The Effect of Variable Rest Period Training Programs on The Motor Skill Acquisition of Dynamic Navigation System: Pilot study

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Abstract

At present, the novel dynamic navigation system (DNS) has been shown to improve the correct 3D position of implant placement in anterior teeth, but quite difficult to gain proficiency. Even though the distributed training (lengthy rest periods) is proved to be better than the massed training (long training with a short break), it is still unclear whether different rest periods of distributed training will gain the best motor skill of dynamic navigation system. Thus, the objective of this study was to evaluate the most efficient training program with variable rest periods to achieve motor skills acquired with the highest level of accuracy in implant placement using DNS. Twenty senior dental students with no experience in implant placement and DNS were randomly and equally assigned into groups with the distributed training programs that last many days (group A) and with distributed training that is done in one day (group B). All participants placed three implants in a training session and one implant after 7 days of the third repetition as a post-test. The accuracy was measured from 3D deviation at implant platform, implant apex, and angle deviation. The independent T-test and Mann-Whitney test were used to determine differences between groups, and the repeated ANOVA test and Friedman-Dunn test were used to determine differences within groups, with a 0.05 significant level. There was no significant difference in the improvement of accuracy between the groups during all repetition and post-test. The training programs that last many days or within one day didn't cause any significant improvement of motor skill acquisition of implant placement by using the dynamic navigation system.

Keywords: *motor skill, dynamic navigation system, dental implant, distributed training, accuracy*

1. Introduction

To ensure that restorations and implants match esthetically and mechanically with neighboring and occluding dentition in the anterior maxillary region, the installation has to be performed properly. Dental implants must be placed correctly at the proper depth, angulation, and crestal position. It is critical due to the importance of the region and because if a high lip line is present, the smile line is more noticeable, which increases the consistency of the smile line.

Implant placement methods have used free-hand or laboratory-fabricated stents to direct implant placement (Block & Emery, 2016). Conventional methods to direct implant placement using teeth or laboratory-fabricated stents(Block, Emery, Lank, & Ryan, 2017; Farley, Kennedy, McGlumphy, & Clelland, 2013; Jung et al., 2009; Tahmaseb, Wismeijer, Coucke, & Derksen, 2014). Nevertheless, conventional techniques are less successful than computer-guided solutions or dynamic navigation systems (DNS) (Block, Emery, Cullum, & Sheikh, 2017; Cassetta & Bellardini, 2017; Deeb et al., 2017; Scherer, Stoetzer, Ruecker, Gellrich, & von See, 2015; Tahmaseb et al., 2014).

Static-guided implant insertion surgery uses a cone-beam computed tomography (CBCT) created a surgical guide with metal surgical tubes. These rigid guides may be assisted by teeth, mucosa, or alveolar bone(Block, Emery, Cullum, et al., 2017; Cassetta & Bellardini, 2017; Deeb et al., 2017; Scherer et al., 2015; Tahmaseb et al., 2014). The research strongly supports static-guided surgery(Block, Emery, Cullum, et al., 2017; Deeb et al., 2017; Scherer et al., 2015; Tahmaseb et al., 2014). Advances in 3D printing have made static guides affordable and thus static guide fabrication is more widespread today(Deeb et al., 2017). The

static guidance doesn't allow for real-time changes, nor does it allow for simulation of the osteotomy. Although tooth-supported or mucosal-supported static directed surgery is preferred in patients who have flapless surgery and do not need bone grafting or osseous alteration, in certain instances, static guided surgery may be challenging (Cassetta & Bellardini, 2017).

Dynamic navigation systems are reliable, cost-effective, and capable of changing implant position, device, and size during surgery. It often needs less invasive flap reflecting as compared to free-hand methods, and it allows in less back and neck bending for the surgeon. With an implant needing installation at a second molar position, dynamic navigation allows for implant placement by utilizing the navigation screen to guide the drills in the patient's mouth without direct visualization(Block & Emery, 2016). Navigation for implant surgeries can offer compelling reasons for surgeons to adopt navigation technologies and appreciate improvements in accuracy, precision, performance, time, and expense. A bonus feature is good training for beginners (Block, Emery, Cullum, et al., 2017; Pellegrino et al., 2020).

Technical skills are important throughout the dental profession. To solve complex navigation devices such as disturbed hand-eye coordination and visual input from a 3D environment on a 2D display, the surgeon must train. Several experiments have shown that VR simulators are extremely effective teaching methods for hand-eye coordination (Duffy et al., 2005; Gallagher, Lederman, McGlade, Satava, & Smith, 2004; Grantcharov, Bardram, Funch-Jensen, & Rosenberg, 2003; Hyltander, Liljegren, Rhodin, & Lonroth, 2002; Schijven & Jakimowicz, 2003; Seymour et al., 2002). The teaching of these skills is performed in a few days in the laboratory and goes on inside the clinic. Reduced trainee hours and greater facility pressure allow a preparation schedule to be used more effectively. The question is “Which training program results in more rapid motor skill acquisition in less training time spent?”

