Short Communication

Clinical relevant haptic simulation learning and training in tooth preparation

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Abstract Clinical dentistry is a complex activity which the procedure of most dental treatment are almost irreversible changes. Patient safety is a major challenge in clinical dental care. This is the reason why simulation-based learning and training is emphasized in dental education. In this article, the authors presented the clinical relevant haptic simulation learning and training in tooth preparation. The practical framework to set up the simulation environment from real patients in haptic 3D virtual reality dental training simulator Simodont® (Nissin Dental Products Inc., Nieuw-Vennep, Netherlands). Then, the trainee can repeatedly practice in Simodont® before performing the clinical procedure on real patient. Taken together, the implementation of this model in dental education may not only enhance trainees' self-confidence and performance, but also facilitate patient safety during clinical dental care.
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Introduction

Clinical dental training must use live patients to hone the core clinical competency in a potentially high risk dental care environment. Dental interns and novice dentists usually treat patient under the supervision of tutors in the beginning of clinical skill training. Insufficient practice and lack of enough clinical experiences will evoke stress and anxiety of them. Operation errors may have highly irreversible damages on teeth and surrounding tissues when performing restorative, endodontic, and surgical procedures. Ensuring patient safety is very important in dental healthcare environments.[1] Simulation laboratory learning and training act as a significant rotation shaft from preclinical dental education to clinical dental care.[2,3] Traditionally, mannequins and acrylic tooth are the tools for learning and training manual dexterity skill and basic treatment procedure in simulation-based dental education.

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However, it is still a gap between pre-clinical dental education and actual clinical situation in the required psychomotor skills.[4]

With the advancement of technology, virtual simulation training is the new way for pre-clinical learning and clinical training. The haptic 3D virtual reality dental training simulator Simodont® (Nissin Dental Products Inc., Nieuw-Vennep, Netherlands) provides the stereoscopic virtual reality vision and haptic force feedback technology for various dental simulation training procedures.[2,5,6] Thus, Simodont® can hone the trainees' psychomotor skill under haptic 3D virtual reality environment such as cavity preparation, access cavity preparation, and crown preparation. These could elevate proficiency and provide more safety dental care environment for patients.

However, each patient's situation is unique and diversified in clinical environments. A patient-centered virtual reality training module in Simodont® has been reported to allow dental students to prepare real patients in the virtual reality environment.[7] This innovation is helpful to ameliorate the skill performance and facilitate the patient safety. In this article, the authors presented two customized patient-specific cases to offer the clinical relevant simulation learning and training in tooth preparation.

Materials and methods

Simulation environment setup

Digital impression by intra-oral scanner was use to capture intraoral situation. The exported stereolithographic (STL) format images were edited with Intra Oral Scan Editor software V1.8 (Nissin Dental Products Inc.) to crop the model to appropriate size and align to proper position as described previously.[7] Finally, the Simodont® Courseware V4.12 (Nissin Dental Products Inc.) was used to import the patient's cropped STL model for assembling patient's custom case to simulate a real intraoral situation in Simodont®. Moreover, the initial cropping position and the limitation of model rotation were customized according to patient's actual clinical view angle. With the selection of proper instruments, trainee can repeatedly practice tooth preparation on the real patients' intraoral haptic volumetric models in Simodont® before the appointment in these patients.

Results

Two clinical cases, one for a crown preparation and the other for a bridge preparation were used for learning and training the clinical skills of crown and bridge preparation.

Case 1

The 72-year-old male came to Department of Dentistry, Chung Shan Medical University Hospital (CSMUH) for left maxillary first molar crown restoration. The complete workflow and stages were illustrated in Fig. 1. Briefly, the TRIOS® intra-oral scanner (3Shape, Copenhagen, Denmark) was used for digital impression. The scanned image was transferred into Simodont® dental trainer for clinical relevant haptic simulation learning and training. Finally, the results of clinical preparation would be expected to achieve apparently satisfactory.

