated during the surgical procedures. Therefore preservation of healthy bone is an essential prerequisite for primary healing, which procures physiological osseointegration of dental implants. Materials of the burs used, bur irrigation, play a key role in

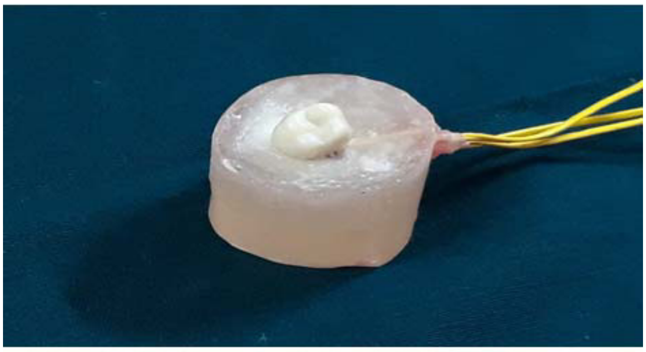


Figure 1: Metal ceramic crown cemented on the abutment

Figure 2: Zirconia crown cemented on the abutment

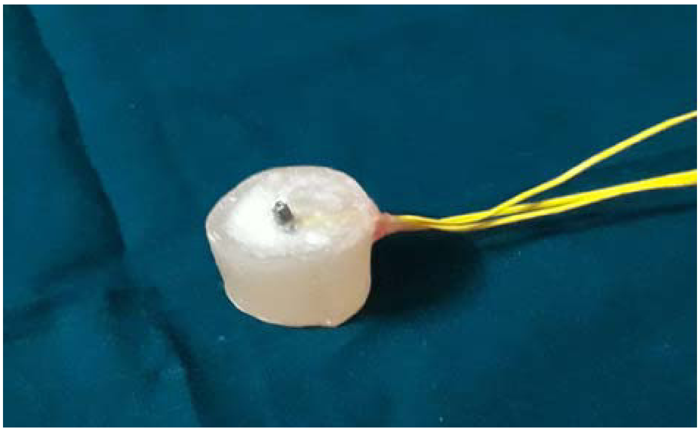


Figure 3: Self-cure acrylic resin block

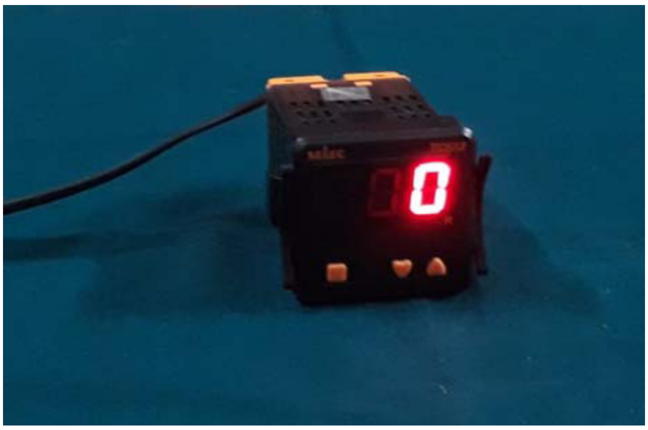


Figure 4 : Thermocouple Controller

avoiding thermal osteonecrosis.

Thus the purpose of the study was to compare heat generation during removal of Metal ceramic and Zirconia crowns in cement retained implant restoration that could cause excessive heat at the bone-implant interface and compromise osseointegration.

Materials and armamentarium.

1. DPI-RR cold cure acrylic repair material
2. HI TECH Logic plus Dental implants (Diameter-4.3 mm, platform- 3.5 mm, Length – 11.5 mm)
3. Abutments (Diameter-3.5 mm, platform -2.4 mm, Length-11mm)
4. Metal ceramic crowns Nickel chromium (VITA)
5. Zirconia Crown (Amann Girrbach)
6. Zinc phosphate cement (Harvard)
7. Straight tungsten carbide bur (No-245)
8. Airotor hand piece
9. Thermocouples (K Type)

Methodology:

In vitro Model Design:

The study compromised of 20 Dental implants (HITECH LOGIC PLUS 4.3 mm in diameter and 11.5 length) which were divided into two groups of 10 Implants each.

