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Effect of a Standardized Training with Digital Evaluation on the Improvement of Prosthodontic Faculty's Performance in Crown Preparation: A Pre-Post Design

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Abstract

Purpose: Standardized crown preparation is an important competency for prosthodontic faculty especially when they take on the dual role of clinician and clinical teacher. Effects of faculty training for enhancing crown preparation competency are seldom reported. This study aimed to analyze the impact of a standardized training workshop with digital evaluation on the dental faculty's performance in crown preparation.
Materials and Methods: The digitally evaluated grades of anterior (the maxillary right central incisor) and posterior (the mandibular left first molar) tooth preparations made by 76 participants who accomplished all six training tasks were collected, including off-site and on-site exercises before the didactic lecture and live demonstration, three rounds of practices with digital feedback, and a final test. Grades of preparations performed in the on-site exercise were adopted as pre-training scores, and those in the final test as post-training scores. Total scores and marks deducted for the parameters including amount of reduction, margin line, and taper were compared among each training task.
Results: The post-training scores of both anterior and posterior tooth preparations increased significantly more than the pre-training scores. The average increased score proportion was 22.95% ± 4.17% for anterior tooth preparations, and 21.78% ± 3.68% for posterior tooth preparations. For anterior tooth preparations, total scores and the parameters except taper significantly improved in the first practice and maintained the same level for the next sessions. Total scores and all parameters for posterior tooth preparations exhibited continual improvement during the training process.
Conclusion: Standardized training can further improve dental faculty's crown preparation performance in a moderate way. Individual design for crown preparation training can be considered based on different tooth positions. Providing such training will aid the calibration of clinical teaching behavior and the elevation of clinical operative standards for prosthodontic faculty.

Crown preparation is one of the essential operative skills in dental practice. The hands-on dental curriculum aimed at the acquisition of crown preparation skill represents a significant part of dental education.[1] A high level of competency, including expertise, knowledge and skills, are expected from dental instructors.[2] Further, in the lists of competencies for effective dental faculty, demonstrating clinical skills is rated as one of the major competencies both for the role of a clinician and a clinical teacher.[3] The term "competency" refers to the ability of an individual to function in a specific context, including the knowledge, skills, and values.[4,5] Due to the disparity in natural talent, personal endeavor, educational background, and clinical experience, the levels of crown preparation competency inevitably vary among individual dental faculty. Especially for the role of clinical teacher, the crown preparation competency emphasizes the standardized knowledge and skills including the calibrated action, posture and position for a specific tooth preparation task. However, customized habits of practitioners are usually developed from clinical practice. While such habits may be practical for clinical settings, they differ from the standard protocols in the fixed prosthodontic textbook that mainly focus on the normative training of basic psychomotor ability for beginners rather than emphasize the skills needed to promote clinical productivity. Besides, the role transition for new instructors may be more difficult now because they must personally demonstrate clinical procedures to teach. These considerations will negatively impact the effectiveness of instructors' teaching performance.[6] Therefore, it is necessary to provide standardized crown preparation training for prosthodontic faculty to further improve their operative skills, and more importantly, to prepare them better for teaching assignments.[7-13] However, the difficulty in conducting faculty training has been reported.[6,13] Barriers such as lack of time, and different attitudes among faculty members, and various available training patterns without proven effects make it difficult to achieve an effective and feasible faculty training.[6,13] Objective evidence is required for the identification of an appropriate training pattern which can ensure effectiveness, while avoiding a waste of time and resources. However, investigations concerning the training for dental faculty are rare.[14,15] The effect of faculty training for the crown preparation competency has not been reported.

