SCIENTIFIC ARCHIVES OF DENTAL SCIENCES (ISSN: 2642-1623)

Volume 4 Issue 2 February 2021

Research Article

Comparative Evaluation of Irrigation System on Bone Temperature Using Thermocouple in Osteotomy Procedures

Pragati Modi, Joann Pauline George* and Prabhuji Munivenkatappa Lakshmaiah Venkatesh

Department of Periodontics and Implantology, Krishnadevaraya College of Dental Sciences and Hospital, Hunsmaranahalli, Bengaluru, Karnataka, India

***Corresponding Author:** Joann Pauline George, Department of Periodontics and Implantology, Krishnadevaraya College of Dental Sciences and Hospital, Hunsmaranahalli, Bengaluru, Karnataka, India.

Received: October 05, 2020; **Published:** February 25, 2021

Abstract

Background: The main objective is to clinically assess the temperature changes during external, internal and combined irrigation while performing osteotomy for implant placement. The aim of the present study was to compare and evaluate the temperatures that were generated under external, internal and combined irrigation technique during intermittent osteotomy drilling for implant placement. A randomized controlled clinical trial was planned to compare the differences in temperature changes among the three modes of irrigation.

Method: The study population consisted of 30 patients aged between 18 - 75 years who underwent implant placement in the maxillary or mandibular region. Temperature changes that were generated under external, internal and combined irrigation techniques during intermittent osteotomy drilling for implant placement were evaluated using K type thermocouple and compared Clinical and radiographical parameters recorded and the outcomes were assessed.

Results: The results of the current trial show that (31.6°C, 32.1°C and 32.5°C) was obtained for initial drill, (31.8°C, 31.8°C and 32.3°C) for intermediate drill and (31.6°C, 31.5°C and 32.4°C) for final drill at three different time thus, there is no difference between internal, external and combined irrigation in terms of heat generation.

Conclusion: All three methods of irrigation provides similar cooling during drilling.

Keywords: *Dental Implantology; External Irrigation; Internal Irrigation; Thermocouple*

Introduction

Since the advent of dental implantology for the restoration of missing dentition, its use has increased markedly due to the phenomenon of osseointegration. This process is dependent on several factors, the most important of which is active primary healing of the implant site. The frictional contact of the drill against bone during the preparation of the implant site heats the adjacent bone [1]. This generation of excessive heat may cause thermal necrosis of the bone, which directly interferes with biological stability through the deterioration of the organic portion of the bony tissue and vascularity in the local circulation. This heat may induce necrosis, fibrosis, bony cystic degeneration and a reduction in osteoblast activity. Temperatures that cross above 47°C can be an impediment for osseointegration [2].

Among the various factors such as drilling depth, drill shape, intermittent vs continuous drilling, irrigation is an important factor that helps regulate temperature changes. Different cooling techniques are used to control the increases in bone temperature caused by friction of the drill during osteotomy [1]. External irrigation disperses irrigation solution over the superficial cortical bone and dissipates heat. The internal irrigation technique propels the irrigating liquid through a hole in the interior of the drill and reach-

es the upper cancellous region of deeper osteotomy and it helps to reduce heat. The combined irrigation technique is a combination of the above two techniques, thus targeting both superficial cortical bone and deeper cancellous bone. It can be hypothesized that combined irrigation will show better temperature control as compared to external and internal irrigation.

Objectives of the Study

The Objective of the current study is to clinically assess the temperature changes during external, internal and combined irrigation while performing osteotomy for implant placement and to compare the differences in temperature changes between internal, external, combined irrigation during implant osteotomy preparation.

Temperature was measured during the use of three subsequent Implant drills for osteotomy preparation. The temperatures were measured with the help of an indigenously fabricated thermocouple in degree Celsius under standardized conditions.

Methodology

The available literatures explores minimally, the heat production using the internal and external irrigation system during implant placement *in vivo*. The comparison of the temperatures generated using various irrigation techniques during implant placement *in vivo* can throw more light in this area of study.

Source of data

Patients aged between 18 - 75 years requiring dental implants were selected from the outpatient Department (OPD) of Periodontology, Krishnadevaraya College of Dental Sciences and Hospital, between November 2016 - March 2018. A detailed explanation of study and procedure was informed to the patients and a written institutional review board approved informed consent was obtained from each patient. (Ref No. 02_D012_72336).

