UTHealth®

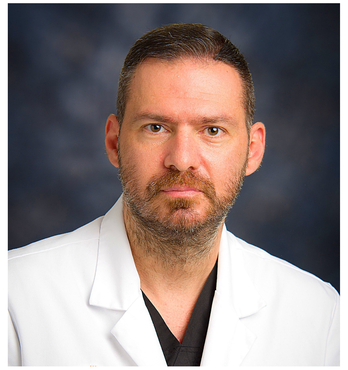
The University of Texas
Health Science Center at Houston

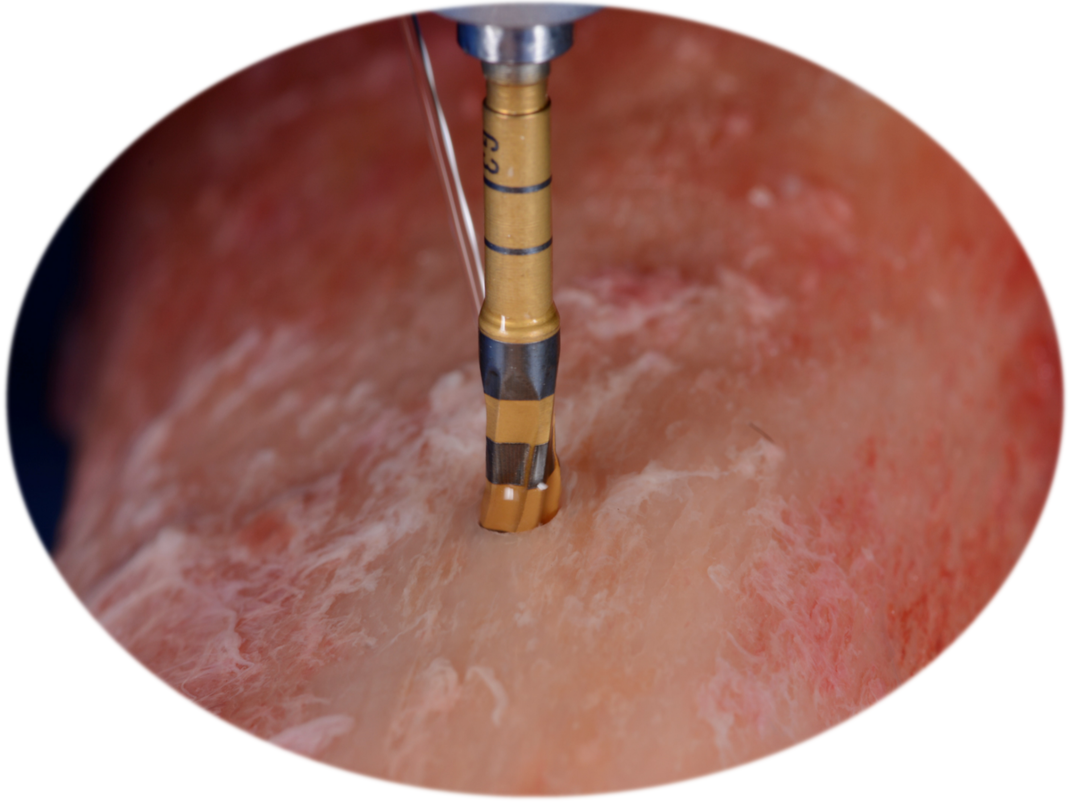
School of Dentistry

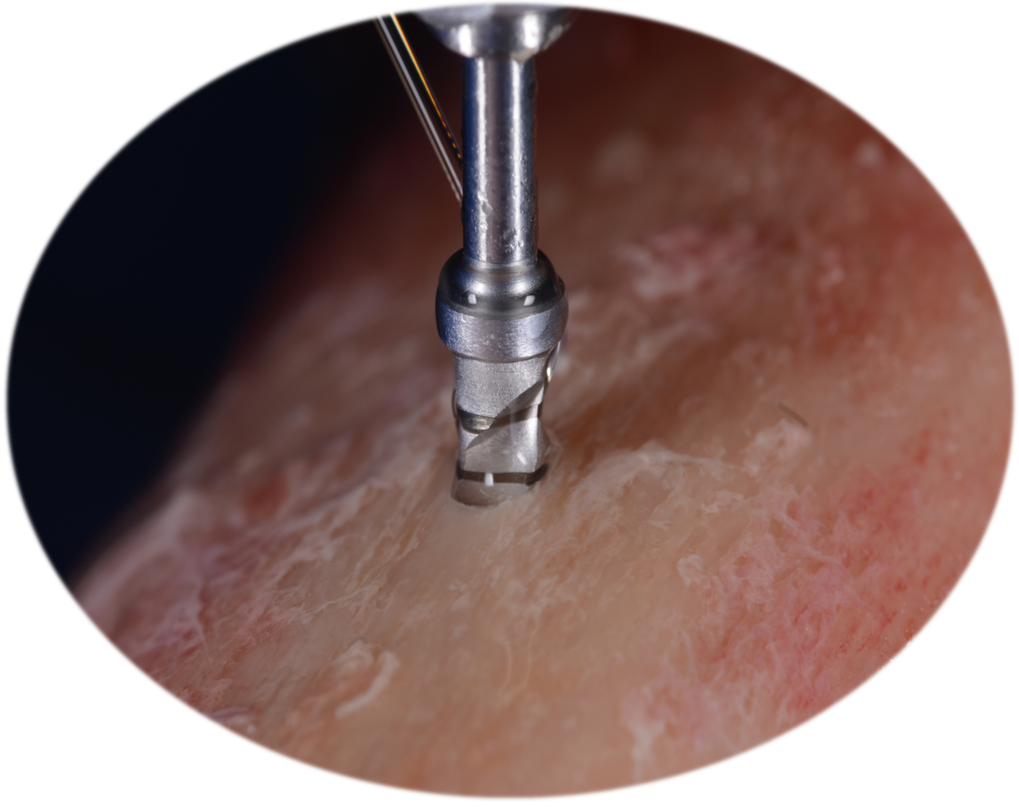
Temperature Changes During Implant Osteotomy Preparations in Human Cadaver Tibiae, Comparing Straight Drills with Densah® Burs

N. Soldatos*, H. Pham, W. Fakhouri

** DDS, MSD, PhD, Associate Professor, Dept. of Periodontics and Dental Hygiene*







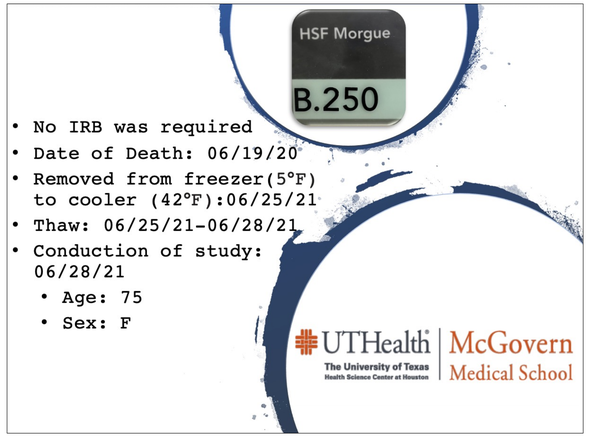
INTRODUCTION

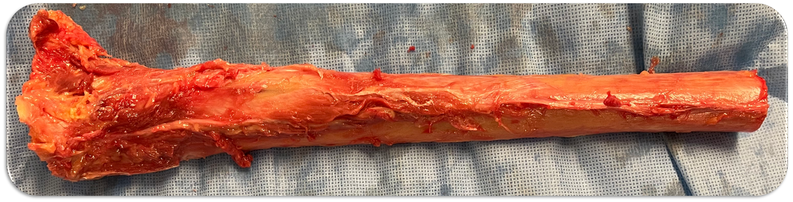
The cutting action of the implant drills, while preparing the osteotomy, converts mechanical work into frictional heat energy. Due to the low thermal conductivity of bone, the energy accumulates at the osteotomy site raising the local temperature. Temperatures beyond a threshold of 47^0C for one minute have been shown to **cause protein denaturation, enzyme inactivation, osteocyte necrosis, bone resorption, and delays in regeneration**. Excessive heat may lead to hyperemia, fibrosis, necrosis, osteolytic degeneration and increased osteoclastic and osteoblastic activity in osseous tissues. Irrigation (internal, external, or combined) is recognized as the single most effective way to reduce the temperatures during implant osteotomy preparation. However, the use of a **surgical guide**, the **drill diameter**, **drill design**, **drill material and wearing**, **duration** of drilling, and the **presence** and **thickness of the cortical bone** may increase the temperature of the alveolar bone.

