Development and Evaluation of a New Dental Model at Tokyo Medical and Dental University for the Practice of Periodontal Pocket Probing


Abstract: Dental and dental hygiene students must acquire the skill of measuring periodontal pockets and learn to identify the bottom of a pocket, especially of deep periodontal pockets. A new dental model that would enable students to practice measuring deep periodontal pockets was developed at the Tokyo Medical and Dental University. The purpose of this study was to evaluate the feasibility and effectiveness of this model. Twenty dental hygiene students in their third year at the school and twenty-four instructors or dental hygienists of the University Hospital measured periodontal pockets on the newly designed dental model. Feasibility and effectiveness of the model were evaluated based on periodontal probing by the students and instructors, as well as results of a questionnaire. The results demonstrated an intraexaminer agreement (within ±1 mm) averaging 91 percent. The mean percentages of correct answers of the students and instructors were 82 percent and 80 percent, respectively. More than 90 percent of the instructors and students reported that the new model would be suitable for pocket probing training. In the questionnaire, they responded that this practice using the new model would contribute to students' future and that they wanted to try other dental models with various probing depths. The new dental model designed for periodontal pocket probing training was reported to be feasible and effective for student practice.

In general, dental and dental hygiene students begin with typodont practice and mock clinical practice and end with clinical practice on real patients to acquire specialized dental skills. Many dental models, which can be utilized for dental education, are commercially available. These have also been used for objective structured clinical examinations (OSCEs) and training for calculus detection. However, there are few dental models that simulate the bottom of periodontal pockets, and no studies have evaluated their effectiveness.

It is very important for dental and dental hygiene students to acquire the skill of measuring periodontal pockets or sulcus properly and identifying the bottom of a pocket. Determination of periodontal pocket probing depth is an essential diagnostic procedure in periodontal treatment. Therefore, many studies have been conducted related to periodontal pocket probing such as proper interpretation of periodontal probing, probing pressure, diameter of the tip of probe, intra- and/or interexaminer difference, and differences between various types of probes. However, in the field of education in general, most students practice on a dental model that does not include a structure simulating the bottom of the pocket. Therefore, students practice only insertion of the probe between artificial tooth and gingiva. It would not be suitable for beginners to practice pocket probing on such a model.

A prototype dental model that enables students to experience a better sense of the bottom of the pocket and learn proper measurement of deep pockets.
was developed in 2008. The model was designed to mimic the periodontal pocket structure with a separate part serving as the bottom of periodontal pocket (Figure 1). This part, called the second layer, was covered by the first layer, which served as the gingiva. The periodontal probe unintentionally penetrated into the gap between the second layer and root surface due to the flexure of the second layer on the model.

A new model was then designed in 2009 (Figure 2). The second layer was made of hard resin with soft silicone elastomer on top of it, serving as the bottom of the periodontal pocket. As the hard material prevents flexure of the second layer, the periodontal probe could not penetrate deeper than the setup depths, which were confirmed with a constant force probe. Several versions of the first layer, which serves as the gingiva, and the second layer, representing the bottom of the pocket, were designed (Figure 3). Furthermore, the model was designed for multipurpose use with deep pockets and subgingival spaces that allowed artificial calculus to be put on the roots, so that students could practice subgingival scaling and root planing on the model when the second layer is removed. The purpose of this study was to evaluate the feasibility and effectiveness of a newly designed dental model in training students to properly measure deep pockets.

Materials and Methods

The pocket distribution of the new model was designed for students to learn measurement of shallow, moderate, and deep periodontal pockets and to experience various patterns of periodontal disease in one model during practice. For full-mouth periodontal probing, pocket depths were set up in six aspects of each tooth: mid-buccal, mid-lingual, mesio-buccal, mesio-lingual, disto-buccal, and disto-lingual. Nissin Dental Products, Inc. was entrusted to produce the new model with setup depths of the periodontal pockets. The setup depths were confirmed with a constant force probe (Shioda; TUCLII; set at 25 g of pressure).