Inclusion criteria were Single/partially edentulous state with minimum soft tissue deficiency (Sieberts class I and II) [3], Replacement of any teeth indicated for extraction due to Chronic periodontitis, abscess or trauma but with adequate bone width and height for implant placement [2], Patients aged between 18 - 75 years of age [4], Patients willing to participate in the study [5], Patients with esthetic/masticatory concerns [5], Patients who demonstrate good oral hygiene maintenance with a plaque score of < 10% good compliance [3], American society of anesthesiology classification of patients as class I, II and III, Stable Occlusion and Healthy Periodontium [1].

The exclusion criteria were uncontrolled metabolic disorders like osteoporosis and diabetes mellitus, pregnant and lactating women, untreated or uncontrolled caries/periodontal disease, Patients with malignancy, Patients who have undergone chemotherapy five years prior to implant surgery, Patients with Irradiation in head and neck region, Patients with history of other metabolic bone diseases, Medical contraindications for implant placement (Bleeding disorders, Risk of Endocarditis, immunosuppressive medications, systemic autoimmune diseases), Patients on current or previous use of oral/IV bisphosphonates, Patients with known bruxism, Patients with habits such as alcohol or drug abuse [6].

Study settings

Sampling technique

Patients were assigned to one of the three groups after randomization as Group A, B, C accordingly:

1) Group A: 10 Patients undergoing internal irrigation.
2) Group B: 10 Patients undergoing external irrigation.
3) Group C: 10 Patients undergoing combined irrigation.

Operator and institution

All the procedures were performed in the Department of Periodontology, Krishnadevaraya College of Dental Sciences and Hospital, Bangalore. This study was conducted by two investigators and one operator. Training and calibration prior to the study were conducted to ensure intra and inter examiner reproducibility with respect to measurement of temperature. The patients were unaware about the type of irrigation.

Study design

A randomized controlled parallel group clinical trial design was employed, according to the Consolidated Standard of Reporting

Trials (Consort Criteria) 2010. All patients completed an initial therapy that included oral hygiene instructions and scaling and root planning. One implant in each patient i.e. a total of 30 implants were randomly placed.

Data collection

Data collection included clinical and radiological measurements at the time of the implant placement. Ridge mapping was done to clinically assess the quantity of bone.

The following clinical measurement for the teeth adjacent to the edentulous site were examined at six sites. Pocket Probing Depth i.e. taken from Gingival Margin to the base of the sulcus or pocket, Clinical Attachment loss i.e. distance from Cementoenamel Junction to base of the pocket or sulcus, Gingival Recession - Distance from Cementoenamel Junction to gingival margin.

Radiographic assessment: The radiographs were taken using standardization such as the positioning device and RVG. Type II bone (Lekholm and Zarb Classification) was selected for the study. Upper and lower study casts was fabricated for occlusal analysis and also to fabricate stents and surgical guides.

Pre-treatment procedures

Initial therapy that included scaling and root planning was completed 4 - 6 weeks prior to the implant placement. Then the patients who demonstrated ≤ 10% O Leary plaque index were subjected to the study protocol. The study was designed so that extraneous factors such as oral hygiene and compliance were controlled within each subject.

Randomization

Allocation concealment was done using a sealed coded envelope containing the treatment of the specific subject. The investigator opened this sealed envelope containing treatment assignment prior to the treatment procedure and allotted the cases to the operator accordingly.

Surgical procedure [6]

Surgical treatment was not scheduled until the patient had an adequate standard of plaque control and no signs of acute infection. The surgical site was kept aseptic, and the patient was appropriately prepared and draped for an intraoral surgical procedure. Pre surgical rinse with 10 ml of 0.2% chlorhexidine gluconate for 1 minute was done. Local anaesthesia was administered at the site of operation.

In edentulous area [7]: A mid-crestal incision extending through the interproximal and sulcular tissues of the adjacent teeth was placed. A full-thickness flap was raised (buccal and lingual) up to or slightly beyond the level of the mucogingival junction, exposing the alveolar ridge of the implant surgical site.

In immediate extraction socket [7]:

- An incision is made into the gingival sulcus of tooth to be extracted extending to and through the periosteum along the long axis of the tooth.
- Atraumatic extraction was done with the help of periotomes and socket was curetted to remove the granulation tissue with the help of curettes. Irrigation of the socket with povidone iodine was performed.

Implant placement:

- A endosseous dental implant was placed in the edentulous ridge according to the standard procedures, with the implant shoulder 2 - 3 mm apical to the mid buccal mucosal margin. The platform of the implant was placed 2 - 3 mm below CEJ of the adjacent teeth.

