A Comparison of Heat Generation in Different Depths of Implant Drilling Site with and without a Sleeve

Original Article

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Abstract

Introduction:
The purpose of this study was to compare the heat generated from different depths of an implant drilling site with and without a sleeve.

Materials and methods:
In this study, 60 cortical bone samples were used and a load of 2.0 kg was applied. rilling for implant surgery, we used a diameter of 4.3 mm and a normal sleeve. Heat was measured from 3 different depths(3,6, and 9 mms). Data was analyzed with a three-way analysis of variance by Newman–Keulsmultiple comparison procedure. The significance level was set to a p-value of 0.05.

Results:
The mean maximum temperature with a sleeve was 35.4°C and without a sleeve was 34.5°C. Thermal rise was lowest in the sleeve group and highest in the sleeveless group. There was a significant difference between the sleeve and non-sleeve group (P= 0.002). There was also no significant differences between the different depths of the three measurements (P= 0.068).

Conclusion:
Within the scope of this invitro study, thermal rise during implant site preparation was lower in conventional drilling compared to the use of a sleeve. Hence, the difference was statistically significant.

Key words:
•Dental Implants• Dental Implantation • Temperature.

Introduction

Functional and esthetic success of dental implant treatment relies on osseointegration and final prosthetic outcome. To achieve the best results, the implant position should be determined by the planned prosthesis. Placement of the implant at a position that corresponds to the apical extension of the predetermined teeth may require the use of a surgical guide. In the past decade, medical imaging technology has been used to ensure that accurate implant placement is established. Guiding systems consist of an imaging workstation for planning the surgery and a technical tool fortransferring the planned surgery to the surgical field.[1]

At present, the most commonly used guides are acrylic resin surgical guides with sleeves or channels along with computerized tomography -derived data. Nowadays, increasing heat during drilling is a major concern regarding successful osseointegration.[2]

Osseointegration has been defined as a close apposition of bone tissue at the light microscopic level with no interposition of connective or fibrous tissue at the bone/implant interface. The early failure of osseointegration may be associated with endogenous factors such as quantity and quality of bone, smoking habits, and host's systemic impairment such as nutritional status and bone metabolic disorders that might impair bone healing or interfere with the maintenance of osseointegration. Failure may also occur from exogenous factors such as excessive surgical trauma or surgical site infection and micro movement.[3]

Numerous methods have been suggested for minimizing interfering factors, which increase heat generation during implant site preparation. Misir et al. evaluated implant surgical guides as an effective factor for the first time and studied heat generated in bone invitro with and without using surgical drill guides. They reported that preparation of an implant site using a surgical drill guide generates more heat than preparation without a drill guide.[4]

Because the heat generated during implant drilling can affect the healing period and the success of implant surgery; therefore, it is important to control it.The aim of this study was to evaluate the heat generated from different depths ofimplant drilling sites with and without the use of a sleeve.

Materials and Methods

In total, 60 uniform fresh bovine femoral cortical bone samples were used in the present study. The rationale for choosing bovine cortical bones was that both human and bovine cortical bones are thermally isotropic.[5] Bovine femurs were obtained within 2 days of slaughter, and all specimens were machined from the mid-diaphysis section of the femur.[5]

The specimens were kept frozen until used. The heat production of the implant drill system (Drill is a Ø 4.3 ceramic drill- SPI VECTO; Thommen Medical, Waldenburg, Switzerland) was evaluated using one with a sleeve and one without a sleeve.

A BEGO Paraskop M Milling machine (Model 288383, Bremen, Germany) was modified to accept a WH 985 AE hand piece. A 2kg constant load and 1,500 rpm speed for drilling were preferred in our study. Further modification of the milling machine allowed a constant load of 2 kg to be applied to the implant hand piece. The hand piece was fixed onto descending arm of the milling machine and 2 kg in weight was replaced on top of descending arm. Drill speed was maintained constant at 1,500 rpm. Allocation of samples in two groups was randomized and torque of motor was 30 NCm. Drilling of the cortical bone was accomplished within the thermostat-controlled water bath. Type K thermocouples (model 5SRTC-TT-KI-36, Omega Engineering, Manchester, UK) were used to measure temperature changes during the drilling sequence of each system. Thermocouples were read by a 3-channel, handheld data logger thermometer (model HH147, Omega Engineering, Manchester), which allowed constant, real-time temperature readings. Temperature measurements were made during site preparation with the final drill of each system.

