Evaluation of the Effects of Two Different Drill Designs on Temperature Measurements During Osteotomy – An In Vivo Animal Study

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ABSTRACT
Purpose: This study was to assess the thermic effects and bone-to-implant contact (BIC) caused by two distinct osteotomy drilling designs.
Materials and Methods: An in vivo animal study was conducted on New Zealand White Rabbits to measure temperatures during osteotomies perforated with standard Zimmer drills (Group A) and Densah burs (Group B). In this way, we prepared the osteotomy sites by drilling groups A or B of drills. We meticulously took temperature readings at the mesial and distal sides for all osteotomy sites. The primary endpoint was to assess temperature changes between both drill designs.
Results: The average temperatures recorded at the osteotomy sites, both mesial and distal to them, did not significantly differ between Group A and B (the group's p for side temperature was 0.3094). However, these temperatures were equivalent to the normal bone temperature at the site of insertion for both groups. The distal side temperature of Group A did not significantly exceed the threshold (P = 0.8871) when compared to Group B.
Conclusion: In terms of temperature distribution during osteotomy away from the implant bed, both standard Zimmer drills and Densah burs demonstrated similar effects. Hence, thermal outcomes from the mini drill design to the twister screw thread drive power can be different during osteotomy procedures, while the choice of such a configuration may not play an important role on these materials. This finding may underlie the clinical interchangeability of these drill designs in cases where temperature control during osteotomies is a relevant issue. More studies are needed to evaluate other parameters of BIC and clinical outcomes for a more complete view of the impact that drill design has on osteotomies.

Categories: Dentistry

Introduction

Osseodensification (OD) is an innovative biomechanical method for bone preparation, designed to supplant traditional bone subtractive drilling, ultimately enhancing the quality of the implant site [1]. It intends to induce a compression movement at the contact point of an osseous drill with a specifically made bur termed a Densah bur, resulting in controlled osseous deformation due to the intrinsic nature of skeletal tissue viscoelasticity and viscoplasticity. However, the success of implant integration depends upon various factors [2], among which the generation of frictional heat during drilling plays a critical role [3].

Elevated temperatures exceeding 47°C can lead to adverse outcomes such as bone resorption and crestal bone loss [4, 5]. Factors influencing temperature changes during drilling include drill design, bone density, technique, and irrigation methods [6]. Although tapered drills have demonstrated efficacy, they often result in higher temperatures compared to straight drills. Nonetheless, advancements in tapered drill design aim to mitigate heat elevation, potentially

offering superior outcomes compared to conventional protocols [7].
Given the limited data on OD, our research aims to evaluate the effects of two drill designs on temperature and BIC during osteotomy.

Materials And Methods

A comparative investigation was conducted to evaluate the impact of two distinct drill designs on temperature during osteotomy in an in vivo animal study. The study was carried out at Skanda Life Sciences Pvt. Ltd, within the preclinical division of the Skanda Life Sciences facility, in collaboration with the Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram. Ethical approval for the study protocol was obtained from the Institutional Animal Ethics Committee (IAEC) of Skanda Life Sciences under IAEC number IAEC-SLS-2022-076, ensuring adherence to the guidelines outlined by the Committee for Control and Supervision of Experiments on Animals (CPCSEA) for animal care. Rigorous safety measures were implemented to ensure the well-being of all personnel involved in the study, including the use of personal protective equipment such as gloves, head caps, face masks, protective eyewear, and autoclaved aprons when working with animals.

The study utilized New Zealand White Rabbits, aged 14 weeks, with a weight range of 2 ± 0.3 kg. A total of 8 female rabbits were obtained from Skanda Life Sciences in BIDADI, India, with adherence to ethical guidelines outlined by the CPCSEA, under registration number 2092/PO/RcBt-S/Rc-L/20CPCSEA.

Premedication during surgery included Ketamine hydrochloride injection (50 mg, Themis Medicare Ltd.) and Xylazine injection (20 mg, Stanex Drugs and Chemicals Pvt. Ltd.). Postoperative care involved Lignocaine and Adrenaline injection I.P 30 mL (Lignox 2%A, Warren, Indoco), Enrofloxacin 2.27% (Baytril, 5 mg/kg for 7 days), Meloxicam injection (Meloxicam 5mg/ml, 0.1-0.2 mg/kg for 5 days, Intas Pharmaceuticals Ltd.), and Nebasulf sprinkling powder (10 mg, Pfizer Ltd.). Euthanasia was performed using a Thiopentone injection (1 g, Neon Laboratories Ltd.) at a dose of 100 mg/kg.

Rabbits were individually housed in suspended stainless-steel cages (Figure 1) with access to pellet food and drinking water. Environmental conditions including temperature (20 ± 3°C) and relative humidity (30% to 70%) were closely monitored (Figure 2). Lighting conditions followed a 12-hour light-dark cycle. All rabbits underwent a minimum acclimatization period of 7 days and were closely monitored for any signs of distress or morbidity.

The study design comprised two groups wherein osteotomy was performed using standard drills of Zimmer Surgical Kit (Group A, Figure 3) and Densah Drills (Group B, Figure 4) in the left and right femoral condyles, respectively. Each group consisted of eight rabbits with a total of eight implants in each group. Zimmer implant systems with internal hex and alumina blasted/acid-etched surfaces (3.3 x 8 mm) were utilized, and implants were placed in all osteotomy sites.

Surgical procedures included temperature measurement. Clinical observations were conducted daily and weekly post-surgery, monitoring general and detailed clinical signs as well as mortality. Body weights were recorded periodically, and euthanasia was performed after 12 weeks for histomorphometric analysis.
Thiopentone sodium was administered for euthanasia, and en bloc sections including implants and femoral bones were harvested for further analysis, including radiographs and histomorphometry.

