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The effect of slow speed drilling on the stability of dental implants during osseointegration: a clinical study

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KEYWORDS Slow speed drilling, resonance frequency analysis

ABSTRACT

Aim This study aimed to evaluate the effect of slow speed drilling on implant stability measurements.
Materials and Methods Twenty-four implants were placed in eight patients. In the test group, the first drill was used at 800 rpm, and the following drills were used at 150 rpm, whereas in the control group, all drills were used at 800 rpm. Resonance frequency analysis (RFA) measurements were recorded at baseline and at weeks 1, 2, 3, 4, and 8.
Results The baseline RFA measurement was 74.08±2.77 in the test group, and the following measurements were 73.58±3.68, 76.50±4.12, 78.83±4.00, 78.83±3.35, and 82.25±2.73, respectively. In the control group, the baseline RFA measurement was 76.58±4.20, and the following measurements were 72.83±5.76, 74,08±3.84, 75.67±3.89, 76.83±3.61, and 79.16±4.20, respectively. The differences were not statistically significant at any time point.
Conclusions Slow speed drilling technique does not affect osseointegration.

INTRODUCTION

Osseointegration, first defined by Branemark as a process linking the bone and load-carrying implant surface, has been studied extensively (1-3). Implant design, bone quality and quantity, primary stability (PS), implant surface characteristics, and surgical technique are some defined factors important to successful osseointegration (4). Different implant bed preparation techniques have been described in the literature. While some of these techniques propose piezoelectric surgery tips (5) or lasers, (6) the majority use classical drills and make modifications by changing the speed, number, or sequence of the drill bits (7,8).

Several studies have proposed different drilling speeds for implant bed preparation, ranging from 50 to 400000 revolutions per minute (rpm)(9-12). These studies mainly focused on the heat generated during drilling and its potential to harm bone tissue. Other studies have also evaluated the effect of irrigation in preventing thermal damage (13,14). Flanagan (15) proposed that irrigation may not be necessary to prevent bone heating during osteotomy when using contemporary drill designs with an expeditious drilling technique. Kim et al. (16) compared the temperature change of three different implant systems at 50 rpm without irrigation and recorded 1.57 °C and 2.46 °C as the lowest and highest temperature increases, respectively. Delgado-Ruiz et al. (17) used 50, 150, and 300 rpm without irrigation and recorded maximum temperatures of 22.11±0.8 ℃, 24.752±1.1°C, and 25.977±1.2°C, respectively. The resulting temperatures in both studies were below the threshold, reported as 47 °C.

Resonance frequency analysis (RFA) is a noninvasive method commonly used to evaluate the stability of dental implants. The resulting implant stability quotient (ISQ) represents the implant stability measurement as a number ranging from 1 to 100. Higher ISQ values represent less displacement of the implant-bone interface (18).

In 2007, Anitua et al. (19) presented an alternative drilling procedure. In their technique, the first sharp drill was used at 800 rpm with irrigation, and all the following drills were used at 50 rpm without irrigation. While using Anitua's technique during routine dental implant procedures, we observed higher PS values compared to conventional drilling. In a previous study, authors compared the effect of two different drilling speeds (50 rpm vs 800 rpm) on dental implant PS in an *ex vivo* setting, by means of RFA, and found a statistically significant difference in favor of low-speed drilling, 77.10±2.65 vs. 74.15±3.91, respectively (20). To the best of our knowledge, no published clinical study has evaluated the effect of drilling speed during the osseointegration period using resonance frequency analysis (RFA). Therefore, the aim of this study was to compare and evaluate the effect of slow drilling speed on implant stability measurements on a weekly basis using resonance frequency analysis.

MATERIAL AND METHODS

All procedures performed in this study were in accordance with the ethical standarts of 1975 Helsinki declaration and its later amendments or comparable ethical standarts. The study was approved by institutional research committee of Istanbul Aydın University. An informed consent was obtained from each patient. All surgeries were performed by an experienced oral surgeon (EB). Twenty-four implants (4.1x10 mm; BEGO Semados RSX Line, BEGO Bremer Gold Wilh. Herbst GmbH & Co. KG, Bremen, Germany) were placed in eight patients (aged 23-67, 7 woman and 1 man). To achieve similar bone qualities, implants were placed either in the opposite dental quadrants in the same jaw or in adjacent sites as a test and control. All drills needed for a 4.1 mm diameter implant were used according to the manufacturers' recommendations. In the test group, the first drill was used at 800 rpm with irrigation, and the following drills were used at 150 rpm without irrigation, whereas in the control group, all of the drills were used at 800 rpm with irrigation. A countersink drill was used, and screw tapping was performed in all the patients. Following bed preparation, implants were placed with a handpiece at the bone level.