Thermocouple placement/removal and assessment of temperature changes

Thermocouple was removed as soon as the drilling stopped and the time was calculated. The temperature was measured during drilling. A total of 3 temperature readings were recorded for each implant osteotomy site preparation at end of each drilling procedure (10 seconds). The temperature of the osteotomy site was measured during the use of pilot drill, and the subsequent drills at a constant drill speed of 850 rpm. A type k thermocouple was indigenously fabricated. The thermocouple measured the temperature at a distance of 0.5 mm lateral to the drill perforation. The temperature measurement was repeated for all the subsequent drills. To prevent cooling of the thermocouple its extraneous parts

were covered by insulated tubing. The tip of the thermocouple was placed for about 10 seconds uniformly for each drilling sequence. This was specially fabricated in isolation and coupled to a portable digital monitor (MODEL -8250 HEATCON) with a measurement range between - 50 and + 1200°C. The type k thermocouple measured the temperature at the installation of site with a response time in seconds.

Drilling sequence for either procedures [8]

The 2-mm Twist Drill. A small twist drill, usually 2 mm in diameter was used at a speed of approximately 800 to 1500 rpm, with copious irrigation to prevent overheating of the bone. Drill was intermittently and repeatedly "pumped" or pulled out of the osteotomy site while drilling to expose them to the water coolant and to facilitate clearing bone debris from the cutting surfaces. Following the 2-mm twist drill, a pilot drill with a noncutting 2-mm-diameter "guide" at the apical end and a cutting 3-mm-diameter (wider) midsection is used to enlarge the osteotomy site at the coronal end, thus facilitating the insertion of the subsequent drill in the sequence.

Subsequent drills

Depending on the implant design, final diameter and desired length subsequent drills were used for osteotomy preparation. The final osteotomy diameter was maintained narrower than the implant diameter as instructed by the manufacturer. The implant site was now prepared for implant insertion. The osteotomy was lavaged and aspirated to remove bone debris and stagnant blood. Implants were inserted at slow speeds ranging from 25- 30 rpm with low speed high torque hand piece or a hand wrench. Torque not greater than 35 Ncm was maintained while threading the implant into position. Insertion of the implant must follow the same path or line as the osteotomy site. When multiple implants are being placed, guide pins in the other sites were used as a visual guide for the path of insertion. Once the implants are inserted and the cover screws secured the surgical sites were thoroughly irrigated with sterile saline to remove debris and clean the wound. A combination of alternating horizontal mattress and interrupted sutures with periosteal releasing incisions if necessary was used for primary closure of the tissues in a tension free manner. Buccal and lingual tissue flaps are approximated. Black braided silk sutures (3-0) were placed to protect the implant site. Patients were prescribed antibiotics and analgesics were prescribed to the patients for 3 days post operatively along with chlorhexidine mouth rinse for 15 days. Patients were instructed to apply cold pack at the surgical site during the first 6 hours after surgery and to rinse with chlorhexidine mouth wash (0.2% twice daily for 10 days). The sutures were removed 7 - 10 days after surgery.

Results

The results for each parameter (numbers and percentages) for discrete data and averaged (mean + standard deviation) for each parameter were presented in tables and figures. The normality of the data was assessed using Shapiro Wilk test and it was noted that distribution is Normal.

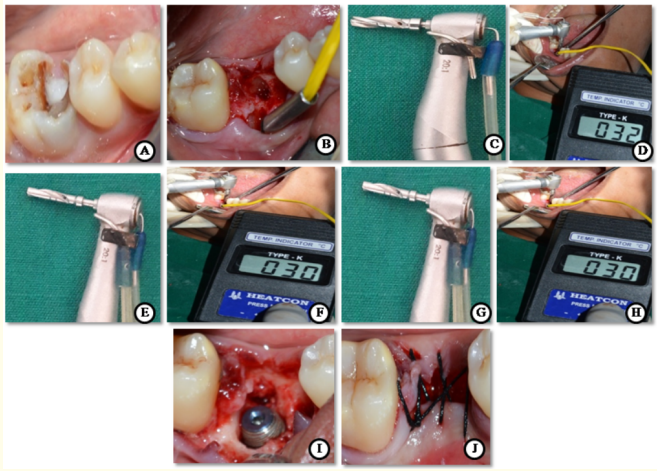

Figure 1: Steps during internal irrigation. (A) Extraction wrt 46, (B) Thermocouple placed, (C) Initial drill, (D) Initial temperature recorded, (E) Intermediate drill, (F) Intermediate temperature recorded, (G) Final drill, (G) Final temperature recorded, (H) Implant placed (I) sutured.

