

ASSESSMENT OF LOW-SPEED DRILLING WITHOUT IRRIGATION VERSUS CONVENTIONAL DRILLING WITH IRRIGATION REGARDING HEAT GENERATION AND PERI-IMPLANT MARGINAL BONE LOSS (RANDOMIZED CLINICAL TRIAL)

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ABSTRACT

INTRODUCTION: Most implant systems use drilling with irrigation to avoid the overheating of the bone. In the relatively high speed technique, irrigation may not reach the full depth of osteotomy. This triggered the use of low speed drilling technique without irrigation.

OBJECTIVES: were the assessment of heat generation and marginal bone loss around implants placed by drilling speed 150 rpm without irrigation compared with implants placed by drilling speed 1200 rpm with irrigation up to one-year follow up.

MATERIALS AND METHODS: A total of 12 patients were enrolled in this study. Forty implants were placed bilaterally in the posterior mandibular region. Each patient received the two types of drilling techniques. The temperature of the bone was measured before and after the implant site preparation by thermocouples. The marginal bone loss was evaluated by CBCT.

RESULTS: there was statistically different in temperature of bone between the two drilling techniques. Marginal bone loss showed no statistical difference.

CONCLUSION: Low speed drilling 150 rpm without irrigation is a successful and applicable drilling technique in implant site preparation regardless of its relatively high temperature, as it did not exceed the critical limit.

KEYWORDS: dental implant placement, low-speed drilling without irrigation, heat generation, thermocouples, biological drilling.

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INTRODUCTION

Implant site surgery should be as atraumatic as possible to prevent necrosis of osteocytes and for effective osseointegration of implant.¹ Numerous researches have studied the outcomes of increased temperature on bone, such as necrosis, fibrosis, bone cystic collapse, and common recession of osteoblastic performance. This may be caused by the physical properties of the bone that allow minimum heat diffusivity and prevent the elimination of the overindulgent heat during preparation. In fact, it was recognized that medullar bone, due to its higher blood supply, has a higher performance of scattering increased temperature than cortical bone. During drilling of the implant location, it was confirmed that the heat level avoiding necrosis of the surrounding structures is between 44°C and 47°C and the preparation period should be minimal by 1 minute. The heat indulgence during preparation is also affected by the drill design, repeated usage of drills, and irrigation.²

Numerous varied ways to implant site preparation had been analyzed: (a) traditional preparation, which is the continuing expansion of the drilling location by gradual additions of the drill width; (b) simplified preparation, which contains the decrease in the count of drills by usage of a pilot drill followed by a definite drill; (c) biological preparation, which contains low speed preparation without irrigation for gradual location preparation; and (d) single bur preparation, which have been established with unique drills with four-bladed surface and external irrigation.³

Concerning the drilling speed, some authors have introduced that there was no significant difference in bone healing from the usage of different drilling velocities. As Ribeiro Junior et al. (2007)⁴ studied the mandibular bone healing defects done in rabbits using three different rotary protocols. Fifteen rabbits were arbitrarily divided into 3 groups (n=5) according to the type of rotary technique used to create bone defects. The first group used air low-speed rotation engine (maximum of 2,000 rpm), the second group used air high-speed rotation engine (maximum

of 330,000 rpm), and the third used electricity driven low-speed rotation engine (maximum of 25,000 rpm). Histological and morphological analysis occurred after 2, 7 and 30 days to the bone. The results showed that there were no significant differences ($p > 0.05$) noticed between the three groups. So, the study concluded that the speed of rotary devices used in surgery didn't affect the bone healing procedure.

The conventional drilling speed technique at 1500 rpm with irrigation is considered as the gold standard technique in most of implant system. Irrigation is used as coolant and to protect cell capability.

Trisi et al. (2014)⁵ examined histomorphometric characters in fixtures that had been introduced with numerous irrigation protocols (no irrigation, with internal irrigation, with external irrigation, and a combination of both). In all study groups, the drilling velocity was 1000 rpm. The outcome of the research suggested that the lack of irrigation caused thermal injury which lead to major resorption of the cortical bone and implant failure.