Statistical analysis

Statistical analyses performed using R statistical software (R 3.02) based in Vienna, Austria, employed a generalized linear model with a gamma distribution to evaluate the impact of temperature on two different drill designs during osteotomy.

Results

In this comparison between Groups A and B regarding the mean mesial side temperature, an independent t- test analysis was employed. Group A exhibited a mean temperature of 30.99°C (SD ±1.57°C). On the other hand, Group B showed a slightly higher mean temperature of 31.56°C (SD ±1.01°C). No statistically significant difference was seen between the groups (P = 0.3985). (Table *1*)

Groups	Mean	SD	SE	95% CI for mean.		t-value	P-value
				Lower	Upper		
Group A	30.99	1.57	0.56	29.67	32.30	-0.8710	0.3985
Group B	31.56	1.01	0.36	30.72	32.41		

TABLE 1: Comparison of groups with mean mesial side temperature

CI: Confidence Interval; SD: Standard Deviation; SE: Standard Error

In the comparison between Groups A and B concerning the mean distal side temperature, an independent t- test was conducted. Group A exhibited a mean temperature of 31.26°C (SD ±1.46°C). Conversely, Group B showed a slightly higher mean temperature of 31.35°C (SD ±0.90°C). No statistically significant difference was observed between the groups (P = 0.8871). (Table *2*)

Groups	Mean	SD	SE	95% CI for mean.		t-value	P-value
				Lower	Upper		
Group A	31.26	1.46	0.52	30.04	32.48	-0.1446	0.8871
Group B	31.35	0.90	0.32	30.60	32.10		

TABLE 2: Comparison of groups with mean distal side temperature

CI: Confidence Interval; SD: Standard Deviation; SE: Standard Error

Discussion

The OD drilling technique differs fundamentally from traditional methods, emphasizing non-subtractive multi-step drilling to preserve bone and facilitate autograft compaction along the osteotomy wall. Central to this technique is the densifying bur, which features a snipping chisel and a tapered shank, enabling it to gradually increase diameter and influence expansion as it penetrates deeper into the osteotomy region.

Moreover, drilling at elevated speeds allows for both clockwise and anti-clockwise rotations. Anti-clockwise drilling is particularly effective for densification, especially in low-density bones, while clockwise drilling is preferred for denser bone types. This approach underscores a nuanced understanding of bone characteristics and drilling dynamics, tailoring the technique to optimize outcomes across varying bone densities [8, 9]. Our study evaluated the effects of two different drill designs on temperature measurements during osteotomy.

The results indicated no significant differences observed between the Groups in terms of temperature measurements.

In a novel OD strategy devised by Rodda et al. [10], Densah burs characterized by multiple grooves and an increasing diameter in an anti-clockwise direction were utilized to optimize

implant site preparation and enhance implant stability upon insertion. The counterclockwise rotation of these burs is hypothesized to compact autogenous bone at the apical extremity, facilitating gentle sinus membrane elevation and making the technique particularly valuable for sinus lifts. This approach obviates the need for post-sinus augmentation graft materials, rendering it minimally invasive with promising clinical implications.
Additionally, OD has been shown to significantly enhance implant stability, increasing insertion torque from 25 Ncm with standard drilling to 49 Ncm in low-density bones [9]. However, due to potential temperature elevation and tissue damage, particularly in cortical or denser bone regions such as the mandibular anterior, careful consideration and profuse irrigation are recommended when utilizing OD drills [11].

In our study findings, no statistically significant differences were observed in the mean mesial side temperature ($P = 0.3985$) or mean distal side temperature ($P = 0.8871$) between the groups. This finding suggests that the choice between these two drill designs may not significantly impact temperature distribution during implant osteotomy preparation. Various studies have delved into the issue of heat generation during such preparations, employing diverse methodologies and bone models. A study conducted by Trisi et al. [12] illustrated that bone temperatures reaching 60°C for 1 minute during implant osteotomies significantly reduced BIC in an iliac crest sheep model. Dos Santos et al. [13] observed higher temperatures with guided drilling protocols in a rabbit tibial model, while Barrak et al. [14] advocated for the inclusion of a metal sleeve on a surgical guide in a bovine rib model, noting significant drill wear following multiple osteotomies. Similarly, Kirstein et al. found that the pilot drill resulted in the highest temperatures [15].

Several limitations need to be acknowledged in this study. Firstly, the sample size was relatively small, limiting the generalizability of the findings. Additionally, the study was conducted in an animal model, and results may not directly translate to human patients. Furthermore, only two drill designs were compared, and other factors such as bone density and irrigation methods were not evaluated.

Conclusions

Our study underscores the importance of careful consideration of drill design in implant site preparation. While temperature elevation during osteotomy remains a concern, our results suggest that both standard Zimmer drills and Densah burs can achieve comparable temperature distributions, supporting their use in implant dentistry. Further research is needed to explore the long-term clinical implications of drill design on implant success and patient outcomes.

Additional Information

Disclosures

Human subjects: All authors have confirmed that this study did not involve human participants or tissue.
Animal subjects: Skanda Life Sciences Pvt. Ltd in collaboration with the Sree Chitra Tirunal Institute for Medical Sciences and Technology This in vivo animal study was approved by the IAEC of Skanda Life Sciences under IAEC number IAEC-SLS-2022-076 and CPCSEA, under registration number 2092/PO/RcBt- S/Rc-L/20CPCSEA. Issued protocol number IAEC-SLS-2022-076. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work.
Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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