Training schedules have been compared across disciplines including psychology and neuroscience in terms of their distributional consequences. Distributed preparation, which combines training with a long rest period, is called distributed training. A long training with a short break refers to massed training. Meta-analytic reviews indicate that distributed training is superior to massed training in better retention of motor skills(Lee & Genovese, 1989). Though, there is a lack of consensus about when or how long of a resting period of training schedule affects retention motor ability. It is also necessary to consider how long general dentists can practice and the changing training schedules’ impact on performance.

2. Objectives

To evaluate the most efficient training program with varying rest periods to achieve motor skill acquired with the highest level of accuracy in implant placement using DNS

3. Materials and methods

Senior dental students who had no prior experience with implant surgery and dynamic navigation system were recruited from the Faculty of Dentistry, Chulalongkorn University. These students were randomly assigned to two groups of 10 subjects each: Group A (a training program that lasts many days) and Group B (training program that is done in one day).

All participants completed a questionnaire about their characteristics (age, gender, dominant hand, and educational background), previous experience (VR games or musical instruments), motivations of the participants (rated themselves on a scale of 1 to 10), dexterity (rated themselves on a scale of 1 to 10), and capacity for performance prediction (rated themselves on a scale of 1 to 10). For their motivation, dexterity, and performance prediction, 1 was considered the lowest score whereas 10 was the highest.

Cone-beam computed tomography (CBCT) scan procedures were taken for each model with a 3D I-CAD machine (Imaging Science International LLC. Hatfield, PA, USA). The DICOM files from the CBCT were uploaded to the DNS and entered into its planning system. A single doctor planned each implant position on the CBCT scan of DNS (E-PED I-ris 100) of the maxillary model. The planning software was used to define the arch, nerve mapping, and implant dimensional manipulation. Multiple views were used to ideally orient the virtual implants and virtual plan the 3.3 mm diameter and 10 mm length BLT implant (Straumann implant system, Basel, Switzerland) and optimal position. The drilling sequence with different diameters of burs was also determined and the 4 radiopaque fiducials that appeared on the CBCT image were marked.

Before the first training, an orientation was given to each participant on the fundamentals of implant placement to ensure a basic understanding of the implant placement fundamentals, how the navigation system works, and how to use surgical handpieces and drills.

The registration of the surgical handpiece was accomplished prior to the procedures by inserting the registration bur into the registration pad and aiming the tracking camera to the pad and the handpiece that contained the registration markers. Identifying the relationship between the geometry of the handpiece tracking array and the axis of the bur was also performed here.

To be prepared for Group A, the participants were given three implantations over three consecutive days. So, on each day, a single implant placement training session was done. Group B performed three implant placements within a single day. The participants in Group B took a 15-minute break after each session. A 7-day post-training test (post-test) was conducted for both groups by placing one implant after the third repetition (Figure 1).

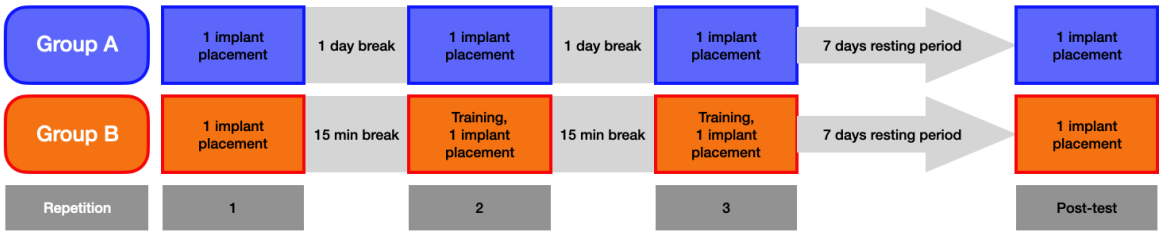

Figure 1 Training program of group A (a training program that lasts many days) and group B (training program that is done in one day)

The accuracy of the implant positioning was calculated by measuring the error in the actual implant position relative to the virtual planning position. Implant planning software automatically superimposed the image data from the postoperative CBCT scan onto the virtual planning image (E-PED Iris 100). The outcomes were 3D platform deviation, 3D apex deviation, and angular deviation (Figure 2).

