



Original Article

# Evaluation of implant stability using different implant drilling sequences

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## KEYWORDS

Dental implant;  
Drilling protocol;  
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**Abstract** *Background/purpose:* Simplifying the drilling sequence would be meaningful for implant surgery, if it does not exert a negative influence. This prospective clinical study was conducted to evaluate the stability of implant placements after simplifying the drilling sequence.

*Materials and methods:* Subjects were divided into a control group that underwent a normal drilling sequence or a test group that underwent only an initial and final drilling. To evaluate the stability of the placed implant, radiography and implant stability quotient (ISQ) measurements were recorded immediately and 5 months after placement.

*Results:* In all subjects, the prosthesis process was completed with no significant resorption of the marginal bones. In contrast, a statistically significant difference was observed between the control and test groups 5 months after the implants were placed in terms of the ISQ score ( $80.72 \pm 6.76$  and  $71.83 \pm 9.00$ , respectively); however, both scores were sufficient to proceed with the prosthesis process.

*Conclusion:* These attempts to simplify drilling protocols are expected to contribute the improvement of implant-related treatments in future.

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## Introduction

The primary success metric of dental implants is achieving osseointegration, which is influenced by many

factors including implant design, surface treatments, as well as treatment method. Implant drilling is also a major influential factor. Previous studies on drilling have largely focused on the heat generated while drilling. This is because osseointegration is affected by the heat produced during implant placement.<sup>1,2</sup> However, studies have demonstrated that procedures generating heat to levels that would lead to implant failure are rare as long as basic principles are adhered to in various situations.<sup>3,4</sup>

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It is widely accepted that the sophisticated surgery process is another important factor in the success of implants.<sup>5</sup> In the process of implant surgery, drilling sequence and speed have been widely known to influence the successful placement of implants. Among these factors, a gradual drilling sequence in the formation of the placement location has been considered a fundamental principle. However, using numerous drills at different stages requires time; this has resulted in various negative factors, such as patient discomfort, increased risk of infection, as well as boredom for experts.<sup>6</sup> As such, simplification of the drilling process would enable an overall reduction in surgical duration and also carries the added significance of reducing complications.

While several factors influence the success of implants, it would be meaningful to reduce the number of steps in the drilling protocol if it does not exert a negative impact on success. Studies addressing this topic have reported that simplification of the drilling process has yielded acceptable results; however, these investigations involved animals.<sup>6–10</sup> Moreover, studies involving humans have only included case series and a study in which two surgeons performed the procedure.<sup>11,12</sup> As such, the present clinical trial aimed to modify the drilling sequence to place implants and was performed by a single surgeon to comparatively evaluate implant stability.

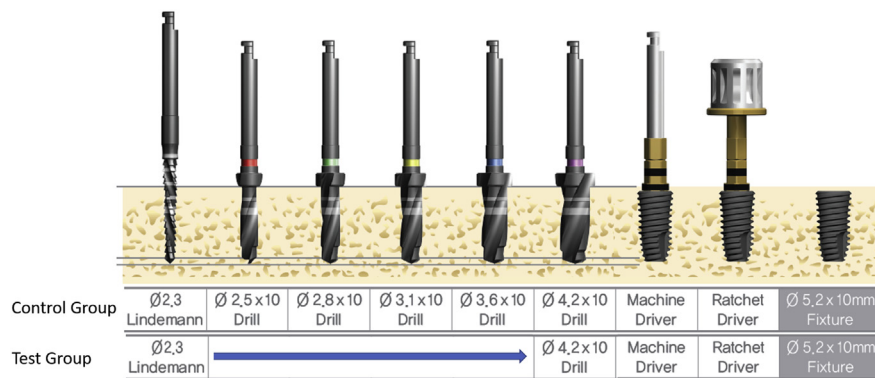
### Materials and methods

This prospective clinical trial was reviewed by the regional Institutional Review Board (IRB) and approved (GAIRB2015-119) for randomized controlled trials. However, the actual research has not been conducted at random. This information has also been approved by IRB. Informed consent was obtained to all patients who enrolled in this study. Specific inclusion criteria are as follows: patients who required implant(s), ≥20 years of age with fully-grown jawbones, no previous drug use influencing bone metabolism, and voluntary consent to participate in the clinical trial and follow the test plan. Patients with uncontrolled medical conditions and pregnant women as well as those with hemorrhagic conditions or requiring anticoagulants, with known or suspected mental conditions, requiring heterogeneous bone grafts due