But, the irrigation could wash away the osteoinductive signaling proteins such as bone morphogenic proteins and growth factors which are responsible for new bone formation

Latterly, a new concept of low speed drilling (50-150 rpm) without irrigation has been suggested as an alternative to the conventional technique. It is a low traumatic implant placement surgery and has relatively less heat generation. This technique preserves bone cells and lead to successful osseointegration³.

Confirming that, Kim et al. (2010)⁷ compared the temperature change in pig ribs when drilling with conventional and low speed drilling systems. Thermocouple was used to assess heat production. They found that low speed drilling without irrigation didn't overheat the bone beyond 47C

In addition, Giro et al. (2011)⁸ assessed osteointegration of implants inserted by low drilling speed (50 rpm) without irrigation and 900 rpm drilling speed with irrigation in dogs. The histomorphogenic outcomes were similar in both techniques. This indicates the viability and safety of low speed drilling technique in animal model.

Pirjamalineisiani et al. (2016)⁹ evaluated the effect of different rotation speeds on the heat generated in a mandible model. The speed used was (200, 400, 800, 1200rpm). They stated that the higher the rotational speed of the drill, the higher the increase in heat during preparation.

Also, Oh et al. (2016)¹⁰ studied the temperature change of low speed drilling surgical protocol without irrigation (50 rpm) and compared it with the conventional technique (1500 rpm) on artificial bone blocks. They proved that low-speed drilling without irrigation increased the temperature but without overheating the bone block during drilling.

Although, the abundance of studies on the low speed drilling technique, no sufficient studies measured the amount of heat generated during osteotomy in patient's mouth. For that, the objective of the present clinical trial was to assess the temperature change during osteotomy by the biological and conventional drilling technique and to measure the marginal bone loss of implant inserted upto 12 months follow-up. The null hypothesis is there will be no significant difference regarding heat generation and marginal bone loss between the two techniques

MATERIALS AND METHODS

Twelve candidates (3 males, 9 females) were suffering from non-restorable posterior mandibular alveolar ridge and seeking implant rehabilitation. They were selected from the Outpatient Clinic of Oral and Maxillofacial Surgery Department, Faculty of Dentistry, Cairo University to be included in this study. The present study was approved by the Ethics Committee at the Faculty of Dentistry, Cairo University (at 26/9/2018; code 18-9-4)

Patient's selection

Patients included in the present study were partially edentulous in the posterior area of the mandible with a minimum alveolar bucco-palatal dimension of 6mm. Their residual alveolar bone height were more than 10mm. Both sexes were included. Patients were free from any intraoral soft and hard tissue pathology.

The selected patients were informed of the nature of the research work and informed consent was obtained. Then, the patients were randomly divided using block randomization with stratification by a formula on Microsoft Excel Software. It was used to divide patients into two groups according to the osteotomy techniques protocol used in implant placement.

Sample size calculation: This study aims to assess the low-speed drilling without irrigation regarding heat generation and evaluate the marginal bone loss of implant inserted by the low-speed drilling technique. Based on a previous study by Pellicer-Chover et al. (2017)³ the difference in marginal bone loss between the 2 groups is 1 ± 0.7 mm. Using power 80% and 5% significance level we will need to study 18 in each group. This number is to be increased to a sample size of 20 to compensate for losses during follow up. Sample size calculation was achieved using PS: Power and Sample Size Calculation software Version 3.1.2 (Vanderbilt University, Nashville, Tennessee, USA).

Patients were divided into group A (Test group) represented the low speed without irrigation (150 rpm) while group B (control group) represented conventional drilling with irrigation (1200 rpm). All surgeries were performed by the same surgeon. The patients who participated in this study received the two types of drilling techniques in each quadrant.