Readings were based on maximum temperature during each drilling sequence due to the temperature rising to the maximum during each drilling. The maximum temperature for each drilling depth was registered. Bone specimens fixed in acrylic jig replaced a mini fixing table placed over a perforated plate and rotating magnet.

Three thermocouples were inserted vertically to the prepared sites into 1mm holes prepared to the depths of 3, 6, and 9 mm. The thermocouples were secured to the holes and insulated from the outer environment with silicon based paste applied to the canal openings. The samples were divided in the following manner. There were five drillings for every sleeve-drill combination, and the drilling sequences of samples were randomly determined to eliminate unwanted variables.

The inferior half of the bone was submerged in the water bath during drilling. In order to stabilize water bath temperature an active hot plate was used. The hot plate was turned on and off for stabilizing the water temperature inside the aluminum chamber at 29°C±2°C. To circulate water in the chamber and stabilize temperate in all locations, one magnet was replaced under a perforated ledge where the bone specimen was fixed. Magnet rotation circulated water so temperature was fixed in all chamber locations.

When the internal temperature of bone reached a temperature of 29°C±2°C by the implanted thermocouples, Site preparation began. A normal saline solution at room temperature was used for irrigation. Tests that were performed in this study included a three-way analysis of variance using the Newman-Keulzmultiple comparisons procedure. Data was also analyzed using the SPSS-16 software.

Results

In this study, the mean temperature of the water bath was 30.2°C. The mean maximum temperatures at the depths of 3, 6, and 9 mms were 34.8°, 35.6°, and 34.5°C, respectively (Figure1). Thermal rise was significantly higher at a 6 mm depth (P= 0.001) and was lowest at a 9 mm depth. There was no significant correlation between maximum temperature generated at the depths of 3 and 9mm (P= 0.300).

The mean maximum temperature at the depths of 3, 6, and 9 mm in the sleeve group were 35.6°, 36.1°, and 34.3°C, respectively. In the sleeve group, the mean maximum temperature was higher at 6 mm and lower at 9 mm. However, there was no significant difference between the depths of 3,6, and 9 at a 0.05 significance level (P= 0.068).

The mean maximum temperature at the depths of 3, 6, and 9 mm in the non-sleeve group was 34.6°, 34.9°, and 34°C, respectively. In the sleeveless group, the mean maximum temperature was higher at 6 mm and lower at 9 mm. There was no significant difference between the depths of 3.6, and 9 mm at a 0.05 significance level (figure 2).Thermal rise was lowest for the sleeveless group and was highest for sleeve group. Hence, there was a significant difference between both groups(P =0.002).