To evaluate the agreement to the setup depths of the new model, the pocket depths were measured at all six aspects of six selected teeth (#04, #07, #15, #20, #24, #31) by three highly experienced examiners. Examiner 1 was a periodontist with twenty-five years of clinical experience, and examiners 2 and 3 were...
Figure 2. Newly designed model in 2009

Note: As the hard material prevents flexure of the second layer, the periodontal probe cannot penetrate deeper than the setup depth.

Figure 3. Several versions of gingiva and bottom of pocket designed in 2009 model

Note: These versions can be exchanged to create various patterns of pocket distribution and shapes of the gingiva, which allows this model to be used for experiencing various forms of periodontal disease. This model also has furcations on all first molars, which allows students to practice probing on furcation-involved teeth.
Results

Intraexaminer agreement of probing depth measurements by the three examiners is shown in Table 1. The results of this study demonstrated an intraexaminer agreement (within ±1 mm) averaging 91 percent. No statistically significant difference was found in the rates of agreement (within ±0 mm, ±1 mm, or ±2 mm; all sites, shallow sites, or deeper sites) between examiners.

The percentages of correct answers for each site measured by students and instructors are shown in Figure 4. The mean percentages of correct answers of the students and instructors were 82 percent and 80 percent, respectively. The accuracy rates of three sites were 50 percent or less (marked with stars on the graph). A significant difference was observed between the accuracy rates of students and instructors at the mid-lingual site of #04 (tooth numbers are those on the U.S. Tooth Numbering Chart, so #04 is the maxillary right upper second premolar). There was no significant difference between the students and instructors in the ratio of the points that were measured too shallow or too deep. The responses to the questionnaire are shown in Figure 5. Most students and instructors answered that the newly designed dental model would be suitable for pocket probing training and that practice with the new model would contribute to the students’ future. Additionally, 90 percent of the students responded that they were interested in other related practices after this trial. However, a considerable number of students and instructors answered that it was not easy to find the bottom of the periodontal pockets, and some answered that the practice was not more effective than mock clinical practice for pocket probing.

In the open-ended responses, students’ comments included the following: “It was good for me because I had not probed any deep pockets in the mock clinical practice sessions” (similar comments: 5); “It was easier to find the bottom of periodontal pockets than the previous prototype model” (similar comments: 2); and “It was difficult to find the bottom of periodontal pockets” (similar comments: 3). Instructors’ comments included the following: “Using this model with deep pockets would be educationally effective because most students practicing mock clinical practice have shallow pockets” (similar comments: 4); and “I could not insert the probe smoothly in some sites because of the stickiness of the gingiva” (similar comments: 11). Most comments were positive; how-

dental hygienists with seven and thirty-four years of clinical experience, respectively. Each examiner measured each site five times at three or four days’ interval using a manual periodontal probe (Hu-Friedy; CP-15 University of North Carolina). To mimic clinical periodontal examination, probing was performed without a stent to guide the position or direction of the probe. The rates of agreement within ±0 mm, ±1 mm, and ±2 mm variation to setup depth were calculated. Probing depths (PD) were analyzed separately for shallow (PD≤3 mm) and deep (PD>3 mm) sites in the same way as described by Wang et al.16

All twenty dental hygiene students in the third year at the School of Oral Health Care Sciences, Faculty of Dentistry, Tokyo Medical and Dental University, who had already completed pocket probing practice on a phantom and mock clinical practice, and twenty-four experienced persons who worked as instructors teaching dental hygiene practices at the school and University Hospital and also worked as dental hygienists at the University Hospital, measured the periodontal pockets on eleven sets of the newly designed dental model using a probe (Hu-Friedy; CP-10) in six aspects of six teeth (#04, #07, #15, #20, #24, #31) as in the intraexaminer agreement study. The same probe (CP-10) used for students’ practice at school was selected for the feasibility study, so that the students would not be confused and make a mistake in reading the marks. The Ethical Committee for Human Research at Tokyo Medical and Dental University decided that this study need not be judged by the committee in compliance with Ethical Guidelines for Clinical Studies and Ethical Guidelines for Epidemiological Studies.

