

The Significance of Motor Speed on Heat Generation During Implant Drilling (Experimental Study on Bovine Bone)

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ABSTRACT

Aims: To measure the heat generated from 3 drilling speeds (1250,2000, and 2500 rpm) using the armamentarium of ELIT implant systems. **Materials and methods:** Temperature was measured with thermocouple technology in vitro using the bovine femoral cortical bone model. Intermittent drilling was accomplished by using normal hand force that used in implant preparations. External irrigation at 40 mL/min with normal saline was used with drilling depth at a depth of 7mm and diameter 3.75. Heat measurements were recorded after final drilling step. **Results:** Result showed temperature increases related to the time of drilling and the speed of 2500 rpm accompanied with lowest temperature. **Conclusions:** From a heat generation, we concluded that preparing an implant site at 2500 rpm could decrease the risk of bone damage, which may affect the initial healing of dental implants. This may decrease the devital zone adjacent to an implant after surgery.

Key Word: Heat generation, irrigation of implant ,osseointegration.

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INTRODUCTION

Dental implants have become an accepted treatment modality. According to recent studies, there are more than 24 implant systems in international dental markets^(1,2) Previously, healing of the implant was considered "successful" when it became encapsulated with fibrous tissue, i.e., fibro-osseous integration⁽³⁾. However, the presence of this pseudoperiodontium was associated with microbial and mechanical problems leading to implant failure⁽⁴⁾. The extensive studies in the 1970s introduced the concept of osseointegration, in which bone has a direct contact with the surface of the implant with no intervening fibrous tissue^(5,6). At the present, there is a general agreement that osseointegration is more stable situation and results in a high success rate for up to 15 years⁽⁷⁾.

The frictional heat generated at the time of surgery will always cause a certain degree of necrosis of the surrounding differentiated and undifferentiated cells, thereby representing a significant risk for failed bone integration⁽³⁾. Thermonecrosis as a result of elevated temperature has been previously reported in the literature⁽⁴⁻

⁷⁾. Eriksson and Albrektsson⁴ heated threaded titanium implants in the rabbit tibia and found that heating the implants to a temperature of 50C for 1 minute was sufficient to cause 30% of the bone to be resorbed. This was not an immediate occurrence but a slow-developing process that extended over a period of 4 weeks. The bone was replaced with fat cells, preventing implant incorporation. The same study demonstrated that heating bone to 47°C for 1 minute reduced the amount of bone that grew into the porous implant. Eriksson and Albrektsson established that the threshold level for bone survival during implant site preparation is 47°C, keeping drilling time below 1 minute .

MATERIALS AND METHODS

The Italia ELITE implant drill systems were evaluated in vitro using bovine femoral cortical bone Figure (1). Bovine cortical bone was selected to keep cortical thickness constant Figure (2). The torque was maintained 35 n\cm by using NSK motor driven(Japan made) also thecooling system was fixed on constant ratio (40m/min).



Figure(1): The drills of ELIT implant systems that are used in implant site preparation only first and second one used (3.25, 3.75mm).



Figure (2): Bovine femoral cortical bone model show the site after final preparation.

Bovine femoral cortical frozen until used. The bone was placed in a thermostat-controlled bath containing physiologic saline at 37°C (K type thermoelectric couple 830c, 837, 838 made in Taiwan and KI&BNT digital thermometer) were used to measure temperature. Site preparation began when the temperature of the bone, reached a temperature of $37^{\circ} \pm 1^{\circ}\text{C}$. Sequential drilling was accomplished following system manufacturer's recommendations. The sites of preparation have been done on the bovine femoral cortical bone.

Temperature measurements were made after final site preparation. The speeds that evaluate are 1250, 2000, 2500 rpm.

Thermoelectric couple probe were inserted into a hole prepared to a depth of 7 mm and diameter 3.75mm.

Normal saline solution at a room temperature was used to irrigate the site and was maintained continuously throughout drilling by using NSK cooling system and at constant ratio (40ml/minute). Drilling

was done in an intermittent fashion. Ten cavities were created following this procedure for each speed, and 2 size for drilling are made and the temperatures are recorded in last size only (3.75mm), Figure (2).