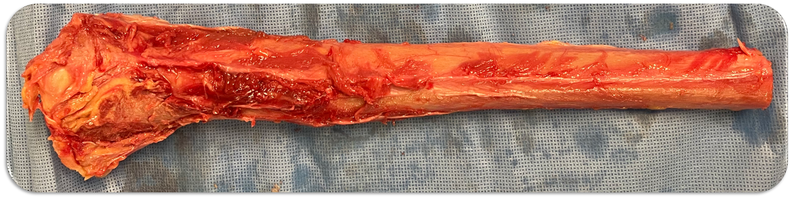
An innovative and highly translational model using fresh human cadaver tibiae immediately postmortem, developed from one of the authors (NS) was used in the present study. Human tibiae and mandibular bone, although have different origin, possess similar compressive strength and elastic modulus. The purpose of the study was to evaluate, in human cadaver tibiae, **the temperature changes (ΔT)** during osteotomy preparations using two different implant systems' drills, with external irrigation and varying RPM.

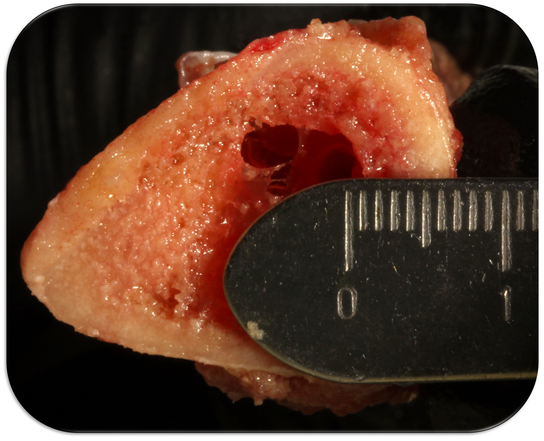
MATERIALS AND METHODS

Institutional review board (IRB) approval was not needed for the conduction of the present study. A seventy-five-year-old female deceased subject was received from the UTHealth McGovern Medical School morgue. The patient had no known history of osteoporosis, bone diseases, HIV, hepatitis, or cancer. At the time of death, she was 5'6'' and 145 lbs. The blood was screened, and the body was immediately placed in the freezer that same day. The lower extremities were removed from the freezer (5°F) and placed in the cooler (42°F) to thaw on June 25th, 2021. The study was performed on June 28th, 2021. Six-inch long unembalmed tibial sections were harvested bilaterally. A temperature regulated water bath, filled with sterile saline, was maintained at a range of 95.2°F to 99.6°F (35.1-37.5°C). Temperature of the saline bath and osteotomies were recorded with an oral thermometer (REF MDS9950) and K-type thermocouple (Fisher Scientific 15-078-187, range -58 to 2000°F, resolution 0.1°/1°, sampling rate 2.5 times per second) with ultra-fast response naked bead probe (maximum range 260°C), respectively. The room temperature was kept at a constant 68 +/-1°F (20˚C). A full thickness flap was reflected, and the specimens were kept submerged in the water bath at body temperature (37˚C). To prepare the osteotomies, the tibial sections were removed from the water bath and placed on a countertop for drilling. After ~2-3 osteotomies, the sections were returned to the water bath to mimic body temperature as much as possible within the bounds of study protocol.