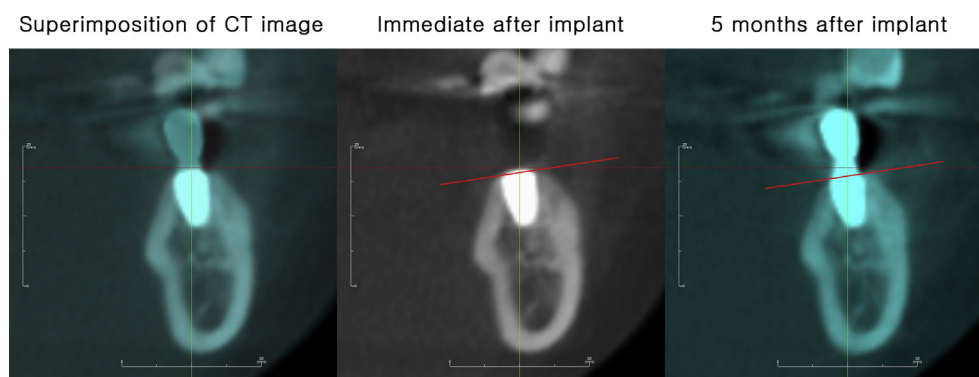
to heavy loss of bone tissue, or otherwise deemed unsuitable for participation according to the researcher’s discretion were excluded.

Study participants who met the aforementioned criteria were divided into one of two groups depending on the drilling methods used for osteogenesis of implant placements. The classification of the control and experimental group was decided by the researcher. Patients were given a number in the order of getting the informed consent, and patients with an odd number were the control group and patients with the even number were the experimental group. All implants in one patient were placed in the same sequence and assigned the same group. Fig. 1 shows a schematic diagram of the drilling method for implant placement in the control and experimental group. In the control group, implants (OneQ-SL, Dentis, Daegu, Korea) were placed using drills with increasing diameters in accordance with manufacturer’s recommendations. In the test group, only the initial and final-stage drills were used to place the implants. Bone quality during implant placement was classified and recorded using subjective assessment (Lekholm and Zarb classification).<sup>13</sup> Clinical observations of adverse reactions were recorded 1 week, 1 month, and 3 months after implant placement. All implants were placed in a submerged manner using the 2-stage process. The secondary surgery was performed 5 months after the placement of the implants, which was followed by prosthesis treatment in the usual manner.

The assessment of implant stability was performed using panoramic radiography and cone-beam computed tomography (CT), as well as measuring mobility using the Osstell Mentor® (Osstell, Gothenburg, Sweden). To distinguish the significant changes in the marginal bones around the implants, panoramic radiography was performed immediately, and at 3 and 5 months after implant placement. Similarly, cone-beam CT was taken immediately and 5 months after the implant placement. The resorption of the marginal bone was compared using InvivoDental software (Anatomage Inc, San Jose, Calif). Immediately and 5 months after the surgery, CT images were superimposed (InVivoDental, Anatomage Inc, San Jose, Calif) to confirm the resorption of the marginal bone (Fig. 2.). The most resorbed area of the marginal bone around the implant top was measured.



**Figure 1** A schematic diagram of the drilling method for placing implant of 5.2 mm in diameter, for example, in the control and experimental groups.



**Figure 2** Cone-beam CT images were superimposed to measure the amount of resorption from the marginal bone.

The Implant Stability Quotient (ISQ), acquired using the Osstell Mentor® was measured at immediately and 5 months after placement. It was repeated 3 times for each measurement and the mean value was used in the analysis. Finally, after prosthesis treatment, the overall process was verified for clinically adverse events. All of the above processes were conducted by a single surgeon (H.M.K.). For the statistical analysis of implant stability, independent t-tests (SPSS version 12 [SPSS Inc., Chicago, IL, USA] for Windows [Microsoft Corporation, Redmond, WA, USA]) were conducted to compare the ISQ measurement values between the two groups;  $p < 0.05$  was considered to be statistically significant.

## Results

A total of 41 implants were placed in 21 patients (13 in the control group and 28 in the test group; [Table 1](#)). The analysis of marginal bone resorption around the implants 5 months after the procedure using panoramic radiography revealed distances of  $< 1$  mm in all cases.