Immediately after implant placement, a SmartPeg (Smartpeg-Osstell , Osstell AB-W&H Dentalwerk Büromoos GmbH, Göteborg, Sweden) was attached to the implant and baseline RFA values were measured using an Osstell Mentor device (Osstell AB-W&H Dentalwerk Büromoos GmbH, Göteborg, Sweden). To measure RFA changes at weeks 1, 2, 3, 4, and 8, gingival formers were placed, and the flaps were sutured. The measurements were performed twice in four directions, and the average value was calculated.

	Test Mean±SD (Median)	Control Mean±SD (Median)
Baseline	74.08±2.77 (0.80)	76.58±4.20 (1.22)
1.week	73.58±3.68 (1.06)	72.83±5.76 (1.66)
2.week	76.50±4.12 (1.19)	74.08±3.84 (1.11)
3.week	78.83±4.00 (1.15)	75.67±3.89 (1.12)
4.week	78.83±3.35 (0.97)	76.83±3.61 (1.04)
8.week	82.25±2.73 (0.79)	79.16±4.20 (1.21)

TABLE 1 Baseline and following measurements for test and control groups.

Compliance with the normal distribution of continuous variables was checked using the Shapiro-Wilk test. Homogeneity of the groups' variances was checked using Levene's test. Parametric test assumptions were available, so the data set was analyzed using a two-factor repeated measures analysis of variance. Data analyses were performed using the Statistical Package for the Social Sciences, version 19.0 (SPSS 19, Armonk, NY, USA). Statistical significance was set at $p \leq 0.05$.

RESULTS

All implants in both the test and control groups healed uneventfully. Baseline and the following measurements at 1st, 2nd, 3rd, 4th and 8th weeks are presented in Table 1 and Figure 1 for the test and control groups.

At baseline, the RFA measurement was 74.08±2.77 for the test group and the following measurements were 73.58±3.68, 76.50±4.12, 78.83±4.00, 78.83±3.35, and 82.25±2.73, respectively. For the control group, baseline RFA measurement was 76.58±4.20 and the following measurements were 72.83±5.76, 74,08±3.84, 75.67±3.89, 76.83±3.61, and 79.16±4.20, respectively. The differences were not statistically significant at any time point (Table 1).

DISCUSSION

This study evaluated the effect of slow-speed drilling on implant stability during the osseointegration period. A previous ex vivo study compared the primary stability measurements of implants placed in beds prepared at drilling speeds of 50 rpm and 800 rpm. The RFA measurements were 77.10±2.65 and 74.15±3.91 for 50 rpm and 800 rpm, respectively (20). Surprisingly, in this clinical study, baseline RFA measurements were 74.08±2.77 for the test group (150 rpm) and 76.58±4.20 for the control group (800 rpm). In the ex vivo study, the authors used bovine bone and placed all implants in the same bone, which might be considered more uniform than this clinical study design. Although implants were placed either in the opposite dental quadrants in the same jaw or in adjacent sites to achieve similar bone quality, bone density changes might have caused the differences in RFA measurements. A study by Almeida et al. (21) showed that the bone quality influences the implant primary stability, whereas the drilling speed does not. However, it should be noted that the drilling speeds in the aforementioned studies were 800 rpm versus 1500 rpm in their study.

Berglundh et al. (2) reported de novo alveolar bone formation adjacent to endosseous implants in a dog model. In their extensive study, the researchers observed a resorption process occurring between the 1st and 4th week interval of wound healing. This resorption occurs at the old host bone, which is responsible for the PS of the implant. Raghavendra et al. (22) reported that, although it