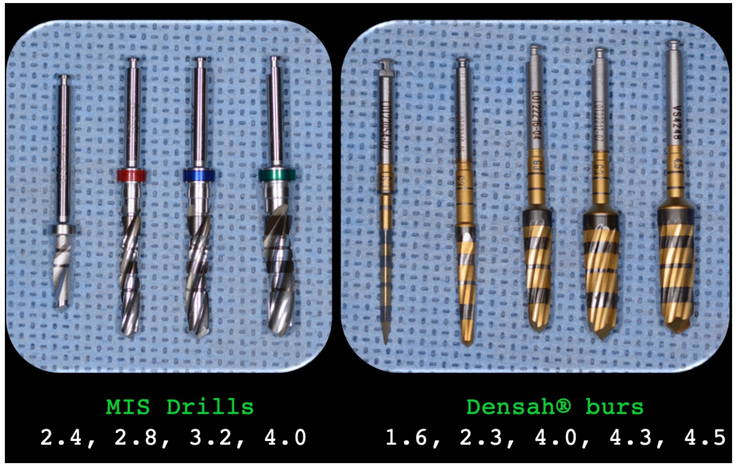


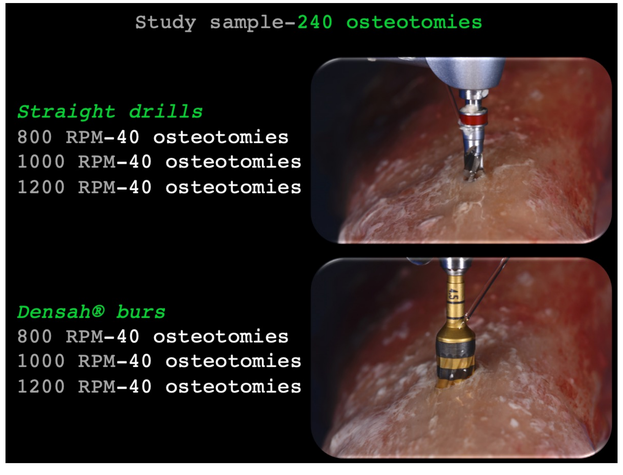


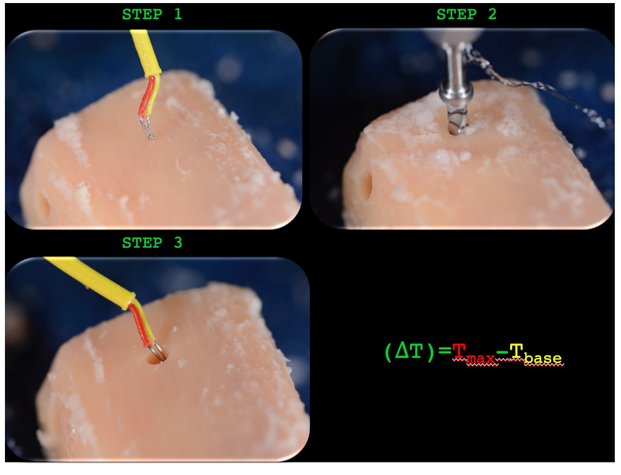






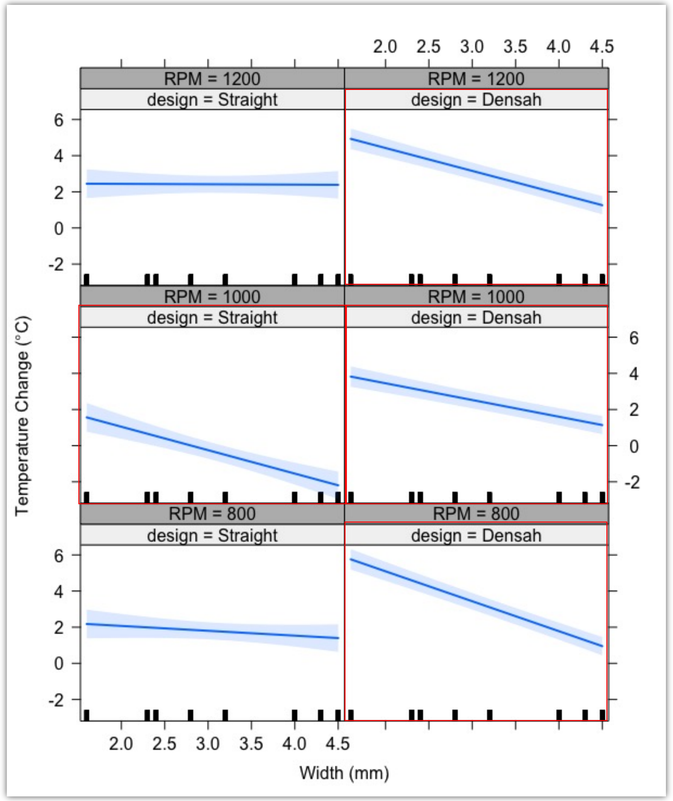






Repeated measurements of the cortical and cancellous bone thickness were taken. The osteotomy depth and the study designs were based on the narrowest region which appeared to be 3 mm of cortical bone and 3 mm of cancellous bone totaling a width of 6 mm. Based on our observations during calibration osteotomies, it was observed that peak temperatures were consistently recorded in the cortical region along the lateral wall of the osteotomy. This is where all temperature readings were recorded. For the statistical analyses the R statistical software was used (R Core Team 2017). A generalized linear model (GLM) analysis was performed, specifying a gamma