For bone quality at the locations where the implants were placed in both control and test groups, type III was the most highly represented, with 10 and 18 sites, respectively. Type II bone quality was found in 1 and 7 sites, and type IV in 2 and 3 sites, respectively. Type I bone quality was not observed in any site in either group ([Table 2](#)).

The overall average of ISQ values after implant placement was  $72.65 \pm 15.23$  and, after 5 months, this figure increased slightly to  $74.65 \pm 9.27$ , but with no statistically significant difference ([Table 3](#)). The average ISQ values after implant placement in the control

and test groups were  $82.12 \pm 10.17$  and  $68.76 \pm 15.75$ , respectively, a difference that was statistically significant ( $p = 0.01$ ). The average ISQ values at 5 months after the procedure were found to be  $80.72 \pm 6.76$  and  $71.83 \pm 9.00$ , with statistically significant differences between the two groups ( $p = 0.003$ ; [Table 4](#)). Comparing the ISQ values immediately and 5 months after the implant within the two groups, the control group exhibited a slight decrease from  $82.12 \pm 10.17$  to  $80.72 \pm 6.76$ , while the test group demonstrated a slight increase from  $68.76 \pm 15.75$  to  $71.83 \pm 9.00$ ; however, these differences were not statistically significant ([Table 4](#)).

The difference in marginal bone resorption between immediately and 5 months after surgery was less than 1.0 mm in all patients. There was no significant marginal bone loss around the implants between groups in radiologic evaluation. Bone resorption between immediately and 5 months after surgery was  $0.47 \pm 0.19$  mm in control group and  $0.34 \pm 0.29$  mm in test group ([Table 5](#)).

## Discussion

Osteonecrosis from heat transfer occurs when temperatures  $> 47^\circ\text{C}$  are generated for  $> 1$  min within the bone.<sup>14</sup> This heat is known to delay the bone recovery process.<sup>1,2</sup> However, the temperatures generated by the simplified drilling protocol in *in vitro* studies were not significantly lower than those used in non-simplified drilling processes.<sup>3</sup> Previous study involving beagle dogs have also indicated that simplified drilling protocols do not result in heat levels that impact the surrounding tissues.<sup>7</sup> Moreover, studies investigating heat generation from specific drill shapes

**Table 1** A total of 41 implants were placed in 21 patients (13 in the control group and 28 in the test group).

Implant diameter (mm)	Implant length (mm)	Control (n)	Test (n)
4.2	10	0	12
4.7	10	2	8
5.2	8	6	5
5.2	10	2	3
5.2	12	3	0
Total		13	28

**Table 2** Bone quality during implant placement was classified and recorded using subjective assessment (Lekholm and Zarb classification). For bone quality at the locations where the implants were placed in both control and test groups, type III was the most highly represented.

	Type I	Type II	Type III	Type IV	Total
Control (number of sites)	0	1	10	2	13
Test (number of sites)	0	7	18	3	28

**Table 3** The Implant Stability Quotient (ISQ), acquired using the Osstell Mentor® was measured immediately and at 5 months after placement and used in the analysis. The overall average of ISQ values increased slightly at 5 months after placement, but with no statistically significant difference.

	Immediate after implant (Mean ± SD)	5 months after implant (Mean ± SD)	p-value <sup>a</sup>
ISQ	72.65 ± 15.23	74.65 ± 9.27	0.378

<sup>a</sup> Paired t-test was used.

have reported that less heat was produced by conical-shaped drills; however, the difference compared with cylindrical-shaped drills was only 2 °C and not meaningfully different.<sup>15</sup> Therefore, it would be reasonable to believe that the drills used in the present study would not influence heat generation due to their shapes. However, considering the results of existing studies reporting that the application of irrigation significantly reduces heat,<sup>3</sup> it is important to perform drilling along with irrigation every time. Considering previous studies that have attributed more significance to sufficient irrigation than implant drill types or methods, we believe that irrigation would have been relevant. Therefore, given that none of the cases in our study have experienced significant resorption of marginal bones, and the lack of clinical failures, performing simplified drilling with irrigation would not result in appreciable heat generation.

Although there are some differences, most studies examining simplification of drilling protocols have generally reported no differences between groups over time.<sup>6–12</sup> In an experimental study involving beagles, the simplified drilling group exhibited more favourable bone reactions 1 week after the placement of implants. These results were interpreted to reflect less damage to the surrounding cortical bones using the simplified protocols.<sup>9</sup> In contrast, another study involving beagle dogs and low-speed drilling at 400 rpm for implant placements reported lower bone reactions in the simplified protocol group after 3 weeks;

**Table 4** The average ISQ values were found with statistically significant differences between the two groups. Comparing the ISQ values within the two groups, the control group exhibited a slight decrease, while the test group demonstrated a slight increase; however, these differences were not statistically significant.