RESULTS

The results showed the temperature decreased in 2500 rpm and it was higher in 2000rpm and 1250 rpm, Figure (3), and the readings are listed in Table (1) showed the minimum mean temperature was 40.280° in 2500 rpm and maximum mean temperature was 42.69° in 1250 rpm. ANOVA revealed significant differences in heat generated between each speed at ($p < 0.001$) and this result indicated that when the speed increase there was decreased in the temperature recorded and these results were listed in Table (2) and Duncan test showed a significant difference between each group, Table (3).

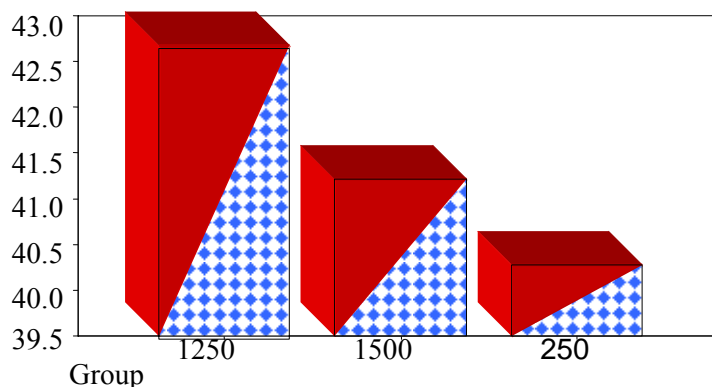


Figure (3): Differences in temperature due to changing in speed.

Table (1): Mean temperature and number of osteotomies.

Drilling speed in rpm	No. of osteotomies	Minimum Temp*.	Maximum Temp*.	Mean Temp*.	SD.** deviation
1250	10	42.0	44.0	42.670	.6129
1500	10	40.0	42.5	41.220	.7714
2500	10	40.0	41.0	40.280	.3521

* Temp: temperature; ** SD: standard deviation, No.: Number.

Table (2): ANOVA test revealed significant value at ($p \leq 0.001$).

Temperature	Sum of squares	df.	Mean square	F-value	Significance
Between groups	28.994	2	14.497	39.726	.000
Within groups	9.853	27	.356		
Total	38.847	29			

Df: degree of freedom

Table (3): Duncan multiple range test of groups.

Group	No.	Mean temp.± SD temp**.	Duncan group*.
1250	10	42.670±0.6129	A
1500	10	41.220±0.7714	B
2500	10	40.280±0.3521	C

* means with different letter were statistically significant at ($p \leq 0.001$); ** Temp: temperature, No.: Number.

DISCUSSION

A variety of drilling materials have been used for heat studies: rabbit mandible⁽⁸⁾, pig maxilla and mandible,⁽⁹⁾ bovine block cortical / medullary bone,⁽¹⁰⁾ polymeric material,⁽¹¹⁾ porcine ribs,⁽¹²⁾ and bovine cortical bone⁽¹³⁻¹⁵⁾.

It has been reported that as bone density increases, temperature also increases^(12,15). In this study, bovine cortical bone was used to eliminate variability and make cortical thickness a constant factor.

There are many parameters that must be considered during implant placement for osseous integration to occur like the speed of rotation,⁽¹⁶⁾ torque,⁽¹⁷⁾ type of serration of drill,⁽¹⁸⁾ and repeated drilling and sterilization,⁽¹⁹⁾ and the temperature of the irrigant can also affect the bone temperature⁽²⁰⁾.

No attempt was made during this study to assess the pressure (load) applied on the drill⁽¹⁶⁾.

So this result showed that the higher the speed, the less heat was generated and this is not mean the rpm is the only factor and this may be explained by the faster the

drill to reach the depth of 7 mm the less time which is needed, slower rotational speed required more drilling time, which produce more frictional heat.

This observations in accordance with Reingewirtz *et al* who also found that the temperature change was a function of the time of drilling and the motor speed rather than the drilling time alone⁽²¹⁾. Also Published clinical trails by BioHorizons Dental Implants used a drill speed of 2,500 rpm during a 3-year period and reported survival above 99% of implant integration in all bone densities⁽²²⁾.

The result was come in accordance with the result of Mohamed Sharawy *et al* which conclude that the bone drilling at 2,500 rpm generated less heat than drilling at slower speeds⁽¹⁶⁾.

CONCLUSIONS

Preparing an implant site at 2500 rpm could decrease the risk of bone damage, which may affect the initial healing of dental implants. This may decrease the devital zone adjacent to an implant after surgery.

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