With the advancement of technology, newly emerging digital tools have been introduced in dental fields. For example, a digital evaluation system that grades tooth preparation by scanning the prepared tooth and comparing it to a stipulated gold standard has been applied for dental training.[16-18] This effectively improves the trainee's learning experience by providing more detailed and objective visual feedback.[19] The application of the digital evaluation system has been shown to facilitate students' learning and enhance their tooth preparation performance.[20-23] In order to (1) popularize the application of the digital grading method for dental education, and (2) enhance dental faculty's competency in standardized crown preparation, a faculty training workshop was launched by the Society of Prosthodontics, Chinese Stomatological Association in 2018. This study analyzed the data of the digitally evaluated preparations completed by trainees in this workshop, which provides a natural pre-post design and sufficient samples with reliable objectivity to explore the effect of a standardized training program on dental faculty's performance in crown preparation. The first null hypothesis was that standardized training would not improve faculty's crown preparation performance. The second null hypothesis was that there would be no difference between the training effect for anterior and posterior tooth preparation.

Materials and methods

This investigation was reviewed and approved by the Institutional Review Board of Peking University School of Stomatology (PKUSSIRB-202054016). A total of 106 prosthodontic faculty members with formal teaching experience from different dental institutions in China (including undergraduate schools and technical colleges) were recommended by their institutions to participate in the training workshop. The training assignment consisted of the preparation of a maxillary right central incisor (11#) for a ceramo-metal crown, as well as a mandibular left first molar (36#) for a metal crown, with an identical tooth model (A5SAN-2002, Nissin Dental Products Inc, Kyotoshi, Kyoto, Japan) and instruments (Mani Inc, Utsunomiya, Tochigi, Japan). The training procedure is detailed in Figure 1. Before the workshop began, all trainees received the standard tooth models by post and were informed of the grading criteria. They were required to perform these crown preparations using the specified instruments with the standard jaw model at their own simulation training site, to familiarize themselves with the process and criteria. After arriving at the workshop, trainees were asked to use the uniform on-site simulation facilities (Senior type II Manikin, Nissin Dental Products Inc) and the instruments to repeat the task before training within a specified time (30 minutes for each preparation). The workshop started with a didactic lecture on the principles, criteria, and rubrics of standardized crown preparation, delivered by a senior fixed prosthodontic specialist. This was followed by a live demonstration of a crown preparation performed under a dental microscope (Carl Zeiss Meditec AG, Oberkochen, Germany) and broadcast to all trainees through the internal video system. Then, a total of three rounds of practice were carried out by all trainees. All the preparations were scanned by the same technical staff using a digital evaluation system (Fair Grader 2000, Nissin Dental Products Inc) that generated the final grades on a 0–100 scale, and marks deducted for the parameters including amount of reduction, margin line and taper. A PDF report with detailed scores was produced, which also showed deviations from the ideal preparation in horizontal, vertical, and oblique cross sections. All the results were provided to corresponding operators in a timely fashion, so the defects would be recognized before the next practice. Finally, a test was conducted with the same procedure as the practice exercise.

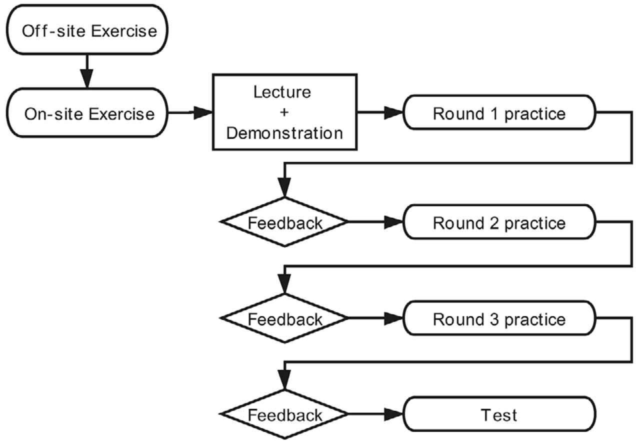

Figure 1 Flow chart of the standardized training workshop.

