Original Article

Infrared thermographic evaluation of rise in temperature with conventional versus trephine drills

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Abstract

Aim: To compare the rise in temperature using trephines over conventional ones during bone site preparation.

Setting and Design: An-vitro, evaluative study

Materials and Methods: Twenty implant sites were prepared using pilot drill up to depth of 10 mm on bovine femoral bone. In first part, no irrigation was used. Five sites were prepared using conventional drill of 2.8 mm, and other five were prepared with help of trephine drills. On completion of each drill, infrared thermometer was used to measure temperature on both the drill tip and the shaft. The same procedure was repeated with bone immersed in saline.

Statistical Analysis Used: Student t test was used to evaluate the significance of difference.

Result: Study showed that the temperature rise at drill tip was significantly higher for trephine drill (52.98 ± 1.67 °C) than conventional drills (48.20 ± 0.67 °C), however the temperature difference in trephine and conventional drills was statistically insignificant.

Conclusion: The temperature increase was more distributed in conventional drills than trephine. Copious irrigation is thus mandatory for trephine drills. Intermittent drilling is preferred with conventional drills.

Keywords: Conventional drills, implant site, irrigation, temperature rise, trephine drills

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INTRODUCTION

The goal of modern dentistry is to provide a patient with the necessary and near-normal contour, function, comfort, esthetics, speech, and health. This can be achieved by merely removing caries from the tooth or, if need be, by replacing tooth. What makes implant dentistry unique is the ability to achieve this goal, regardless of atrophy, disease, or injury to the stomatognathic system.[1]

Implant dentistry has become the face of dentistry in recent times. It is the first choice of treatment for replacement of missing teeth. Implant survival majorly depends on the phenomena of osseointegration.[2] This process, though progressive in nature, is dependent on several factors,

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the most important of which is active primary healing of implant site.[3]

Atraumatic implant site preparation and aseptic environment are critical precursors to primary bone and soft-tissue healing. While preparation of implant site using drills or trephines, it is therefore required to keep a check on the thermal and mechanical trauma to the bone. It is known that bone cell survival is dependent on temperature. Eriksson, in rabbits, has demonstrated that bone temperatures as low as 3°C above normal are capable of causing bone cell necrosis.[4] The temperature rise is mainly caused due to friction between cutting surface of the drills and the bone. It is therefore advocated to use copious irrigation during drilling procedures. Changes in drill designs are also advocated for the same reason, drills with internal irrigation for instance. Recently, trephine use is being promoted by some implant companies. These offer an advantage of cutting surface only on the tip of the drill, thus causing very less increase in temperature. However, there is still a dearth of literature that directly suggests significant benefits in terms of thermal insults to bone with the usage of trephine drills.

Several studies have been performed to estimate temperature rise during osteotomies using methods such as thermocouple instrument, infrared thermographic imaging, and flourotropic thermometer.[5] These methods have been employed to measure the temperature of drill within the bone substrate itself.

This study aims to compare the rise in temperature while using trephines [Figure 1] and conventional [Figure 2] drills during bone site preparation for implants. The method involved was the use of a single operator and infrared thermography.

MATERIALS AND METHODS

This comparitive study was approved by institutional review board. It was carried out using convenience sampling technique. The study was conducted on bovine femoral bone to mimic the clinical situation. Two types of drills of the same company (Ards implant system, Israel) were used. One was a conventional three-blade drill of 2.8 mm diameter, while the other was a trephine drill of 2.8 mm diameter. Apart from these, a marking drill and a pilot drill of 2 mm diameter were also used. The rise in temperature was measured using an infrared thermometer (JBP HealthCare).

Methodology

This study consisted of two parts. In the first part, drilling procedures were done without irrigation and a rise in the temperature was measured. In the second part of the study, drilling procedures were carried out with the bone submerged inside saline. This was done to mimic drilling with irrigation. The bone site was prepared by drilling 20 equally spaced points using the marking drill. Finally, pilot drilling was done up to a depth of 10 mm using 2 mm diameter pilot drill.

After bone preparation, the first part of the study was conducted. The stabilized bone was drilled intermittently using conventional drill (2.8 mm diameter) at a constant speed of 800 rpm at 35 nm of torque. Once the drilling was done till the designated depth, temperature measurement was done at the tip and at the shaft of the drill using an infrared thermometer. This process was done at 5 points on bone. While using the trephines, a guide pin (ARDS Smart System) was first placed inside the 5 pilot holes, and then, trephining was done at 800 rpm and 35 nm of torque. Once the trephine reached the predetermined depth, temperature measurement at the tip and the shaft of the trephine was done.

In the second part of the study, the bone was submerged in saline and the same procedure as mentioned above was followed for both types of drills.