Case 2

The 35-year-old male came to CSMUH for the restoration of his left lower posterior teeth. After physical examination, missing of lower left first molar was noted. The fabrication
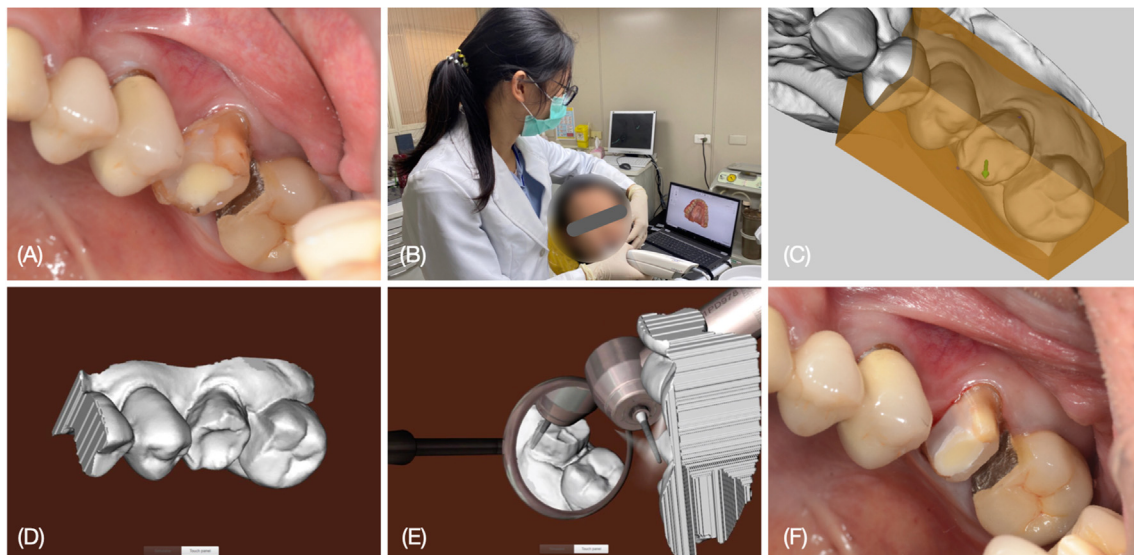

Figure 1 A case of single crown preparation in clinical relevant haptic simulation environment. (A) Intra-oral view before #25 crown preparation. (B) Intra-oral scanning for left posterior maxillary arch. (C) Intra-oral STL model cropped by Intra Oral Scan Editor software. (D) Patient's virtual model in Simodont®. (E) Training procedure in haptic simulation environment. (F). Clinical picture of final crown preparation.
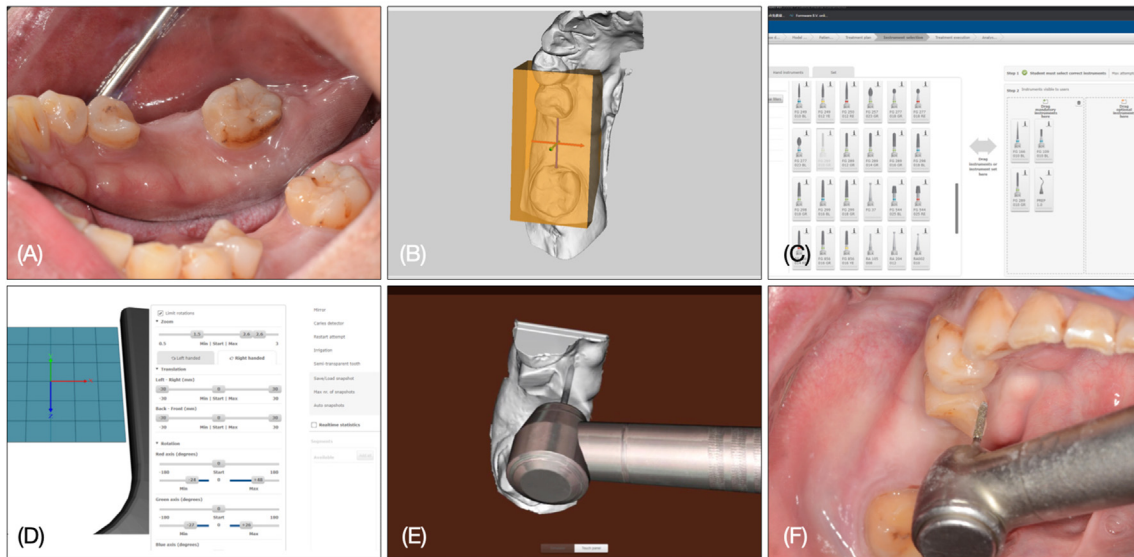
Figure 2 A case of #35 to #37 crown bridge preparation in clinical relevant haptic simulation environment. (A) Patient's intra-oral condition before #35 to #37 tooth preparation. (B) Aligning STL model to correct angle of axis and edited by Intra Oral Scan Editor software. (C) Manual instruments listed in Simodont®. (D) Setting clinical view and rotation angle for simulation environment. (E) Virtual simulation preparation view. (F) The correspondence clinical preparation view.