Data acquisition

Only the preparations made by the trainees who completed all the required tasks were included; 30 trainees who only had partial training records were excluded from the analysis. This made a final inclusion of 76 trainees. The demographic information of these trainees was collected, including the age, gender, and type of institution they work for (Table 1). The total scores of preparations were generated by the digital

Table 1 General characteristics of the 76 trainees

Age (y)	Gender		Type of institution	
Mean ± SD	Female (n)	Male (n)	Undergraduate school (n)	Technical college (n)
38.7 ± 6.4	57	19	51	25

Table 2 The criterion for predefined ideal 11# and 36# preparations and the grading rubric

	Criterion		
Parameter	11#	36#	Rubric
Occlusal reduction	1.5-2.0 mm	Nonfunctional cusp: 1 mm; Functional cusp: 1.5 mm	Amount of reduction: The range of –5% to 5% difference is acceptable; For every 5% increase, 10 points will be deducted.
Labial/buccal reduction	1.2-1.5 mm	0.5-1.5 mm	
Lingual/palatal reduction	0.5-0.8 mm	0.5-1 mm	
Taper	0-6 degrees	0-6 degrees	Taper: For every 10 degrees difference, 2 points will be deducted; If the taper <0 or >35 degrees, 10 point will be deducted.
Margin line	Labial: 1 mm shoulder; Palatal: 0.5 mm chamfer at gingival level	0.5 mm chamfer at gingival level	Margin line: The range of –5% to 5% difference is acceptable; For every 5% increase, 2 points will be deducted.

evaluation system based on a predefined ideal preparation. The criteria for the ideal preparations are listed in Table 2. To reduce the potential negative impact of unfamiliarity with the simulation operation, the grades of the second preparations before training were adopted as the pre-training scores. The grades of preparations in the final test were used as the post-training scores. The increased score proportion for every trainee was calculated using the following formula: Increased score proportion = (post-training score-pre-training score)/pre-training score × 100%. The average increased score proportion of all trainees was used to represent the overall magnitude of the improvement through the training. The marks deducted for amount of reduction, margin line and taper were produced digitally according to the difference between the prepared tooth and the ideal preparation. The grading rubrics are detailed in Table 2.

Data analysis and statistics

Data were analyzed using SPSS 20.0 (IBM Corporation, Chicago, IL). Data distributed normally with equal variance were expressed as the mean ± SEM. The Pearson correlation analysis was performed to explore the relationship between age and the pretraining scores. Student's t-test was used to identify the influence of gender, age, and the type of institution on the pre-training scores. To verify the effects of these factors on the increased score proportion, Mann-Whitney U test was adopted. To analyze the effect of each training session on the tooth preparation performance, the total scores and marks deducted for amount of reduction, margin line, and taper of preparations completed during the training process were compared by repeated measures one-way analysis of variance (ANOVA), followed by the Bonferroni post hoc test. $p < 0.05$ was considered statistically significant.

Results

Effect of the gender, age, and type of institution on the pre-training scores and increased score proportions

For both 11# and 36# preparations, no significant correlation was detected between the age and the pre-training scores (11#: R = 0.002, $p = 0.988$; 36#: R = 0.138, $p = 0.323$). There was no significant difference in the pre-training scores between male and female (11#: $p = 0.533$; 36#: $p = 0.4996$), young (< 40) and middle aged (≥ 40) (11#: $p = 0.7805$; 36#: $p = 0.5346$), or faculty from undergraduate school and technical college (11#: $p = 0.4733$; 36#: $p = 0.2297$). No significant difference in increased score proportions was observed between male and female (11#: $p = 0.1691$; 36#: $p = 0.2187$), young (< 40) and middle aged (≥ 40) (11#: $p = 0.8665$; 36#: $p = 0.5881$), or faculty from undergraduate school and technical college (11#: $p = 0.2387$; 36#: $p = 0.3293$).