Pre-operative preparation

A thorough preoperative examination of all enrolled candidates was carried out including history taking, clinical, and radiographic examination. Each patient was interviewed to obtain a comprehensive history, including full medical and dental history. Patients were inspected for adequate Inter- arch space, normal covering mucosa, and periodontal status of adjacent teeth .The ridge was palpated to check the contour for any abnormalities that may contraindicate implant placement. Primary impression was taken to make the diagnostic cast together with face bow registration and mounting on a semi-adjustable articulator. The radiographic examination included a preoperative digital panoramic radiograph with 1:1 magnification for each patient. Then, Cone-beam computed tomography (CBCT) was performed in our X-ray department with the same machine for each patient.

Surgical procedure

All surgical procedures were performed under strict aseptic conditions, all patients received infiltration local anesthesia (Articaine 4% 1:100 000 epinephrine) .A crestal incision is made using No. 15 blade extending over the edentulous area and a full mucoperiosteum flap elevated to provide access to the alveolar ridge.

A small osteotomy 2 mm depth with 2 mm width was made by pilot drill on the crest of the ridge away from the implant site to gain access to insert the thermocouple sensor (figure 1). Ten to fifteen minutes were needed for the bone to return to its initial temperature. The baseline bone temperature was recorded. Implant osteotomies were drilled at 150 rpm without irrigation and 1200 rpm with irrigation in each quadrant bilaterally (figure 2). Immediately after the final drill, the thermocouple sensor was inserted in the full depth implant osteotomy to record the temperature after drilling (figure 3). The diameter of implants (Dentis, S-clean implant system, Korea) placed was 3.9 mm and height 10mm to assure the standardization of the drill numbers. Finally, mucoperiosteal flap was sutured in an interrupted pattern using 4-0 proline suture material.

Radiographic assessment of crestal bone loss

The immediate and 12 months' post-operative CBCTs were assessed using RomexisPlanmecadicom viewer software (figure 4).On the 3D orthogonal plan, the long axis of the software was put on the long axis of the implant and perpendicular on the buccolingual and mesiodistal axis. A standardized thickness and gap distance of 0.4 mm for all explorer views of all implants were set. A tangential line on the base of the implant and other lines on the highest point buccal, lingual, mesial, and distal were put and the distance between them was measured. Three readings for three cuts were measured which were the middle cut of the implant, cut before, and cut after for taking the average of these three cuts and this was done for each side. The radiographs were made with the same machine and same exposure parameters. Image reconstruction was performed using special software.

Statistical methods

Data management and statistical analysis were performed using the Statistical Package for Social Sciences (SPSS) version. 24. Numerical data were summarized using means and standard deviations. Data were explored for normality using the Kolmogorov-Smirnov test and Shapiro-Wilk test. Comparisons between the 2 methods and overtime were done using the paired t-test and Wilcoxon signed-rank test. All p-values are two-sided. P-values ≤ 0.05 were considered significant.

Figure (1): Showing thermocouple sensor



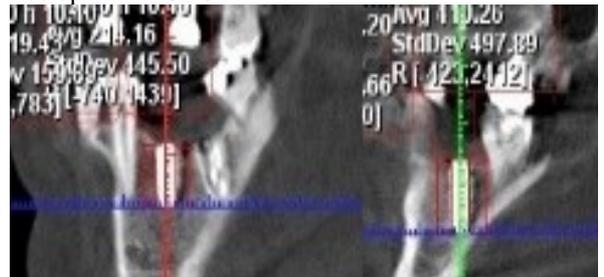
Figure (2): Showing preparation of osteotomy site



Figure (3): Showing the temperatures changes record



Figure (4): Showing radiographic assessment of crestal bone level of buccolingual view of Postoperative CBCT



RESULTS

For group A, the mean baseline temperature was 34.1 ± 0.8 C° that increased to 34.6 ± 1.0 C° after drilling. This was statistically significant $p < 0.001$. For group B, the mean baseline temperature was 34.1 ± 0.8 C° that changed to 33.2 ± 0.8 C° after drilling. This was statistically significant $p < 0.001$. The temperature of bone decreased in group B (conventional drilling). As revealed in table (1).