of #35 to #37 bridge was planned for rehabilitation. As shown in Fig. 2, intra-oral scanner image was imported into Simodont® dental trainer to crop STL model and the output of custom case. In addition, the selection of preparation kits such as burs and hand instruments could be designed as the checkpoint and reference for instructor's evaluation. Moreover, the functions of zoom and rotation restriction could also be adjusted corresponding to real clinical situation.

Discussion

For dental interns and novice dentists, more proficient psychomotor skill level is required especially in irreversible dental procedures such as tooth preparation. Patient safety is an important goal in clinical dental education. Conducting the clinical relevant haptic simulation learning and training in tooth preparation may provide several advantages such as the reducing the probability of patient injury, the enhancing confidence of trainee, and the improving the efficiency in each treatment procedure.

Serrano et al.[7] have reported that patient-centered virtual reality training module can improve trainees' self-confidence and performance. In this clinical relevant simulation training model, tutor can monitor trainees how to prepare each process mimicking the same clinical view angle. By the instruction, suggestion, demonstration, and real time feedback, trainees can repeatedly practice at their own paces and the self-assessment of their results. Then, they are supposed to be full with comfort in their own skin to treat the patient in real clinical situation. However, the collection of more clinical relevant simulation cases is necessary to improve this uniqsue characteristic of Simodont®. It may be used for standardizing the current scoring system in clinical training curriculum.

Recently, Hattori et al.[8] found that the simulated cutting sensation and the simulated 3D images created by stereo viewers can affect operators' performance and evaluators' rating compared with traditional mannequin simulator. This raised an important issue for current scoring system in dental curriculum. It is worth to further investigation. There are some limitations in the current model. First, the restricted section of model, only 3−4 teeth could be assembled in Simodont®. Second, only mono color and single tactile impression of teeth were provided. Third, the cross arch case is not available in the current version. However, the initial cropping position as well as the rotation of model were limited for customizing each patient's actual clinical intra-oral views. This innovation learning mode could be a new way toward dental clinical training curriculum.

Learning and training on real patient usually exists the ethical problem in clinical education.[9] Simulation-based dental education seems to be a good tool in extenuating ethical issue as well as practical dilemmas. Moreover, it could reach the precision medicine in dentistry and promote patient safety within the clinical relevant haptic simulation learning and training. Taken together, equitable quality education implemented with clinical relevant haptic simulation-based dental education is meant to achieve the goal of good oral health.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

References

1. Cheng HC, Yen AMF, Lee YH. Factors affecting patient safety culture among dental healthcare workers: a nationwide cross-sectional survey. *J Dent Sci* 2019;14:263−8.

2. Chang TY, Hong G, Paganelli C, et al. Innovation of dental education during COVID-19 pandemic. *J Dent Sci* 2021;16:15—20.

3. Liu CM, Huang PS, Chang YC. Perspectives on the challenge and change of COVID-19 crisis on dental education. *J Dent Sci* 2021;16:1039—40.

4. de Boer IR, Bakker DR, Serrano CM, Koopman P, Wesselink PR, Vervoorn JM. Innovation in dental education: the "On-the-Fly" approach to simultaneous development, implementation and evidence collection. *Eur J Dent Educ* 2018;22:215—22.

5. Mirghani I, Mushtaq F, Allsop MJ, et al. Capturing differences in dental training using a virtual reality simulator. *Eur J Dent Educ* 2018;22:67—71.

6. Yang PY, Chang YC. The haptic 3D virtual reality dental training simulator as a good educational tool in preclinical simulation learning. *J Dent Sci* 2022;17:618—9.

7. Serrano CM, Wesselink PR, Vervoorn JM. First experiences with patient-centered training in virtual reality. *J Dent Educ* 2020;84:607—14.

8. Hattori A, Tonami K, Tsuruta J, et al. Effect of the haptic 3D virtual reality dental training simulator on assessment of tooth preparation. *J Dent Sci* 2022;17:514—20.

9. Ziv A, Wolpe PR, Small SD, Glick S. Simulation-based medical education: an ethical imperative. *Simulat Healthc J Soc Med Simulat* 2006;1:252—6.