A correct answer was defined as the setup depth ±1 mm. The accuracy rate by site (between students and instructors) was analyzed by chi-square test. The following is a list of multiple-choice questions which the participants answered with yes/somewhat yes/somewhat no/no:

- Did you think the dental model was suitable for pocket probing training (for students)?
- Was it easy to find the bottom of the periodontal pockets?
- Do you think that this practice will contribute to your/the students’ future?
- Are you (Do you think students are) interested in other related practices after this trial?
- Do you want to try other dental models with various periodontal probing depths?
- Do you think this practice is more effective than mock clinical practice for pocket probing?
Table 1. Rates of agreement within ±0 mm, ±1 mm, and ±2 mm variation to setup depth

<table>
<thead>
<tr>
<th>Examiner</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>All sites n=180 ±1mm</td>
<td>93.9%</td>
<td>91.1%</td>
<td>86.7%</td>
<td>90.6%</td>
</tr>
<tr>
<td>±2mm</td>
<td>98.9%</td>
<td>99.4%</td>
<td>97.2%</td>
<td>98.5%</td>
</tr>
<tr>
<td>Shallow sites n=40 ±1mm</td>
<td>85.0%</td>
<td>87.5%</td>
<td>70.0%</td>
<td>80.8%</td>
</tr>
<tr>
<td>±2mm</td>
<td>100.0%</td>
<td>100.0%</td>
<td>97.5%</td>
<td>99.2%</td>
</tr>
<tr>
<td>Deeper sites n=140 ±1mm</td>
<td>96.4%</td>
<td>92.1%</td>
<td>91.4%</td>
<td>93.3%</td>
</tr>
<tr>
<td>±2mm</td>
<td>98.6%</td>
<td>99.3%</td>
<td>97.1%</td>
<td>98.3%</td>
</tr>
</tbody>
</table>

n=number of measurements

Note: Probing depths (PD) were analyzed separately for shallow (PD ≤3 mm) and deep (PD >3 mm) sites. No statistically significant difference was found in the rates of agreement (within ±0 mm, ±1 mm, or ±2 mm; all sites, shallow sites, or deeper sites) between examiners (Kruskal-Wallis test).

Figure 4. Percentages of correct answers by students and instructors in each site

D=distal, B=buccal (mid-buccal), L=lingual (mid-lingual), M=mesial

Note: Tooth numbers follow the U.S. Tooth Numbering Chart.
comparable with those in clinical cases reported by Badersten et al.,
Walsh and Saxby, and Wang et al.
The prototype dental model developed in 2008 had a problem in penetration due to the flexure of the parts, and the probe went in too deep.
Decreased flexure of the material of the second layer reduced the risk of overestimation of the probing depths in the newly developed dental model.
A significant difference was observed between the accuracy rates of students and instructors at the mid-lingual site of #04, which is probably an isolated problem. The contour of the crown and excessive constriction force of the gingiva at the site would have prevented smooth insertion of the probe. Although proper pressure of probing allows the probe to reach the bottom of the pocket, excessive pressure would likely allow the probe to reach the bottom more easily. Accordingly, the probability of reaching the bottom would have been higher in the students because most students tend to insert the probe with almost half of the instructors pointed out that the gingiva was too sticky when inserting the probe.

Discussion

The feasibility and effectiveness of a newly designed dental model that would enable students to learn proper measurement of deep pockets were evaluated. The results indicated that the new model would be feasible and effective in the practice of periodontal pocket probing for dental and dental hygiene education. Studies on intraexaminer variability of pocket depth measurements in patients using a conventional probe demonstrated that approximately 80-97 percent of the recordings could be reproduced within ±1 mm difference. Thus, a correct answer was defined as the correct setup depth ±1 mm in this study. The intraexaminer agreement of probing depth measurements in this model was comparable with those in clinical cases reported by Badersten et al., Walsh and Saxby, and Wang et al. The prototype dental model developed in 2008 had a problem in penetration due to the flexure of the parts, and the probe went in too deep. Decreased flexure of the material of the second layer reduced the risk of overestimation of the probing depths in the newly developed dental model.