Total scores of 11# and 36# preparations during training

Repeated ANOVA presented a significant difference among training tasks both for total scores of 11# (F = 19.56,

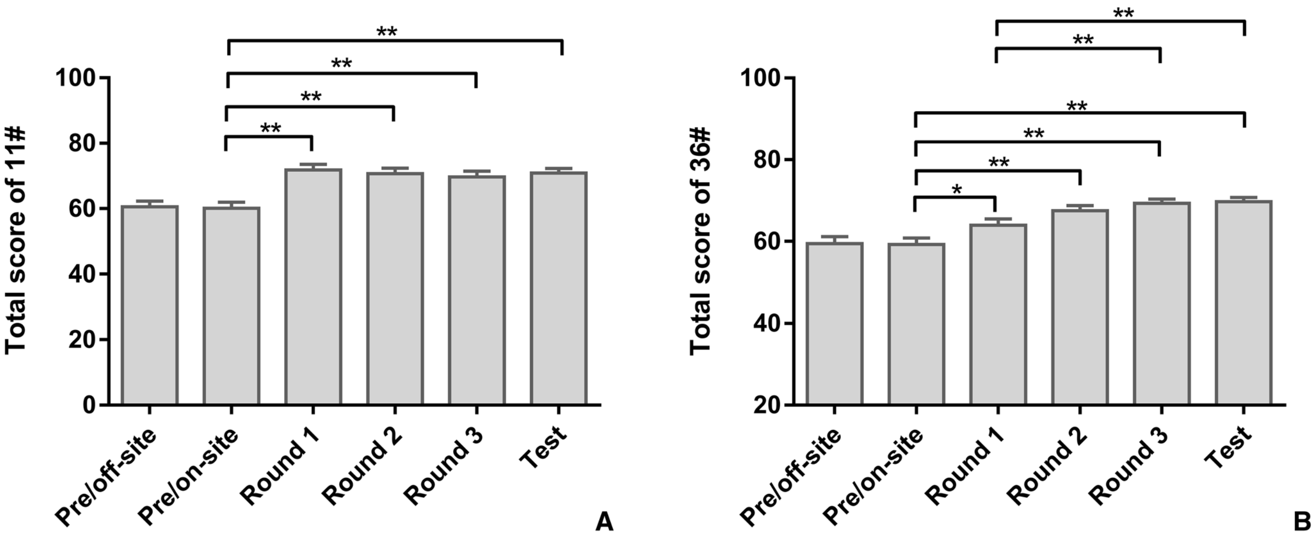

Figure 2 Total scores of 11# (A) and 36# preparations (B) performed off-site and on-site before the training course, in the three rounds of practice, and in the final test. *, $p < 0.05$; **, $p < 0.01$.

$p < 0.0001$) and 36# preparations (F = 18.4, $p < 0.0001$). For the 11# preparations, the post-training scores (70.91 ± 1.37) significantly increased than the pre-training scores (60.12 ± 1.84) ($p < 0.0001$). The average increased score proportion was 22.95% ± 4.17%. There were 42/50 trainees with an increased score proportion > 0%, 34/50 trainees > 10%, and 21/50 trainees > 20%. For the 36# preparations, the post-training scores (69.68 ± 1.08) significantly increased from the pre-training scores (59.22 ± 1.59) ($p < 0.0001$). The average increased score proportion was 21.78% ± 3.68%. There were 44/53 trainees with an increased score proportion > 0%, 36/53 trainees > 10%, and 21/53 trainees > 20%.

No difference in total scores of 11# or 36# preparations was observed between off-site and on-site exercises before training ($p > 0.9999$). Total scores of 11# preparations in the first practice following the didactic lecture and live demonstration significantly increased from the pre-training scores ($p < 0.0001$) and remained the same level in the second and third practice with digital feedback as well as in the final test (Fig 2A). Total scores of 36# preparations in the first practice significantly increased from the pre-training scores ($p = 0.017$), and further increased in the third practice ($p = 0.002$) and remained the same level in the test (Fig 2B).