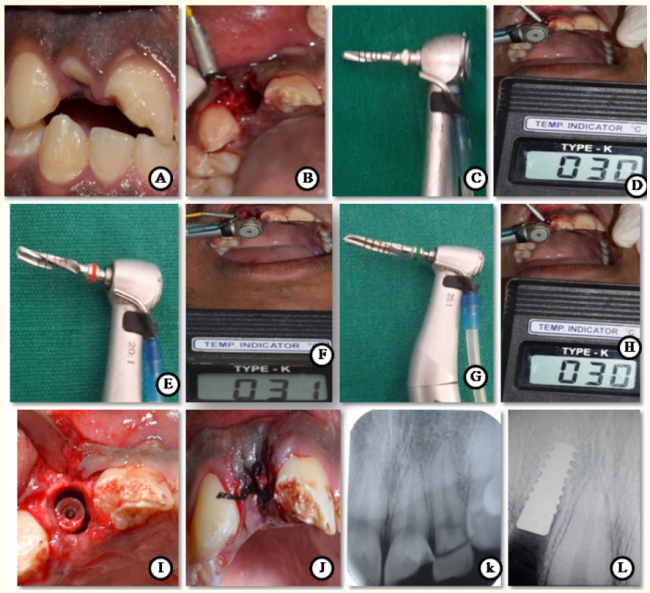

Figure 2: Steps during external irrigation (A) Fractured 12, (B) Thermocouple placed, (C)Initial drill, (D) Initial Temperature recorded, (E) Intermediate drill, (F) Intermediate temperature recorded, (G) Final drill, (G) Final temperature recorded, (H) Implant placed, (I) Sutured, (J) Pre op IOPA, (K) Post op RVG.

Figure 3: Steps during combined irrigation (A) Edentulous wrt 16, (B) Thermocouple placed, (C) Initial drill, (D) Initial temperature recorded, (E) Intermediate drill, (F) Intermediate temperature recorded, (G) Final drill, (G) Final temperature recorded, (H)Implant placed, (I) Sutured, (J) Pre op RVG, (K) Post op RVG.

Intergroup comparison of mean temperature difference obtained in initial, intermediate and final drill between different irrigation systems (Table 1).

Irrigation	Between	Mean Difference	SE of Diff	P value
Initial	Internal External	-0.5000	1.199	0.682
	Internal Combined	-0.99	1.158	0.448
	External Combined	-0 .400	0.572	0.493
Intermediate	Internal External	0.000	0.984	1.000
	Internal Combined	-0.500	0.985	0.587
	External Combined	-0.500	0.647	0.450
Final	Internal External	0.100	1.059	0.926
	Internal Combined	-0.800	1.120	0.484
	External Combined	-0.900	0.767	0.256

Table 1: *Intergroup comparison of mean temperature difference obtained in initial, intermediate and final drill between different irrigation systems.*

Statistical Test – Students t test.

If p value < 0.005, Not significant.

The mean temperature difference observed during initial drill use between group A and group B was -0.5°C ± 1.1, between group A and group C it was -0.9°C ± 1.1 and between group B and group C was -0.4°C ± 0.5. There was no statistically significant difference between the groups. The mean temperature difference observed during intermediate drill use between group A and group B was 0°C ± 0.9, between group A and group C it was -0.5°C ± 0.9 and between group B and group C it was -0.5°C ± 0.6. There was no statistically significant difference between the groups. The mean difference observed during final drill use between group A and group B was 0.1°C ± 1.0, between group A and group C it was -0.8°C ± 1.1 and between group B and group C it was -0.9°C ± 0.7. There was no statistically significant difference between the groups.

Students t test was used to assess whether there was the difference between the temperatures and irrigation.

Intragroup comparison showing mean change in temperature between three drilling sequence during Internal, External and Combined Irrigation (Table 2).