	Control (Mean ± SD)	Test (Mean ± SD)	p-value <sup>a</sup>
Immediate after implant	81.02 ± 10.17	68.76 ± 15.75	0.014
5 months after implant	80.72 ± 6.76	71.83 ± 9.0	0.003
p-value <sup>b</sup>	0.92	0.31	

<sup>a</sup> Independent t-test was used.

<sup>b</sup> Paired t-test was used.

this was attributed to the differences in pressure due to low-speed drilling.<sup>10</sup> Moreover, a study has reported that there are no significant differences between the two groups.<sup>6</sup> The present study revealed that ISQ values 5 months after placement were significantly lower in the simplified protocol group, which could be interpreted to mean that simplification of the drilling procedure influences stability. Compared with the existing gradual method of drilling, the simplified protocol may have led to a higher possibility of uneven bony preparation for implant placements. As such, it would be important to establish a higher degree of expertise in using the simplified protocol or use a surgical guide throughout the placement process to increase stability. Nevertheless, both aforementioned studies involving beagle dogs reported similar levels of bone reaction after 5 weeks. The present study demonstrated significant differences between the 2 groups in terms of ISQ scores evaluated 5 months after implantation. However, both groups demonstrated values that were sufficient to proceed with the prosthesis treatments (80.72 versus 71.83); this difference did not influence clinical progress.

The amount of marginal bone resorption between immediately and 5 months after surgery was less than 1.0 mm in all patients. There was no significant marginal bone loss between groups in radiologic evaluation. It is thought that period of 5 month and non-loading circumstances could not affect the significant change of marginal bone. However, this suggests that the simplification of the drill sequence did not also affect the bone resorption around the implants.

Guazzi et al. reported that simplification of the drilling sequence reduced operative time by an average of 3.6 min, in addition to the number of complications.<sup>12</sup> Though we could not estimate the operation time, the surgeon in this study also has experienced convenience with the simplified drilling protocol. This is expected to be particularly meaningful when placing multiple implants. However, large amounts of drilling using only the final-stage drill following the simplified sequence have led to concerns of damage to the surrounding bony tissues depending on bone quality.<sup>16</sup> Therefore, the authors recommend sufficient irrigation and adhering to basic rules to ensure that excessive forces are not applied during drilling.

**Table 5** Comparison of bone resorption between control and experimental group using CBCT between immediately and 5 months after implant installation. There was no significant marginal bone loss around the implant between groups in radiologic evaluation.

	Marginal bone resorption (mm, Mean ± SD)	95% CI	p-value <sup>a</sup>
Control (N = 13 sites)	0.47 ± 0.19	-0.05 ~ 0.3	0.18
Test (N = 28 sites)	0.34 ± 0.29		

<sup>a</sup> Paired t-test was used.

A possible limitation to this study could be the lack of randomized sampling. Considering that the influence of the patients' bone quality is highly significant to implant success, random sampling appears to be an important method of increasing reliability and should be implemented in future studies. Furthermore, other confounding factors could be worn drills due to cumulative drill use; however, existing studies have reported that the use of stainless steel drills do not lead to significant drill deformations until they are used at least 100 times. As such, it would be safe to consider this factor as insignificant.<sup>17</sup>

There have been no issues with the prosthesis process among the patients who participated in this study. However, future studies should be conducted to investigate the accuracy of implant placement related to simplified drilling processes. Harder bone tissues have led to difficulties in simplified drilling, and this could be a factor leading to changes in the expected position of the implants. In this study, no patients exhibited type I bone quality. If there was harder bone, simplified protocols may have led to disappointing results; therefore, caution is advised for less experienced surgeons.<sup>12</sup> The authors expect that using the surgical guide would result in more stable results with the simplified protocol.

Despite the study limitations, in which random sampling was not implemented, the results suggested that simplifying the drilling protocol would not interfere with the osseointegration process. Statistically significant differences in implant mobility have been observed in simplified drilling sequences. However, these differences were not clinically influential in terms of their absolute values. Therefore, attempts to simplify the drilling protocol are expected to contribute to improvements in future implant-related treatments.

## Conflicts of interest

None declared.

## Acknowledgement

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