All the Implants were mounted in a self-cure acrylic resin block (Figure-3) in such a way that the abutment and smooth implant neck will be exposed. Each abutment will be screwed onto the implant and tightened to 20 Ncm (0.48 Hex Driver, Hi Tech Logic plus Dental implant prosthetic) .Over these abutments, metal ceramic and Zirconia crowns will be cemented.

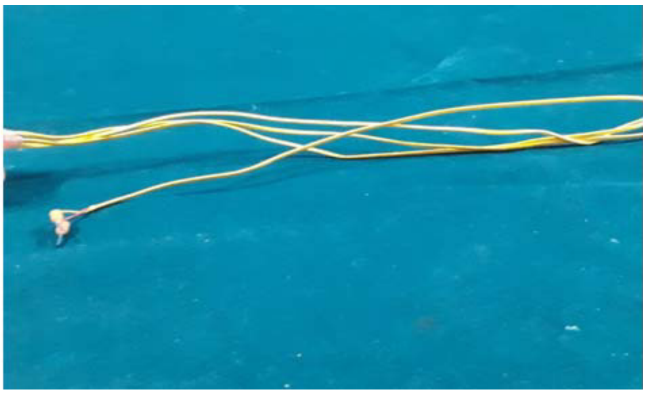


Figure 5 : K Type Electrodes

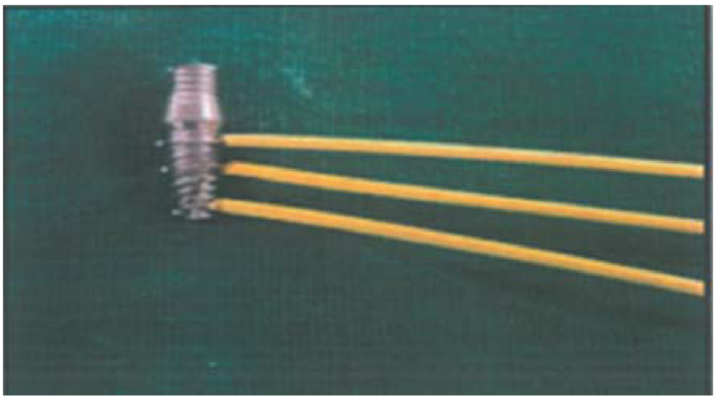


Figure 6 : Implant body at the Cervical, Middle and Apical Regions

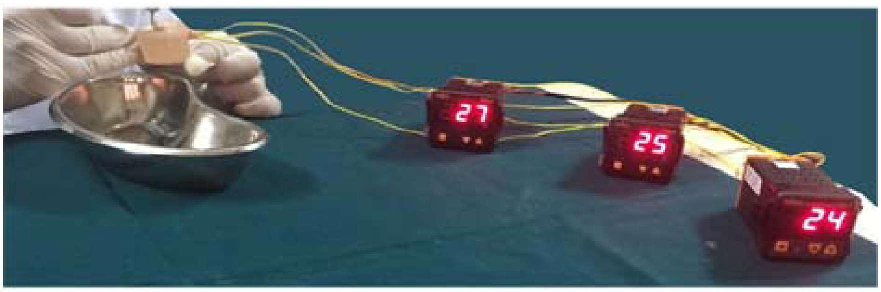


Figure 7 : values Obtained while sectioning Zirconia crowns

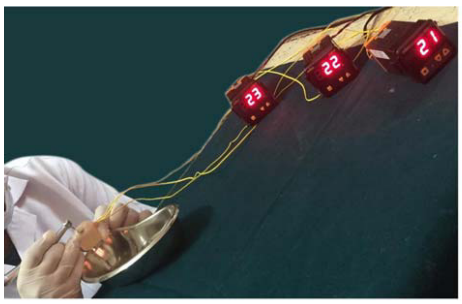


Figure 8 : Values obtained while sectioning Metal ceramic crowns

Temperature Recording system:

The heat generated during abutment preparation was recorded by a thermocouple controller (Figure-4). This controller records any temperature variations starting from the room temperature through thermocouple K type electrodes (Figure-5) which was attached to the three regions of the flattened peripheral surface of the implant body at the cervical, middle and apical regions of the implant body (Figure-6) via thermal adhesive (Omega-bond 101:omega Engineering Inc.) to aid in thermal conductivity. Thermal K type are solid state temperature sensors that are capable of measuring temperature changes of 0.10C which is connected to a thermocouple controller. The data was recorded at a rate of one sample per 0.55 Secs

Sectioning of the crowns:

The crowns were sectioned by using a high-speed turbine hand piece which was used at maximum running speed with pressure of 20 psi and continuous water irrigation for Zirconia Crowns (Figure-7) and Metal ceramic crowns (Figure-8) .