Irrigation	Drill	N	Mean temp (°c)	SD	Min (°c)	Max (°c)	F value*	P value
Internal	Initial	10	31.6	3.502	27	39		
	Intermediate	10	31.8	2.616	27	36	0.014	0.986
	Final	10	31.6	2.989	28	36		
External	Initial	10	32.1	1.449	30	34		
	Intermediate	10	31.8	1.687	29	35	0.374	0.692
	Final	10	31.5	1.509	30	34		
Combined	Initial	10	32.5	1.080	31	34		
	Intermediate	10	32.3	1.160	30	34	0.049	0.952
	Final	10	32.4	1.897	30	36		

Table 2: *Intragroup comparison showing mean temperature during internal, external and combined irrigation.*

*Statistical Test - *Two Way Anova.*

If p value < 0.005, Not significant.

In group A the mean change in temperature between initial and intermediate drill was -0.2°C ± 1.3 which was not statistically significant (p value- 0.8), between initial and final drill it was 0°C ± 1.4 which was not statistically significant (p value- 1.0) and between intermediate and final drill it was -0.2°C ± 1.2 which was not statistically significant (p value- 0.8). In group B the mean change in temperature between initial and intermediate drill was 0.3°C ± 0.7 which was not statistically significant (p value- 0.6), between initial and final drill it was 0.6°C ± 0.6 which was not statistically significant (P value- 0.3) and between intermediate and final drill it was 0.3°C ± 0.7 which was not statistically significant (P value- 0.6). In group C the mean change in temperature between initial and intermediate drill was 0.2°C ± 0.5 which was not statistically significant (P value- 0.6), between initial and final drill it was 0.1°C ± 0.6 which was not statistically significant (p value- 0.8), between intermediate and final drill it was - 0.1°C ± 0.7 which was not statistically significant (p value- 0.8). The maximum reduction in temperature 0.6°C was noted in group B from initial to final drill whereas the highest gain in temperature was noted in group A from initial to intermediate drill of 0.2°C. However, these differences were not statistically significant.

Discussion

In the current trial the temperature noted during the use of external irrigation was 32.1°C ± 1.4°C (Initial drill), 31.8°C ± 1.6°C (Intermediate drill), 31.5°C ± 1.5°C (Final drill). The same temperatures were also noted by Misir [9] and Ercoli [10]. The mean temperature noted in the current trial during internal irrigation was 31.6°C ± 3.5°C (Initial drill), 31.8°C ± 2.6°C and 31.6°C ± 2.9°C (Final drill). Strbac [11] noted a temperature of 25.86°C while using internal irrigation which is similar to the outcomes of the current trial. When combined irrigation was used in the current trial a temperature of 32.5°C ± 1.0°C (Initial), 32.3°C ± 1.1°C (Intermediate) and 32.4°C ± 1.8°C (Final drill). The outcomes are relatively similar to that of Strbac of 25.68°C [11].

No change in temperature was noted during external irrigation 0.6°C ± 1.8°C, from initial to final drill which is similar to that of Strbac [11] -0.4°C and Strbac [12] 0.48 - 1.48°C. Whereas in the internal irrigation group no change in temperature was observed. While combined irrigation was used, a temperature increase of -0.1°C ± 2.2°C was seen. Strbac [11] reported that a temperature decrease of 0.27°C and 0.51 - 1.51°C. The increase in temperature seen in the present trial was very minimal and clinically/statistically insignificant.

No differences in temperature changes were noted between external irrigation and internal irrigation. Literature suggests that external irrigation is mainly suitable in superficial locations and internal irrigation may be beneficial in deeper site osteotomies however this may be considered controversial as both the outcomes are equivalent (Table 2) as also been seen by other authors [13-15]. However, in contrast Strbac., *et al*. observed that internal and com-

bined irrigation procedure may be more beneficial in deeper osteotomies and prolonged drilling protocols such as surgical template guided implant site preparation. However, such results were not noted in current trial, these difference may be attributed to the *in vivo* nature of the current trial while the above mentioned trials were *in vitro*. The results of the current trial observe that there is no difference between external and internal irrigation [14]. The maximum temperature recorded was 39°C for internal irrigation group, 35°C for external irrigation group, 36°C for the combined irrigation group. Also, different sequences in drilling (Initial, intermediate, Final) did not show any difference in temperatures.

There is very scanty information reporting the different modes of irrigation on temperature changes in human trials. Hence the current study being the first of its kind comparing three modes of irrigation and temperature change, it was not possible to corroborate the outcomes with similar trials. From the current trial it can be concluded that neither internal irrigation nor combined irrigation provided better cooling than external irrigation during drilling. The limitation of the present study is that temperatures were recorded using thermocouple at only one point close to the superficial part of the drill. The temperature alteration in the middle and the apical portion of the osteotomy site was not measured. Record of changes in temperature at different time intervals during drilling would have been more informative. Another limitation is other signs such as implant survival rate or peri-implant bone loss could have been useful in analyzing the clinical impact of these drilling techniques.