Repeated ANOVA presented a significant difference among training tasks for marks deducted for amount of reduction (F = 23.79, $p < 0.0001$) and margin line (F = 7.697, $p < 0.0001$) of 11# preparations, and marks deducted for amount of reduction (F = 8.603, $p < 0.0001$), margin line (F = 4.04, $p = 0.005$), and taper (F = 10.32, $p < 0.0001$) of 36# preparations. There was no difference in marks deducted for amount of reduction and margin line of 11# or 36# preparations between off-site and on-site exercises ($p > 0.9999$; Fig 3A-3D). No difference in marks deducted for tape of 11# preparations between the off-site and on-site exercises was detected ($p = 0.9742$; Fig 3E). Marks deducted for taper of 36# preparations in the on-site

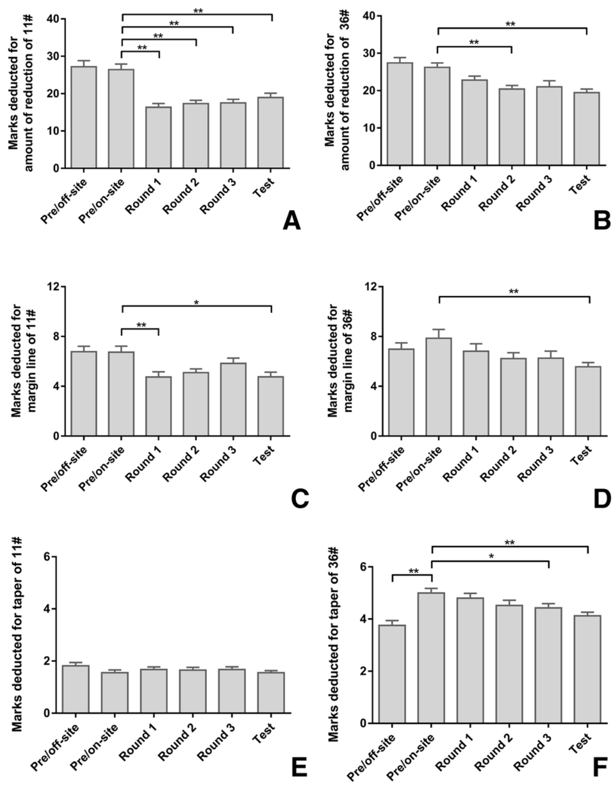

Figure 3 Marks deducted for amount of reduction, margin line and taper of 11# (A, C, and E) and 36# preparations (B, D, and F) performed off-site and on-site before the training course, in the three rounds of practice, and in the final test. *, $p < 0.05$; **, $p < 0.01$.

exercise significantly increased from those prepared off-site ($p < 0.0001$; Fig 3F).

For 11# preparations, points deducted for amount of reduction and margin line in the first practice following the didactic lecture and live demonstration significantly decreased from those in the pre-training exercise ($p < 0.01$) and remained the same level in the second and third practice with feedback, as well as in the final test (Fig 3A and 3C). No significant change in marks deducted for the taper during the training was observed ($F = 1.433$, $p = 0.2292$; Fig 3E). Inadequate reduction mainly occurred at the lingual fossa, the junction of the lingual fossa and axial wall, as well as the line angle around the lingual fossa. Excessive reduction was often found at the incisal part of the labial axial surface.

For 36# preparations, points deducted for amount of reduction, margin line, and taper tended to decline during three rounds of practice, but the difference was not all statistically significant (Fig 3B, 3D, and 3F). Marks deducted for these parameters in the test significantly decreased compared with the pre-training exercise ($p < 0.01$; Fig 3B, 3D, and 3F). Inadequate reduction usually occurred at the center of the occlusal surface and the functional bevel. Excessive reduction was generally observed at the distal axial surface and buccal cusp.