The various values of heat generation by tungsten carbide burs on three different aspects of the implant surface were obtained in degree Celsius and was subjected to statistical analysis.

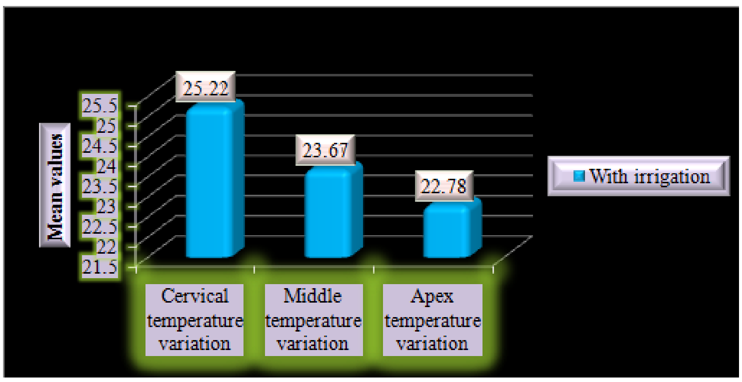
Statistical analysis of data

Microsoft Excel was used for tabulation of data and IBM, SPSS (statistical all package for social sciences) software version19,0 (Armonk, New York)

Figure 9: Tungsten carbide bur

	With irrigation (Mean ± SD)	Z	p
Cervical temperature variation	25.22±0.44	-3.698	0.00*
Middle temperature variation	23.67±0.86	-3.627	0.00*
Apex temperature	22.78±0.66	-3.645	0.00*

TABLE 1: Comparison of temperature variation in Zirconia crowns group.



Graph 1: Comparison of temperature variation in Zirconia crowns group.

	With irrigation (Mean ± SD)	Z	p
Cervical temperature variation	23.89±0.78	-3.662	0.00*
Middle temperature variation	22.89±0.78	-3.662	0.00*
Apex temperature variation	22.22±0.44	-3.748	0.00*

TABLE 2: Comparison of temperature variation in ceramic-veneered crowns

was used for evaluation, Wilcoxon signed – Rank test Mann-whitney U test and Kruskal Wallis test was used for statistical analysis of data obtained from the microbial study. Probability (p) value < 0.0s was considered to be significant.

Results:

Statistical procedure:

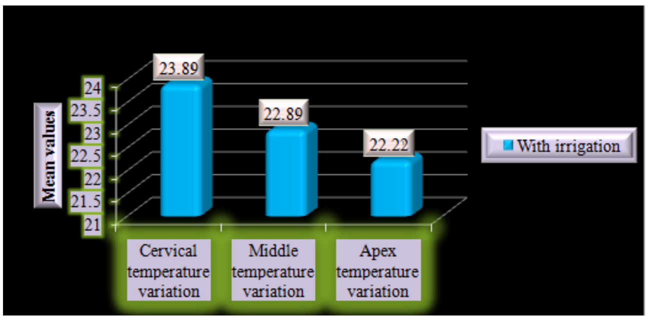
Non-parametric tests, Wilcoxon signed-rank test, Mann Whiteny U-test and Kruskal Wallis tests were performed to evaluate the data with a significance of p-value kept <0.05.

Wilcoxon signed-rank test

It is a non-parametric statistical hypothesis test used when comparing two related samples, matched samples or repeated measurements on a single sample to assess whether their population mean ranks differ. It is used when population cannot be assumed to be normally distributed.

Mann-Whiteny U test

It is a non-parametric test of null hypothesis. It is used to compare two sample means that come from same population and used to test whether two sample means are equal or not.



Graph 2: Comparison of temperature variation in ceramic-veneered crowns

Kruskal Wallis test

The Kruskal-Wallis test by ranks or one-way ANOVA on ranks is a non-parametric method for testing whether samples originate from the same distribution. It is used for comparing two or more independent samples of equal or different sample sizes.