distribution, to access the effect on ΔT using four variables, (i) drill design, (ii) drill diameter, (iii) drill usage (drillfreq), and (iv) RPM. The variables were evaluated both for their individual effect and for their synergistic effect on ΔT with the use of one-, two-, three- and four-way interactions.

RESULTS



Analysis of deviance table (Type II tests)

(one-way, two-way and three-way interactions)

Source	SS	dF	F	P
design	681.5	1	160.67	$<2.2x10^{-16}$
RPM	496.6	2	58.54	$<2.2x10^{-16}$
width	1312.8	1	309.51	$<2.2x10^{-16}$
design/RPM	228.4	2	26.93	$<3.9x10^{-12}$
design/width	79.2	1	18.68	$<1.7x10^{-5}$
RPM/width	35.6	2	4.19	<0.15
design/RPM/ width	88.7	2	10.46	$<3.17x10^{-5}$

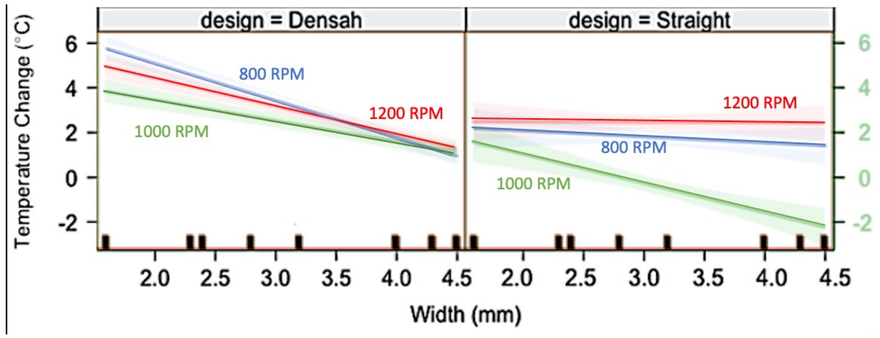
Significant p<0.05

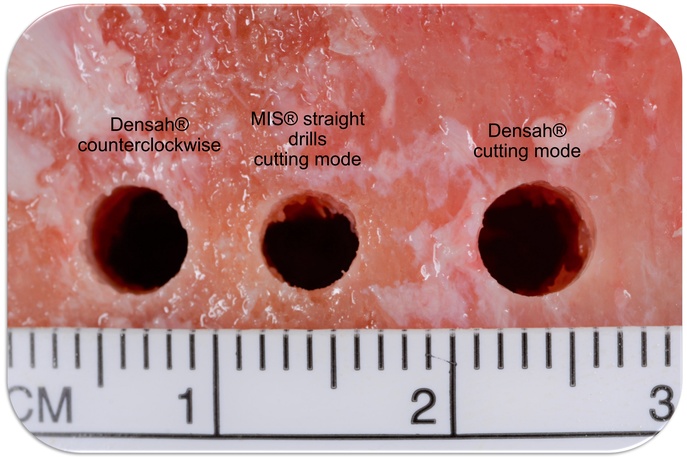
Analysis of deviance table (Type II tests)