Discussion

The goal of this study was to evaluate the effect of a standardized training workshop on the faculty's crown preparation performance. The results demonstrated that the crown preparation scores significantly increased through training, and anterior tooth preparation performance improved faster than posterior tooth preparation. Thus, both null hypotheses were rejected. The increase in the scores through training was moderate, which is reasonable considering the trainees as prosthodontic faculty have mastered the basic technique of crown preparation before training. The modest increase is still practically meaningful for faculty to achieve the high level requirement in dental teaching. In Mainland China, clinical instructors responsible for dental education are typically full-time faculty in academic institutions rather than part-time faculty from private practice. Generally, the competencies of faculty employed in undergraduate schools are considered better than those working for technical colleges.[24] One study reported that age and gender affect the performance in the operative task among surgery residents;[25] however, this investigation observed no significant correlation between any of these factors (the type of institution, age or gender) and the scores of preparations. This may be explained by that the crown preparation task and the grading rubrics are not sensitive enough to identify the potential differences caused by these factors. This suggests that in terms of the data analyzed in this particular investigation, the effects of the institutional type, age and gender are not significant, and the participants can be considered a population with similar nature. No difference in the total scores and most of the parameters of preparations between the off-site and on-site exercises was detected, suggesting that the lack of familiarity with simulation procedure does not affect the crown preparation performance. This result also indicates that repeated practices without further training are ineffective in improving trainees' crown preparation performance. Marks deducted for taper of 36# preparations completed on-site significantly increased compared with those prepared off-site. This may be explained by the possibility that some trainees prepared 36# directly in their hands without supervision, which is an easier way to meet the criterion of taper, rather than in the simulation set-up. No significant change in the deduction of taper of 11# perpetrations during this training was detected, suggesting that the trainees may have already mastered how to control taper of anterior tooth preparation.

Different training effects between anterior and posterior tooth preparations were observed in this investigation. These different effects due to tooth position is not surprising, as the anterior crown preparation is generally easier than posterior tooth considering the ease of access for the operation. So, in order to enhance faculty's crown preparation performance, a detailed illustration and demonstration will be sufficient for the anterior tooth, while one or two rounds of practice will be beneficial for the posterior tooth. The results also suggest it would be unnecessary to add more training sessions, since no further improvement was exhibited.

The faculty training workshop comprised a didactic lecture, a live operation demonstration, as well as three rounds of practice with digital feedback. As skilled dental practitioners, the trainees may not gain new knowledge from the didactic lecture and live demonstration. Instead, these training patterns may refresh the trainees' existing knowledge regarding the operation skill and the tips to minimize errors. Nevertheless, this training session appears to be very effective in improving the trainees' crown preparation performance. The live lecture and demonstration can be replaced with a recorded instructional video with similar content to reduce the cost of future training. The repeated hands-on practices with feedback also function in further improving the trainees' crown preparation performance, especially for the posterior tooth. Feedback has been considered fundamental for effective clinical teaching.[26] In this workshop, immediate feedback was provided by a digital evaluation system following each practice, which can reduce potential subjective errors and enhance the efficacy of feedback in comparison with self-assessment. However, it should be emphasized that this study cannot prove whether this digital feedback is indispensable for the effectiveness of this training. Unlike undergraduate students who are incapable of accurately evaluating the prepared tooth on their own, the trainees are skilled dental faculty who should have a reliable self-assessment ability.[27] Considering the inherent limitations of the one group "pre-post" design of this investigation, further studies with a rigorously controlled trial design should be conducted to confirm the role of digital feedback. Besides, this investigation only provided a short-term observation for the training effect. It will be beneficial to further explore the long-term effect of a standardized training pattern.

Conclusion

This study suggests that short-term standardized training improves prosthodontic faculty's crown preparation performance in a moderate way, and can be provided to elevate the clinical operative standard of crown preparation for dental faculty, and aid to calibrate their clinical teaching performance in dental education. Individualized crown preparation training patterns for dental faculty can be considered based on different tooth positions.

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