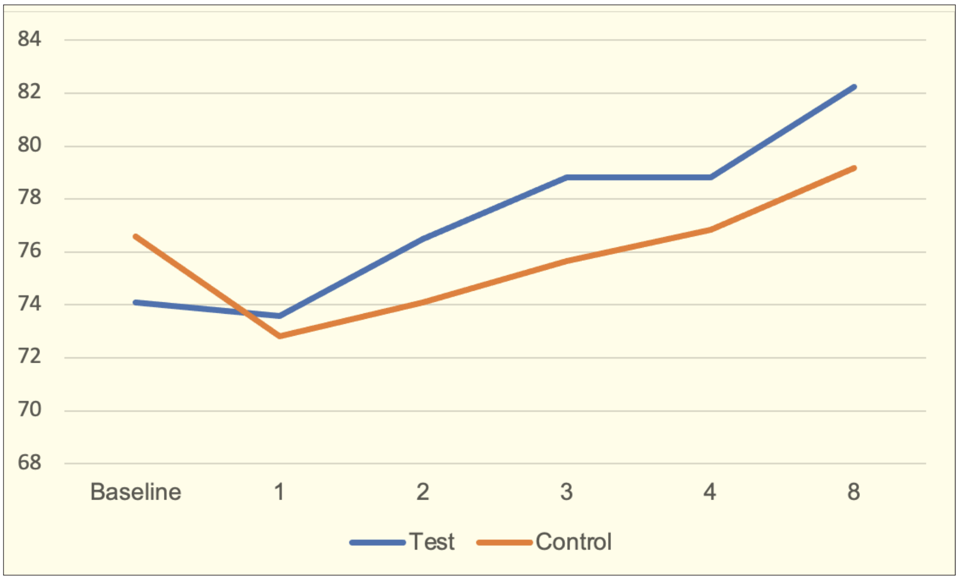

FIG. 1
Baseline and following measurements for test and control groups.

is difficult to correlate the findings of the canine model with the timeline of events in human bone, the critical time frame for implant healing in humans is 2 to 3 weeks. Demir et al. (23) recorded the ISQ measurements of 42 implants in 19 patients at baseline and 1st, 2nd, 3rd, 4th, 6th and 8th weeks, and reported that RFA values were significantly lower at 2, 3, and 4 weeks, compared to baseline and 8-week measurements, a finding reflective of bone resorption. In our study, 1-week RFA measurements decreased in both groups, with a more significant decline in the control group. For all the continuing measurements, the test group presented higher values than the control group at all time points. Although the differences were not statistically significant, the recovery was better in the test group.

One of the advantages of low-speed drilling without irrigation is that it helps to obtain autogenous bone from the implant bed, thereby eliminating the need for a second surgical site (24). Liang et al. (25) compared the osteoblastic activity and osteogenic potential of bone particles harvested using three different techniques, and found that low-speed drilling was effective in collecting autogenous bone. Another study by Tabassum et al. (26) showed that the efficacy of autogenous bone particles using low-speed drilling was superior to that of standard drilling samples.

Low-speed drilling without irrigation creates a substantial amount of bone debris at the preparation site. Yeniyol et al. (27) investigated the effect of different drilling speeds (100, 500, and 1000 rpm) on the primary stability and early bone-to-implant interactions in an animal model. The authors reported more bone chips for lower drilling speeds (100 and 500 rpm) at 1 week and noted that lower amounts of bone debris at 1000 rpm might have induced direct osteogenesis. Conversely, in a cell culture study, Dhore et al. (28) placed and immediately removed implants from rat tibia and showed that bone debris occurring during implantation has osteogenic potential. A human biopsy study of 28 volunteers also identified osteoclasts on old bone surfaces undergoing resorption, but not in association with bone debris; therefore, bone debris and bone remnants should be preserved within the implant bed (29). A new drill design by Chen et al. (30), ran at 50 rpm without irrigation, created a large amount of debris, preserved implant site viability, and enhanced osteogenesis.

Lee and Bance (31) stated that osseointegration is an immunologically driven process that relies on inflammatory pathways, which, in this case, is caused by implant placement trauma. The authors speculated that low-speed drilling might cause an optimal inflammatory response, and therefore, more rapid osseointegration may explain the improved recovery in the test group. This optimal inflammatory response may be due to less trauma and should be identified biochemically.

The main difficulty of slow-speed drilling is the wobbling of the drill bit; therefore, the technique requires a certain level of surgical expertise. To overcome this problem, our study group is currently conducting a study using surgical guides. Prevention of wobbling with the help of a surgical guide may provide more accurate data on the effect of slow speed drilling on osseointegration.

One limitation of this study is the small sample size. This theory should be tested in larger groups using different implant brands, since the macrogeometry and thread profile of dental implants might have an influence on primary stability (32). In addition, although the authors tried to place implants with similar bone qualities, bone densities at the planned placement sites could be identified with the help of Houndsfeld unit measurements (33).

CONCLUSION

Within the limitation of the present study, it can be concluded that slow speed drilling technique does not adversely affect osseointegration process when compared with conventional drilling. Additionally, the advantage of collecting autogenous bone should be kept in mind.

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Conflict of interest

There are no conflicts of interest to declare.

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