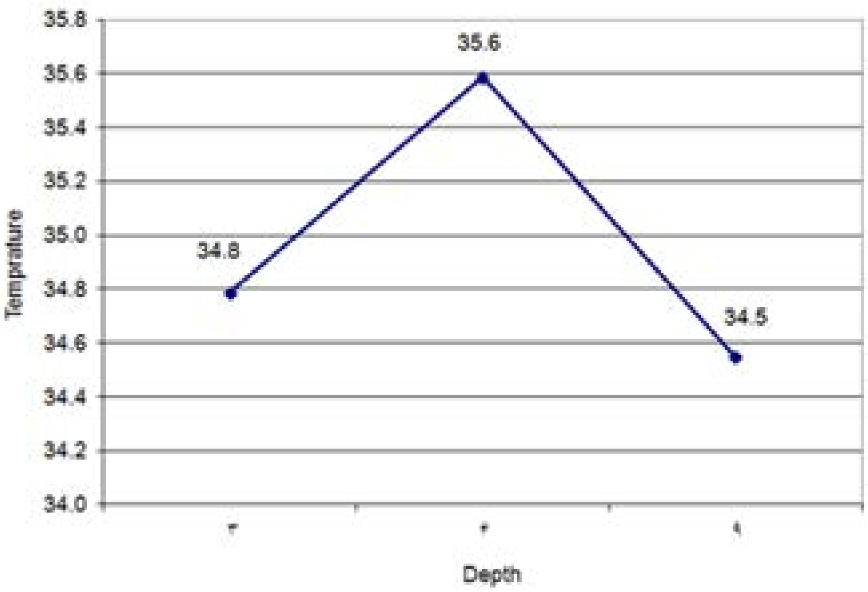

Figure 1. Mean maximum temperature at three depths

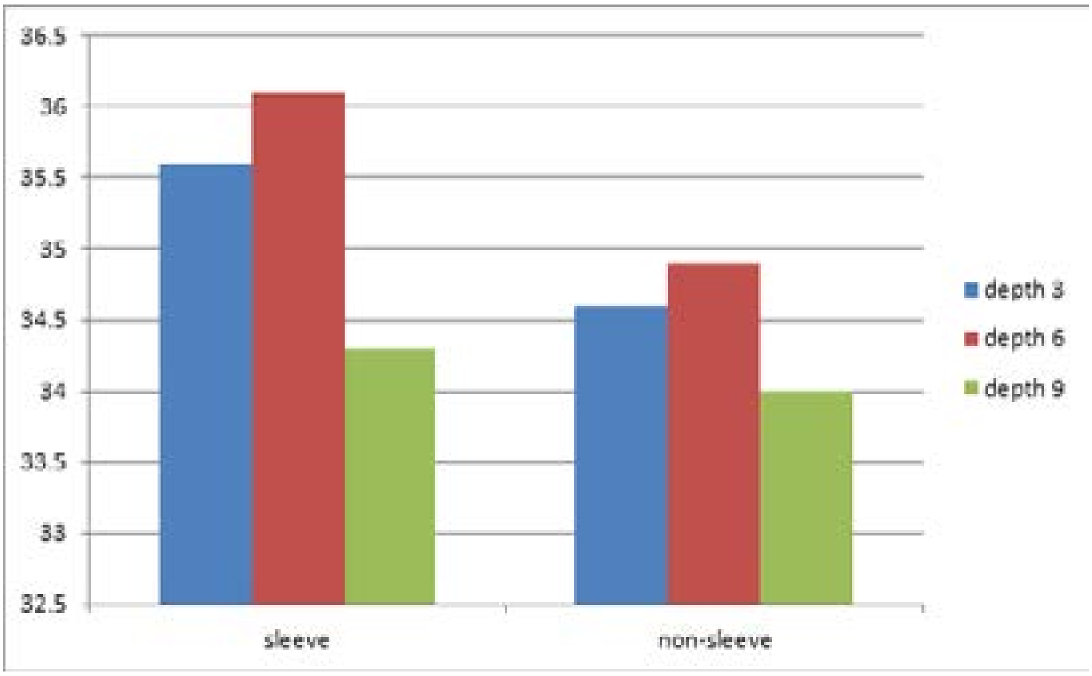

Figure 2. The mean maximum temperature in both groups atthree depths

Discussion

As treatment protocols have progressed, implant manufacturers have met the challenge of providing both surgical and prosthetic components to maximize outcomes in function and esthetics. With the development of modern surgery, bone drilling hasbecome a common step of an everyday procedure in implant dentistry. Many parameters influence the loosening of the bone–implant interface, one of which is thermal osteonecrosis. Bone temperature must, therefore, be below a temperature of 47°C during drilling to avoid thermal necrosis.[6,7]