A significant difference was observed between the accuracy rates of students and instructors at the mid-lingual site of #04, which is probably an isolated problem. The contour of the crown and excessive constriction force of the gingiva at the site would have prevented smooth insertion of the probe. Although proper pressure of probing allows the probe to reach the bottom of the pocket, excessive pressure would likely allow the probe to reach the bottom more easily. Accordingly, the probability of reaching the bottom would have been higher in the students because most students tend to insert the probe with

<table>
<thead>
<tr>
<th>Question</th>
<th>Students</th>
<th>Instructors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you think the dental model was suitable for pocket probing training</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(for students)?</td>
<td>45</td>
<td>29</td>
</tr>
<tr>
<td>Was it easy to find the bottom of the periodontal pockets?</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>Do you think that this practice will contribute to your/the students’</td>
<td>30</td>
<td>42</td>
</tr>
<tr>
<td>future?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are you (Do you think students are) interested in other related practices</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>after this trial?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you want to try other dental models with various periodontal pocket</td>
<td>45</td>
<td>29</td>
</tr>
<tr>
<td>depths?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you think this practice is more effective than mock clinical practice</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>for pocket probing?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 5. Results of multiple-choice responses to the questionnaire

Note: Red bars indicate affirmative answers (Yes and Somewhat Yes), and blue bars indicate negative answers (No and Somewhat No).
too much pressure against the constriction force. The model may have to be further improved to avoid the excessive constriction force of the gingiva.

Since the periodontal probe unintentionally penetrated into the gap between the second layer and root surface due to the flexure of the second layer on the prototype dental model in 2008, to learn how certain the examiner felt in detecting the bottom of the pockets, the question “Was it easy to find the bottom of the periodontal pockets?” was included. Only 55 percent of the students and 59 percent of the instructors answered that it was easy to find the bottom of the pocket, but the actual accuracy rates of students and instructors were means of 82 percent and 80 percent, respectively. In other words, many correctly identified the bottom of the pocket despite feeling uncertain. Therefore, it was considered that this model was appropriate to be used as a practice model.

Many students and instructors made errors when measuring the sites at pockets with a sloped bottom at the border in the six-point periodontal pocket probing. The shape of the bottom of the pocket at the site with the worst accuracy is shown in Figure 6. The sloped bottom of the pocket at the border of the sites on six-point periodontal pocket probing can be seen. Sloped bottoms of the pocket are usually encountered in the real clinical situation, but they would not be appropriate in models for training because they should have an exact setup depth for each site of six-point periodontal pocket probing in order to give definite feedback to students after training. The design of the pocket should be improved by eliminating the sloped bottom at the border of the sites on six-point periodontal pocket probing in the next model.

To the question “Do you think that this practice is more effective than the mock clinical practice on pocket probing?,” 60 percent of the instructors responded positively; however, only 35 percent of the students responded positively. The percentage of the students’ positive responses was rather low. The students and instructors who answered negatively to this question may think that mock clinical practice is more advantageous because it uses human beings. Consequently, they might tend to prefer mock clinical practice over using models. This tendency might be stronger in students than in instructors because students have not measured deep pockets during practice. They would not recognize or realize the importance of measuring deep pockets, but instructors (who measure deep periodontal pockets on a daily basis in the clinic) tend to understand its importance.

The material of the gingiva should be improved by reducing its stickiness, and the design of the bottom of the pocket should be modified in order to

---

**Figure 6. Shape of bottom of pocket at site with worst accuracy**

*Note: The sloped bottom of the pocket at the border (red lines) of the sites in six-point periodontal pocket probing.*
develop more appropriate models for the training of periodontal pocket probing for dental and dental hygiene students. Overall, however, the new dental model designed for periodontal pocket probing training was reported to be feasible and effective for student practice.

Acknowledgments

The authors would like to thank the students and instructors at the School of Oral Health Care Sciences, Faculty of Dentistry, and dental hygienists at the University Hospital, Tokyo Medical and Dental University, for participating in the evaluation of the dental model. The new dental models evaluated in this study were produced and provided by Nissin Dental Products, Inc., Kyoto, Japan based on our requirements. The new model was jointly patented by Tokyo Medical and Dental University, Tokyo, Japan, and Nissin Dental Products, Inc., Kyoto, Japan. Two of the coauthors, Keiko Kondo and Atsuhiro Kinoshita, are listed as joint inventors of the patent.

REFERENCES