Temperature variations in individual groups

INFERENCE: The table shows that the temperature variation was more in cervical area compared to Middle and Apex area with irrigation This difference was statistically significant. ($p=0.00$)

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Discussion:

The effect of overheating the bone at the interface may cause bone death and compromise its ability to survive as a differentiated tissue and prosthesis repair.[12] After cutting, a zone of devitalized bone forms the outer walls of the osteotomy, and the extent of the necrotic zone will vary exponentially based on the magnitude of the cutting temperature. Denaturation of the bone proteins causes necrosis, which results in soft tissue encapsulation of the implant, thereby preventing integration and causing implant failure.[13]

Intraoral implant abutment preparation can cause excessive heat generation at the implant-bone interface resulting in irreversible bone damage and compromise osseointegration. Hard titanium is difficult to cut through and the metal has high thermal diffusivity with kinetic friction generating heat.[14] Burs differ from each other by design, carrier material, coating, and degree of roughness which may affect the efficacy of the bur and the amount of heat produced. Carbide burs composed of nitrogen and carbon alloy that are characterized by their high cutting efficiency also dissipates heat during cutting.[10] Diamond bur seems to cause higher temperature increases than tungsten carbide ones, despite the time of application and cooling methods. This is probably due to its abrasive action and its wider contact surface .This factor can enhance heat production because of attrition and also seems to reduce cooling efficiency. On the contrary, tungsten burs shape allows the presence of water between the blades, so that detritus can be removed, dissipating excessive heat.[4]

The temperature of the water coolant itself is an effective tool in reducing the temperature during cutting. Therefore using a cooling system can be an acceptable offer to prevent the thermal injury caused in abutment preparation. The use of a water irrigation not only provides cooling but also lubrication, reducing the tool temperature and lessening the cutting forces and chip welding commonly experienced with titanium alloy. Heat generated can be dissipated by conduction through the cutting tool, by conduction through the material being cut or by the chip itself at, is removed, and by the coolant. When the water-coolant is low, more heat is dissipated through this cool water, which absorbs most of the heat generated during cutting and reduces the amount of heat absorbed by the material being cut.[3]

Time is also an important factor in generating heat when the bur is applied to the tooth or abutment. During crown or abutment preparation removing the bur intermittently for even a few seconds can reduce the heat generated considerably.[3]

There is a relationship between the temperature in the coronal part and the bone surrounding the implant. Prolonged friction would give rise to higher temperature increases, and differences in the bone structure between the superficial and deep aspects would produce different types of friction. The cortical bone that covers the external of bone is stronger and has a higher coefficient of friction compared with spongious bone. The implant bone interface is surrounded by cortical bone therefore during abutment preparation excessive heat can be dissipated around the cortical bone region.[14] Thermography studies of abutment preparation of 2-piece implant abutment assemblies have demonstrated that heat is transferred through the abutment into the implant body and that the highest temperatures were concentrated in the crestal bone region.[15]

Gross et al[17] in his study prepared abutments for 30 secs with high speed cutting instruments and found that there was a mean increase of 1°C with a maximum of less than 2°C for 30 seconds of continuous cutting with diamond burs and standard turbine coolant whereas a mean increase of 2°c for 30 seconds of continuous cutting with tungsten burs and standard turbine coolant. Temperature changes were found to be more at the apex than the implant cervix and found that the amount of heat transferred to the interface was not sufficient to cause bony alterations, provided air-water spray was used. Similarly, the present investigation found that the amount of heat transferred to the implant-bone interface was concentrated in the cervical part without causing any irreversible damage to the bone if irrigation was used during preparation with diamond or carbide bur.

Bragger et al[1] used temperature probes to evaluate heat generated in 2- piece transmucosal implants during abutment preparation with diamond and stainless steel finishing burs under copious irrigation and found that the maximal increase in temperature was found at the coronal aspect. The use of additional spray and pressured air significantly reduced the temperature.

Therefore Sectioning of Crowns using Tungsten carbide burs with irrigation will ensure that the heat generated during Sectioning of Crowns will not cause irreversible damage and compromise osseointegration. Hence irrigation can be used

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to minimise potential heat damage at the bone-implant interface.

Limitation of the study:

1. In vitro study.

2. Vitro set up could not document reactions of cells or tissues.

3. Heat variation in 1 piece and 2 piece implants.

Conclusion:

During comparison of heat generation with Metal ceramic and Zirconia Crowns, the result obtained signifies that both have affinity for heat generation in the absence of irrigation. Therefore, it is concluded that sectioning of Metal ceramic and Zirconia crown in cement retained restoration under the presence of Irrigation would not cause a significant rise in temperature above the threshold value of 470C.

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