The temperature was recorded after drilling at all 20 sites, and the data were entered in the Excel sheet. The data were analyzed using the Statistical Package for the Social Sciences 20.0 version, IBM, Chicago, IL, USA, and were checked for probability distribution using the Kolmogorov–Smirnov test. $P = 0.200$ indicated that the data were normally distributed, and thus, a parametric test of significance (unpaired t-test) was applied. $P < 0.05$ was considered statistically significant. Confidence interval was set at 95%. This methodology was further reviewed by an independent statistician.

Observation

Statistical evaluation

Tables 1 and 2 illustrate the temperature recorded at the drill shaft and the tip of the drill, without irrigation and with irrigation, respectively, for the conventional drill and the trephine drill. The significance of the differences observed was evaluated with Student's t-test.

RESULTS

The analysis of data revealed a highly significant difference between the mean temperature at the tip and shaft of trephine drill and that of conventional drill under both the conditions, i.e., without irrigation and with irrigation.

The mean temperature of the tip of trephine drill was significantly higher than that at the tip of conventional drill [Tables 1 and 2]. On the contrary, the temperature

Table 1: Comparison of temperature at drill shaft and tip between conventional drill and trephine drill without irrigation

Type of drills	Temperature (°C)			
	At drill shaft		At tip of the drill	
	Mean±SD	Minimum–maximum	Mean±SD	Minimum–maximum
Conventional drill	43.62±0.58	42.90–44.30	48.20±0.67	47.30–49.10
Trephine drill	34.88±0.81	34.00–36.00	52.98±1.67	51.10–55.20
Unpaired *t*-test	*t*=19.701, *P*=0.000 (<0.001), significant		*t*=−5.936, *P*=0.002 (<0.01), significant	

SD: Standard deviation

Table 2: Comparison of temperature at drill shaft and tip between conventional drill and trephine drill with irrigation

Type of drills	Temperature (°C)			
	At drill shaft		At tip of the drill	
	Mean±SD	Minimum–maximum	Mean±SD	Minimum–maximum
Conventional drill	31.70±0.33	31.30–32.00	32.92±0.72	31.80–33.50
Trephine drill	29.98±0.23	29.70–30.20	35.06±0.68	34.20–36.00
Unpaired *t*-test	*t*=9.556, *P*=0.000 (<0.001), significant		*t*=−4.846, *P*=0.001 (<0.01), significant	

SD: Standard deviation

at the shaft of conventional drill was highly significantly greater than the temperature at the shaft of trephine drill, when drilling was done with irrigation as well as without irrigation [Tables 1 and 2].

On comparing the temperature of the shaft and tip of conventional drill without irrigation and under irrigation, it was found that the temperature of the drill under irrigation was less statistically significant as compared to that without irrigation [Table 3]. Similar findings were observed for trephine drill.

DISCUSSION

The success of dental implants depends on atraumatic implant site preparation.[5-7] Implant site preparation with drills generates heat,[8-13] which can lead to bone necrosis. The amount of bone injury increases exponentially with the increase in temperature and with the duration of the thermal exposure.[14-17]

Over the past decade, many investigators have tried to study the structure of the implant–bone interface and also the influence of drilling on bone healing.[15,18-21] After the bone drilling and the placement of dental implants, a sequence of cellular and molecular events is initiated, which represent a combined response of wound healing.[6]

The rise in temperature during surgical site preparation may delay bone healing process.

Many factors have been reported to influence the temperature rise during surgical preparation for implant placement. Some of these factors include drill geometry, time of preparation, depth of osteotomy, pressure of drill, drill speed, variation in cortical thickness, use of graduated versus one-step drilling, intermittent versus continuous drilling, use of irrigant, and temperature of irrigant.[4]

Various drill designs and geometries have been suggested over the years, as studies have demonstrated that heat generation during drilling procedures plays a significant role in implant failure.[9,10] It has been shown in research that heat induces denaturation of alkaline phosphatase, bone devascularization, and loss of vitality of the periosteum.[11] It is therefore of paramount importance that thermal and mechanical damage to the bone must be reduced during preparation of implant bed.

In this study, the conventional drills were compared with newer trephine drills, which produce less heat in theory because of a single cutting edge. The temperature rise was measured at the apical portion of the drill and at the shaft of the drill. The osteotomies were carried out by a single operator in such a way as to simulate clinical conditions.

This study was conducted without irrigation to compare the effect of drill design on the heat generation. The temperature was compared both at the tip of the drill and at the drill shaft (10 mm above the tip) to get a complete picture of temperature change at the center and at the depth of the osteotomy site. While comparing the rise in temperature (without irrigation) at drill shaft, temperature in conventional drill was found to be significantly higher than trephine drill, whereas at the tip of the drill, temperature of the trephine drill was significantly higher than conventional drill.