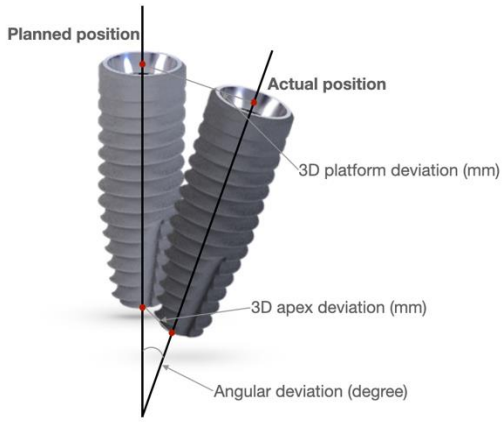

Figure 2 Illustration of the parameters indicates the implant deviations.

Statistical analysis

SPSS Statistics program version 26.0 (SPSS 26.0, Inc., Armonk, NY) was able to import the measurements. The Shapiro-Wilk test was used to determine the normality of the characteristic and accuracy (3D deviation at the implant platform, implant apex, and angle deviation). In the case of parametric data, the independent T-test was used to determine whether there was any significant difference in the characteristics and accuracy of Groups A and B, and the Mann-Whitney test was used for nonparametric data. The Repeated

ANOVA test for parametric data and the Friedman-Dunn test for nonparametric data were used to analyze the difference within the groups. A ρ-value of less than 0.05 was found statistically significant.

4. Results and Discussion

4.1 Results

A total of 20 participants were recruited and divided randomly into 2 groups. Table 1 shows the answers to the questionnaires and statistic calculation. Chi-square tests revealed no significant difference between Group A and Group B regarding the questionnaires' scores.

The results of the accuracy and statistical analyses were summarized in Table 2. The results of the multivariate analysis of accuracy demonstrated no significant effect of all the parameters between the groups ($p<0.05$). Also, there was no significant difference within the groups in both groups ($p<0.05$) (Table 2).

Figures 3-5 show the line graphs that indicate the accuracy in 3D platform deviation, 3D apex deviation, and angular deviation, respectively.