Implant position may affect the esthetics and function of the restoration.[8] Recently, new surgical guides have been developed for precise implant placement. Precision surgical guides may be defined as metallic guides, these metallic guides are closely matched to the diameter of the drills and/or implants, and are fabricated with the aid of computer-assisted design and computer-assisted manufacturing (CAD/CAM) technology and rapid prototyping.[9,10] We selected an invitro study design using specimens of dead bone, which might have certain limitations. In the invivo conditions, blood flow could dissipate some heat generated during the implant site preparation. In addition, during the preparation of the bone, coagulation and occlusion of small blood vessels are likely to occur quickly, which questions the cooling effect that blood flow could have. Matthews and Hirsch, for instance,drilled human femoral cortices invivo and invitro and obtained similar values.[11]

We applied a 2 kg constant drilling load based on the result gathered by Tehemar,who found that a low hand pressure in the range of 2 kg should be applied throughout the complete bony housing preparation in order to generate less heat.[12]Using a speed of 1,500 rpmfor drilling was preferred in our study. In addition, Eriksson and Adel demonstrated that a low-speed dental implant hand piece running between 1,500 and 2,000 rpm is considered the ideal instrument for implant bed preparation.[13]

In this study, a 4.3 mm drill was used due to the dominant effects of larger drills according to previous studies. Kalidindi and Augustin et al, for example, showed that an increase in drill diameter exponentially increases temperature.[14,15]

Both studies show that a drill diameters of 4–4.5 mm causes an increase in bone temperature above a critical level of 47 °C in comparison with smaller drill diameters (2–3.5 mm). Hence, a 4–4.5 mm diameter is defined as critical.

On the other hand, larger drills have larger flutes, which contribute to the better elimination of heated bone chips and debris resulting in more efficient drilling with a lesser increase in bone temperature. Another problem is that with a decreased drill diameter (≤3.2 mm), a relevant drill bending within the bone can occur. The deviation of the actual to the planned target point ranges from 1 to 10 mm and is significantly influenced by the drilling channel length and the drill bit length.[16] In the current study, temperature changes for the final drill were recorded as this instrument should theoretically exert maximal friction heat owing to its large diameter and high peripheral velocity.[17]

Ceramic tools have advantages such as high-temperature resistance, abrasion and corrosion resistance, and low chemical affinity. However, their use is limited because of their low resistance to mechanical shock, fracture toughness, and low thermal conductivity.[18,19] The temperature in the cutting zone increases because more heat is being generated and/or is concentrated in a small area. Hence, less heat is dissipated.[20] Therefore, the effect of the cutting conditions such as cutting speed, feed rate, and depth of cut could increase the temperature and have less effect on conditions such as tool geometry, material, and cutting fluid.[21]

A higher temperature was observed when using the sleeve, due to no vent for irrigation.

Needle-type (segmented) chips, which were found to clear the flutes as the drill advanced into the bone material and reduce the undesirable heat build-up during drilling.[22] More studies are needed for determining the relationship between quantity and type of bone chip formed in drilling with a surgical guide.

Heat generation is greatest at the drilling cavity base.[23] In this study, cortical bone and continuous drilling was used. It prevents the escape of cut bone chips and access for the irrigation fluid, which may cause clogging of the twist drill bit and increase the generated temperature. This result was consistent with the findings of Ferhat M et al, who found a significantly greater temperature increase was observed at 6 and9 mm depths compared with a 3mm depth.[24]

While drilling, the superficial aspect of a cavity would be subjected to frictional forces for a longer time than the deeper parts of the cavity. Therefore, considering duration, the deeper layers of the cavity were exposed to less friction, and thus the temperature rise was significantly lower than that at shallower levels.

External irrigation was the chosen irrigation method in this experiment. It is obvious that irrigation was effective up to a 3mm depth, as at a 6mm depth, the highest temperature was observed and 9mm a lower frictional force was observed. It, therefore, could be suggested that adding a 4mm sleeve prevents irrigation from reaching the drilling site and decreases irrigation efficacy. As well as this, in a flapless implant placement, using a surgical guide sleeve is essential. Meaning, 3mm added soft tissue thickness prevents irrigation from efficiently cooling superficial bone.[25,26]

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