As revealed in table (2): mean change in temperature after drilling of the group A (150 rpm) was 0.5 ± 0.5 compared to temperature after drilling of the group B (1200 rpm) by -0.5 ± 0.5 ; this was statistically significant $p < 0.001$.

For the marginal bone change, in group A (150 rpm): the mean peri-implant bone level was 11.44 ± 1.12 that decreased to 9.93 ± 1.22 after 12 months. This was statistically significant $p < 0.001$. In group B (1200 rpm): the mean peri-implant bone level was 11.41 ± 1.36 that decreased to 10.38 ± 1.41 after 12 months. This was statistically significant $p < 0.001$ as shown in table (4).

Comparing the bone changes overtime; as revealed in table (3): the mean bone loss in group A group was -1.5 ± 1.16 mm that compared to -1.03 ± 0.68 in group B; this was statistically not significant $p = 0.118$.

Table (1): Mean, SD of temperature in Side (A) low-speed drilling and Side (B) conventional drilling.

	Side A (Low Speed)		Side B (Conventional)		P-value (1)
	M	SD	M	SD	
Baseline	34.1	0.8	34.1	0.8	NA
After Drilling	34.6	1.0	33.2	0.8	<0.001
P-value (2)	<0.001		<0.001		

NA: not applicable, M; Mean, SD: Standard deviation, $P \leq 0.05$ is considered statistically significant, P value1: comparing different methods at different times, p value2: comparing change from baseline to after drilling in the same group or side; analysis done by paired t test.

Table (2): Mean, SD of temperature change in Side A low-speed drilling, and Side B conventional drilling.

	Side A (low speed)		Side B (conventional)		P-value
	Mean	SD	Mean	SD	
Temperature change from baseline	0.5	0.5	-0.5	0.5	<0.001

Table (3): Mean, SD of Bone change in Side A and Side B

	Side A (low-speed)		Side B (conventional)		P value
	Mean	SD	Mean	SD	
Bone change from baseline	-1.5	1.16	-1.03	0.68	0.118

SD: Standard deviation, $P \leq 0.05$ is considered statistically significant, the analysis was done by paired t-test and repeated by Wilcoxon signed-rank test.

Table (4): Mean, SD of Bone change in Side A low-speed drilling and Side B conventional drilling:

Bone	Baseline		After one year		P-value
	Mean	SD	Mean	SD	
Side A (low-speed)	11.44	1.12	9.93	1.22	<0.001
Side B (conventional)	11.41	1.36	10.38	1.41	<0.001

SD: Standard deviation, $P \leq 0.05$ is considered statistically significant, the analysis was done by paired t-test

DISCUSSION

Low-speed drilling without irrigation possesses several advantages especially for beginners in the dental implant field. It allows the operator to be more controllable to osteotomy direction or even modify it if it is necessary. Unlike conventional high-speed drilling that might cause an unintentional deviation of the drilling path¹¹. Also, the risk of damaging the inferior alveolar nerve or invading the vital structures such as the maxillary sinus is minimized with low-speed preparation³. Moreover, the operator could harvest bone chips from the implant site preparation. The bone chips are considered as a source of autogenous bone that could be used in bone augmentation procedures when needed. Drilling without irrigation allows better visibility of the determined length graduated on the drill and during osteotomy³. Thus, the low-speed drilling without irrigation is considered the best comfortable choice for initiators and convenient in difficult cases in dental implants.^{6,11}

In the test group of this research, implants were placed by low-speed drilling with a speed of 150 rpm rather than the others speed (50 or 300 rpm). The drilling speed (150 rpm) is considering a proper speed with the dense bone-like mandible. Unlike, the (50 rpm) speeds that may be a proper drilling speed in less dense bone and less resistant like maxilla. The denser bone, the more resistant, the more contact between the drill and surrounding tissues, and the more heat generated that may lead to bone necrosis. Furthermore, drilling at the speed 300 rpm is not

suggested as that the concept of biological preparation (low-speed drilling without irrigation) might be compromised.