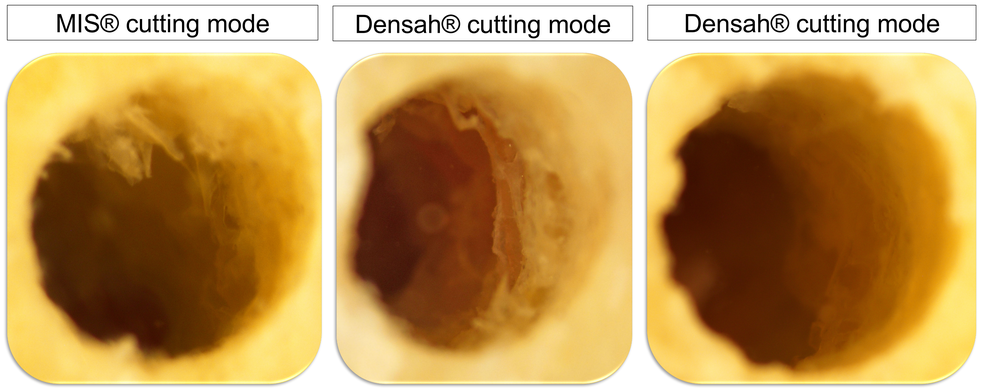
(one-way, two-way, three-way, and four-way interactions)

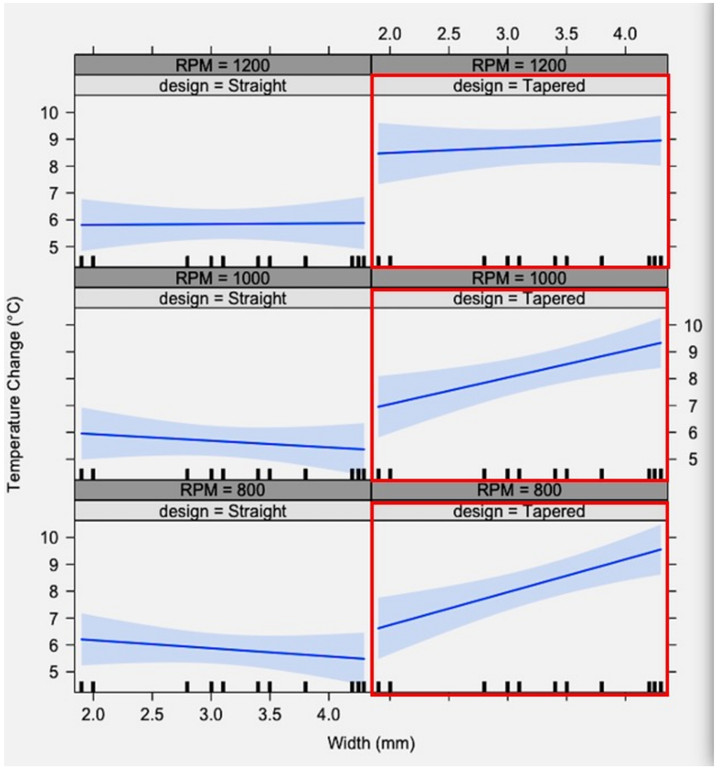
Source	F	dF	DF.res	P
drillfreq	1.8168	1	227.78	0.179037
design:drillfreq	0.1195	1	230.63	0.729868
RPM:drillfreq	2.0348	2	227.78	0.133073
width:drillfreq	0.5810	1	828.22	0.446119
design:RPM:drillfreq	1.2534	2	230.63	0.287477
design:width:drillfreq	0.0228	1	828.22	0.880126
RPM:width:drillfreq	2.2881	2	828.22	0.102096
design:RPM:width:drillfreq	0.1012	2	828.22	0.903756

Significant p<0.05









Analysis of deviance table (Type II tests)

(one-way and two-way interactions)

Source	SS	dF	F	P
design	28.4	1	98.9	<0.001
RPM	0.2	2	0.4	<0.68
width	1.2	1	4.3	<0.04
design/RPM	0.1	2	0.2	<0.79
design/width	2.2	1	7.5	<0.01
RPM/width	0.3	2	0.6	<0.55
design/RPM/ width	0.9	2	1.7	<0.18

Significant p<0.05

CONCLUSIONS

Within the limits of this *in vitro* human tibiae model study, the three-way interaction of drill design, diameter, and specific RPM significantly affected the change in temperature generated during osteotomy preparations in both straight drills and Densah® burs. Nonetheless, within the 95% confidence interval, neither drill system at 800 RPM, 1000 RPM, nor 1200 RPM was observed to generate a ΔT that would surpass the 47˚C threshold to induce cellular damage.