This result can be correlated with the fact that during implant site preparation with the conventional drill, the blades at the shaft of the drill also come in contact with the bone surface. This, in turn, results in friction and rise in temperature. In case of trephines, the design is such that the shaft is 0.5 mm away from the bone surface and has no cutting surface. Thus, there was a very little rise in the temperature. The little rise in temperature can be attributed to the heat transmission from tip to shaft of the trephine. The rise in temperature (without irrigation) at the drill tip was found to be significantly higher for trephine compared to conventional drills [Figure 3]. These readings can be associated with the fact that in case of conventional drill, cutting is done throughout drill surface. Hence, the heat generated was distributed. Further, only three cutting

Figure 1: Temperature of trephine drill recorded with infrared thermometer

Figure 2: Temperature of conventional drill recorded with infrared thermometer

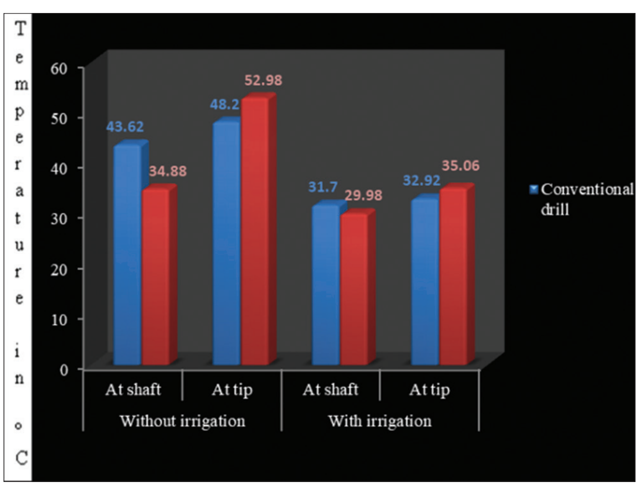

Figure 3: Graph representing the mean temperature rise at drill shaft and drill tip of the conventional and trephine drills

tips of the drill come in contact with the bone surface. In case of trephine drill, cutting was done by closely placed

Table 3: Comparison of percentage reduction in temperature after irrigation at drill shaft and tip between conventional drill and trephine drill

	Conventional drill (temperature in °C)		Trephine (temperature in °C)	
	At shaft	At tip	At shaft	At tip
No irrigation	43.62±0.58	48.20±0.67	34.88±0.81	52.98±1.67
Irrigation	31.70±0.33	32.92±0.72	29.98±0.23	35.06±0.68
Unpaired *t*-test				
t	40.091	34.745	13.059	22.227
P	0.000*	0.000*	0.000*	0.000*

*$P<0.05$ was considered statistically significant

blades present only at the tip, so the amount of friction at the tip was high, and hence, heat generation was high and localized with only some amount of heat transferred to shaft.

Drilling with irrigation leads to decrease in temperature for both the drill types. When comparing the temperature difference between the conventional and trephine drills, almost similar results were achieved in terms of statistical significance. The rise in temperature at drill shaft in conventional drill was significantly higher than the trephine drills, and at the tip, the rise in temperature was significantly higher in trephine as compared to conventional drills.

On comparison of the temperature reading with irrigation and without irrigation, it was found that there was a significant decrease in temperature in conventional drills as compared to trephine drills. These readings can be explained by the fact that irrigation leads to cooling of the drill shafts in case of conventional drills.

At the tip of the drill [Table 1], though there was found to be a definite decrease in temperature with irrigation both for conventional and trephine drills, this difference was found to be statistically insignificant when compared with nonirrigated drilling. These readings can be explained by the fact that the accessibility of the irrigant at the drill tip was less as compared to the shaft of both the drills; thus, temperature dissipation was limited.

The results of the present study demonstrate that the characteristics of drill geometry are an important factor in heat generation during implant site preparation. In the present study, no consideration was given to the extent of the drill use. Although many factors may play a role in drill cutting efficiency and bone temperature, it is their net effect that has a clinical relevance.

The results of this study are influenced by the geometry of the drill. The difference in other factors is not important because, in this study, the increase in temperature was evaluated between two types of drill.

CONCLUSION

Based on the findings and statistical analysis carried out by an independent statistician, we concluded that:

Copious irrigation is a must during osteotomy procedures to prevent bone trauma. The temperature increase during drilling was found to be more at the tip of the drill as compared to the drill shaft. In case of conventional drills, the temperature increase was distributed more evenly as compared to the trephines in which there was heat concentration at the tip of the drill. When using trephines, it very important to have irrigation which can reach till the apex of the drill as the heat concentration is highest in this part of the drill. It can also be concluded that when using conventional drills, the drilling should be done intermittently as heat production is at the shaft as well, so long durations or use of blunt drills can cause trauma to the bone.

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Conflicts of interest
There are no conflicts of interest.

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