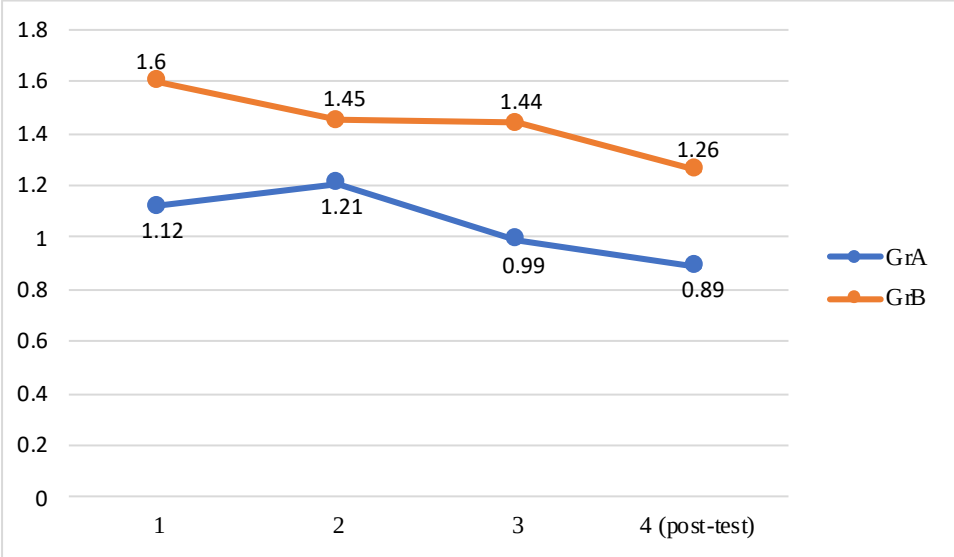

Figure 3 Line graph shows 3D platform deviation(mm) in each repetition

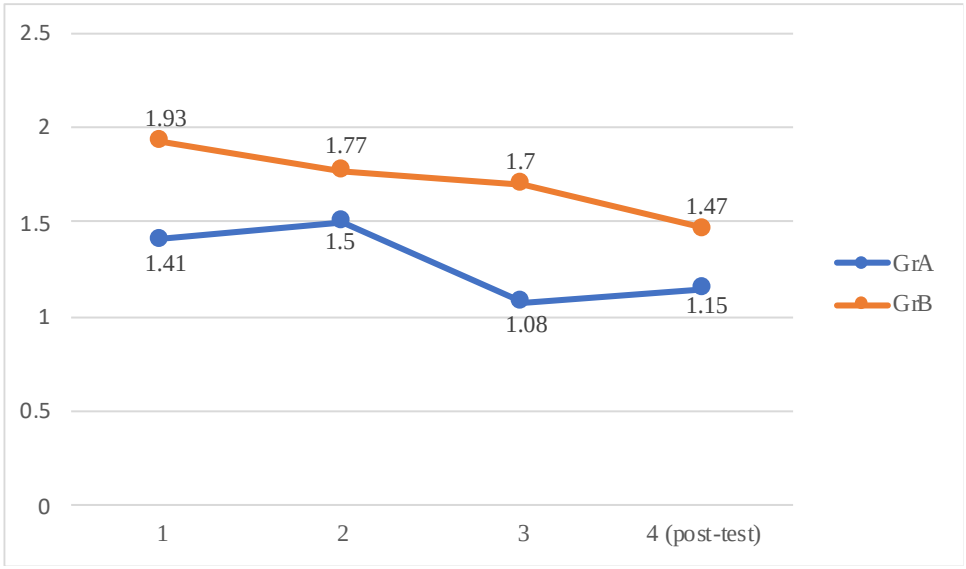

Figure 4 Line graph shows 3D apex deviation(mm) in each repetition

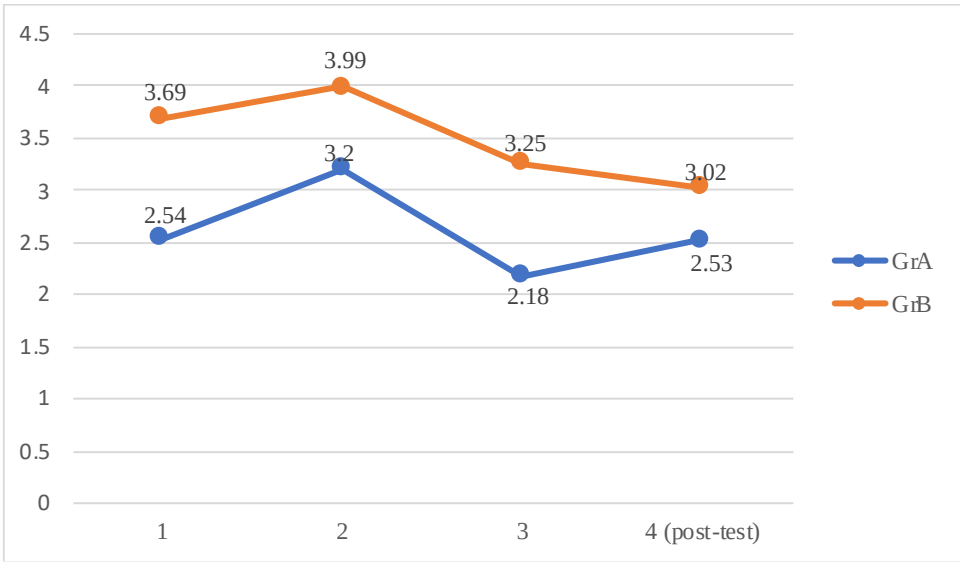

Figure 5 Dot graph shows angular deviation(degree) in each repetition

Table 1 The answers to the questionnaires of the participants in Group A (training program that lasts many days) and Group B (training program that is done in one day)

	Group A	Group B	ρ-value (0.05)
Number of participants	10	10	
Age in year: median(range)	29(27-31)	29.5(27-32)	0.308
Gender (male: female)	4:6	3:7	0.639
Dominant hand (right: left)	8:2	8:2	1.000
Educational background	9:1	8:2	0.531
Prior experience			
Experience of VR game	6:4	5:5	0.653
Playing musical instrument	6:4	6:4	1.000
Motivation to learn a skill for DNS (self-rating)[a]			
Motivation of participant (self-rating)[a] : median (range)	10 (5-10)	9 (7-10)	0.853
Dexterity (self-rating)[a]: median(range)	6.5 (5-9)	6 (3-8)	0.663
Performance prediction (self-rating)[a] : median (range)	5.5 (2-8)	7 (5-9)	0.067

VR, virtual reality
DNS: dynamic navigation system
[a] Rating on a scale of 1 (the lowest score) to 10 (the highest score)
* indicates statistically significant difference