Conclusion

Thorough use of irrigation is beneficial during osteotomy procedures. External irrigation provides similar cooling during drilling as compared to internal and combined irrigation. The three modes of irrigation during initial drill was similar There was no difference in the temperatures recorded found during intermediate drill usage There was no difference found during final drill. The temperature changes from initial to final drill was similar in all groups (0.5°C, 0°C, 0.1°C). It can be concluded from the current trial that all the three modes of irrigation (External, Internal, Combined) showed similar temperature during the use of three different drills for implant site preparation. The Internal and Combined irrigation did not provided any advantage despite the fact that internal irrigation dissipates heat in the deep cancellous layer of the implant osteotomy site. Further studies that assess the implant success by evaluating the crestal bone level and clinical parameters over a longer follow up of more than 1 year is deemed necessary. Randomised Controlled clinical trials with increased sample size will throw more light regarding the three modes of irrigation and its influence on implant success.

Authors Contribution

Pragati Modi - Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Software.

Joann Pauline George - Formal analysis, Writing - original draft, Writing-review and editing.

Prabhuji M.L.V - Supervision, Validation, Visualization, Resources.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Bibliography

1. Flanagan D. Osteotomy Irrigation: Is it Necessary? Implant Dentistry. 2010;19(3):241-249.

2. AD Pye, DEA Lockhart, MP Dawson, CA Murray, AJ Smith. A review of dental implants and infection. Journal of Hospital Infection. 2009;72(2):104-110.

3. Schneider D, Grunder U, Ender A, Hammerele CHF, Jung RE. Volume gain and stability of peri-implant tissue following bone and soft tissue augmentation: 1 year results from a prospective cohort study. Clin Oral Implants Res. 2011;22(1):28-37.

4. Sohn J, Park JC. Simultaneous placement of interpositional free gingival graft with non submerged implant placement. J Periodontal Implant Sci. 2014;44(2):94-99.

5. Becker W, Gabitov I, Stepanov M, Kois J, Smidt A, Becker BE. Minimally invasive treatment for papilla deficiencies in aesthetic zone: a pilot study. Clin Implant Dent Relat Res. 2010;12(1):1-8.

6. Temmerman A, Rasmusson L, Kübler A, Thor A, Merheb J, Quirynen M. A Prospective, Controlled, Multicenter study to evaluate the clinical outcome of Implant Treatment in Women with Osteoporosis/Osteopenia: 5 year results. J Dent Res. 2018;98(1):84-90.

7. Misch E C. Contemporary Implant dentistry, 3rd edition, Mosby, St. Louis Missouri, 2008:557-668.

8. Carranza F A. Clinical Periodontology, 10th edition, Elsevier, St Louis Missouri, 2010:1125-1127.

9. Misir AF, Sumer M, Yenisey M, et al. Effect of surgical drill guide on heat generated from implant drilling. J Oral Maxillofac Surg. 2009;67(12):2663-2668.

10. Ercoli C, Funkenbusch PD, Lee HJ, et al. The influence of drill wear on cutting efficiency and heat production during osteotomy preparation for dental implants: a study of drill durability. Int J Oral Maxillofac Implants. 2004;19(3):335-349.

11. Strbac GD, Giannis K, Unger E, Mittlbock M, Watzek G, Zechner W. A novel standardized bone model for thermal evaluation of bone osteotomies with various irrigation methods. Clin Oral Impl Res. 2014;25(5):622-631.

12. Strbac GD, Unger E, Donner R, et al. Thermal effects of a combined irrigation method during implant site drilling. A standardized *in vitro* study using a bovine rib model. Clin Oral Implants Res. 2014;25(6):665-674.

13. Benington IC, Biagioni PA, Briggs J, Sheridan S, Lamey PJ. Thermal changes observed at implant sites during internal and external irrigation. Clin Oral Impl Res. 2002;13(3):293-297.

14. Haider R, Watzek G, Plenk H. Effects of drill cooling and bone structure on IMZ implant fixation. Int J Oral Maxillofac Implants. 1993;8(1):83-91.

15. Lavelle C, Wedgwood D. Effect of internal irrigation on frictional heat generated from bone drilling. J Oral Surg. 1980;38(7):499-503.

Volume 4 Issue 2 February 2021