In the control group, implants were placed in the lower posterior area by speed 1200 rpm with saline irrigation. Drilling speed at 1200 rpm was used rather than higher speed such as 2,000 rpm or 30,000 rpm¹². This higher speed maximizes the risk of injury of vital structure¹³. Otherwise, the lower speed such as 600 rpm -800 rpm was not recommended as it prolonged the drilling time¹⁴.

A thermocouple is an electrical device consisting of two different metals with two different resistances joined at the ends, there is a temperature difference between the joints, and a magnetic field is generated. The magnetic field will convert to thermo-electric current. Type K (chromel–alumel) is the most common general-purpose thermocouple with a high sensitivity of small temperatures degrees¹⁵. Thermocouples are popular in the dental field to detect heat generation^{10, 16,17,18,19}. It's low in cost, easy to use where no need to technical experience and can be applied in the dental clinic. Thermocouples are not autoclavable because their practical lifetime is limited in case of high temperature. For that, in the present study, every patient received a new thermocouple sensor sterile by CIDEX disinfectant solution.

Limitations of thermocouples are the ability to record only spot temperature and not detect the overall thermal profile and heat leakage²⁰. Alternatively, Infrared thermograph allows an overall assessment of the heat in area rather than spot. It is a technology depends on the electromagnetic radiation. The limitations of using infrared technology are its high cost, need technical experience and the procedure cannot be applied in conjunction with irrigation²⁰.

In our research, high temperature was noticed in osteotomies drilled by a low-speed preparation without irrigation. The mean temperature of osteotomies done by the low-speed preparation without irrigation was 34.6 C° compared to 33.2 °C in osteotomies done by conventional drilling with irrigation.

These outcomes coincide with the previous study conducted by Calvo-guirado et al. (2014)¹² where 120 random osteotomies were established in pig bones. The temperature was recorded after low-speed preparation without irrigation by paired thermocouples. The results showed that low speed preparation emitted higher temperatures (36.7 °C) than the temperatures observed with conventional preparation (35.3°C).

Similarly, Kim et al. (2010)⁷ found that the preparation at 50 rpm without irrigation increased heat by 2.46°C in pig ribs using infra-red thermography but didn't overheat the bone.

The cause of the heat generated may be due to extended drilling time with low speed technique. This heat did not exceed 35 °C. It was beyond the critical limit 47 °C. Consequently, bone necrosis and

failure in osseointegration would not occur^{21, 22, 23}. So, the low-speed technique is harmless and does not cause heat indulgence of the bone.

Prolonged preservation of crestal bone height around osseointegrated implants is considered one of the most critical criteria when assessing implant success. Crestal Bone Loss (CBL) can be affected by numerous factors including surgical distress, implant abutment micro-gap, bacterial proliferation of peri-fixture tissues and bio-mechanical affections considering loading. The amount of CBL after 12 months 'visits showed statistically insignificant difference between the two groups. The biological drilling group showed (-1.5± 1.16mm) while the conventional drilling group (-1.03± 0.68); this was not statistically significant p=0.118.

Our results agreed with the outcomes addressed in Pellicer-Chover et al. (2017)³. A recent RCT compared conventional speed drilling with low speed drilling protocol regarding the marginal bone loss at 12 months follow up. The mean bone loss was 0.83± 0.73 mm in the conventional drilling group and 0.7±0.62mm in the low speed drilling group. There were statistically insignificant differences detected between irrigation and non-irrigation implant insertion techniques.¹⁵

In contrast to our results, Trisi et al. (2014)⁵ an in vivo study on mandible of sheep that which analyzed the histology and morphometric parameters in implants that had placed by drilling without irrigation. The outcomes of the study suggested that due to the absence of irrigation, hard bone caused massive loss of the cortical bone and implant failure.

CONCLUSION

The low-speed preparation (150 rpm) with no irrigation is a successful and applicable preparatory technique in dental implants site preparations. The drilling speed 150 rpm offered two advantages. The first is the profound control of the preparation direction as the marks of the drill are obvious during drilling. The second is the collection ability of a large number of viable particulate bone grafts, which allows immediate augmentation.

The authors declare that they have no conflict of interest Self-funded study

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