Table 2 Resulted deviations of implant placement using DNS

Parameter	Repetition	Group A	Group B	ρ-value (0.05)
3D Platform deviation (mm)	First	1.12 ± 0.49	1.60 ± 0.60	0.073
	Second	1.21 ± 0.67	1.45 ± 0.65	0.421
	third	0.99 ± 0.36	1.44 ± 0.81	0.134
	Post-test	0.89 ± 0.30	1.26 ± 0.51	0.062
3D Apex deviation (mm)	First	1.41 ± 0.63	1.93 ± 1.12	0.209
	Second	1.50 ± 0.81	1.77 ± 0.76	0.449
	Third	1.08 ± 0.40	1.70 ± 0.98	0.084
	Post-test	1.15 ± 0.40	1.47 ± 0.57	0.163
Angular deviation (degree)	First	2.54 ± 1.61	3.69 ± 2.64	0.280
	Second	3.20 ± 1.26	3.99 ± 1.93	0.289
	Third	2.18 ± 0.83	3.25 ± 2.23	0.631
	Post-test	2.53 ± 1.31	3.02 ± 2.07	0.912

DNS: dynamic navigation system
* indicates statistically significant difference

4.2 Discussion

This prospective study aimed to evaluate the most effective training program in different distributed training schedules using a dynamic navigation system by the senior dental study. The important thing is the background knowledge and skill of participants that affect our outcome (Arora et al., 2015). The researchers gave the orientation to all participants on the fundamental of implant placement, how the navigation system works, and how to use handpieces and drills to ensure basic knowledge. Moreover, the researchers also requested them to fill out the questionnaire about their characteristics, prior experience, and motivations to learn a skill for the DNS to estimate motor skills before the experiment start.

The research by Ting-Mao Sun (2019) that measured the operating performance of dental implant navigation systems used by different levels of implant experience showed that the systems' operational accuracy is not affected by the participants' implant experience levels (Sun, Lee, & Lan, 2019). While other studies (Arora et al., 2015; Eversbusch & Grantcharov, 2004) demonstrated that prior experience enhances motor skills in the Learning Curve. Since the findings of the participant-prepared questionnaire scores before the start of the experiment were not statistically relevant (Table 1), thus, the researchers concluded that the participants in the two groups started with the same level of motor skills.

The word "skill acquisition" implies an improvement in one's performance while in training, whether the training is broken up or carried out as a mass effort. One's ability to retain new abilities over time is known as skill retention.

Some other studies have shown that significant improvements in motor skill, such as both speed and accuracy, appear when measurements are taken 24 hours after training, though no additional training occurs during the intervening period (Brashers-Krug, Shadmehr, & Bizzi, 1996; Shadmehr & Brashers-Krug, 1997).

In the current study, when tested 7 days after the last training, the training program that was done within one day had similar accuracy to the training program that lasted several days. Figures 3-5 show that the overall accuracy within groups was statistically equal even though it appears to be improved.

There was no significant difference in the accuracy between the two groups. The precise explanation for this is unclear. The most possible cause of the deviation is a cognitive one (Verdaasdonk, Stassen, van Wijk, & Dankelman, 2007): preventing deviation. Regarding the navigation system, there is a display that indicates the instrument's deviation in real-time. Participants will notice the virtual implant position deviating from the plan, and they will automatically change the position to the plan. As a result, the participants were quickly able to reduce the mistakes.

Additionally, measuring the deviations in dental implant work is a very delicate and small-scale task, and it is performed on a millimeter scale. So, it is so difficult that even the two groups of participants doing the same task but with completely different levels of motor skill may have no significant statistical difference in their performance.

An alternative hypothesis may be that the participants were not sufficiently trained, and therefore, were still undergoing their learning curve. In a study performed by Krakauer et al. (Krakauer, Ghez, & Ghilardi, 2005), who used a cursor dexterity task on a computer screen where trainees were not allowed to see their hands, they found that further initial preparation resulted in better retention. Thus, further cycles of the activities before the posttest may have increased the difference between groups A and B. Researchers Krakauer et al(Krakauer et al., 2005). Notice that when the intervals between the repetitions (acquisition of skills) are longer than 24 hours, the outcomes are less effective.

In our pilot study, the expected advantage in clinical application is that the senior dental students or dentists with no experience performing implant surgery can train in the most efficient schedule and learn effectively using DNS to acquire motor skill rapidly in term of accuracy even though the result in both groups were similar.

The limitation of our study is that only accuracy was focused on as a parameter to evaluate motor skill acquisition from the implantation using the DNS. However, not only accuracy but time is also the most important parameter that should be investigated. Besides, this experiment had a small sample size and repetitions of implantation in each group. So, further research should include time as a parameter and a larger sample size and perform with more repetition.

5. Conclusion

From our pilot study, The training program, whether it lasts many days and is done in one day, has no significant effect on the development of motor skills for implant placement (in terms of accuracy) when the dynamic navigation system is used.

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