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Original Article

Personalized Preclinical Training in Dental Ergonomics and Endodontics in Undergraduate Dentistry Students (Pilot Study)

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The curriculum at the Department of Pathophysiology in the Periodontal Sciences program at Okayama University includes normative preclinical training (NPT) using phantoms. NPT is given to the whole class of 5th year students divided in groups of 8 students/instructor. In 2019, an innovative personalized preclinical training (PPT) pilot study was implemented for this group of students whereby two students, each with their own dental unit, were coached by one instructor. The main topics covered were dental ergonomics and endodontics. We aimed to evaluate the effectiveness of PPT in dental ergonomics and endodontics toward increasing the knowledge and future clinical skills of students who had already undergone NPT. A test on endodontics was taken before and after PPT. A questionnaire was completed to assess their perception of improvement regarding the above-mentioned topics. Test scores and questionnaire results both showed that the students' level of knowledge and awareness of future clinical skills was significantly higher after PPT. This pilot study demonstrated that PPT increased the students' knowledge and future clinical skills. As preclinical training forms the foundation for clinical practice, investment in future research regarding this personalized approach is likely to enhance students' understanding and clinical performance.

Key words: preclinical personalized education, dental ergonomics, endodontics, clinical skills improvement, undergraduate students

Dental professionals are heavily dependent on their hand skills; thus, preclinical training in different specialties and skills for undergraduate students is a necessary foundation for the high-quality future dental treatments they will perform. Preclinical skills gained in the undergraduate years was shown to have a positive correlation with dentists' later clinical skills [1].

The undergraduate curriculum at the Dental School at Okayama University includes lecture courses on various subjects as well as preclinical and clinical training.

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During the first- and second-year, general education is taught (a). In addition, from the 2nd year to the 4th year (1st and 2nd trimester) theoretical and practical lectures on basic and specialty dentistry are given (b). Starting the 3rd trimester of the 3rd year, students can join a basic research training class (c). Clinical dentistry (lectures and practice) (d), which includes normative preclinical training (NPT), starts in the 1st trimester of the 4th year, and continues to the 2nd trimester of the 5th year. From the 3rd trimester of the 5th year up to the 2nd trimester of the 6th year, students pursue participatory clinical practice (e) and conclude their studies in the last 2 trimesters of the 6th year with comprehensive dentistry training (f), which includes study for the National Board Dental Examination (Fig. 1).

Participatory clinical practice (Fig. 1e) includes hands-on treatment of patients that can be performed by 5th and 6th year students depending on the instructor's evaluation of their skills and pre-authorization of their preparedness. Therefore, the only opportunity for students to develop their manual skills related to dentistry is during the NPT. It is crucial that they make the most of this pre-clinical training, as it will be the foundation of their future clinical performance.

NPT at the Department of Pathophysiology, Periodontal Science and Endodontics, is offered during the 1st trimester of the 5th year and includes theoretical lectures, preclinical practical instructor's demonstrations, and students' skill practice. During this preclinical course the students use phantom models (simulated learning mannequins). This training lasts for 18 h and is given to the whole class — an average of 50 students — usually divided into groups of eight with one instructor per group. Because of the large number of students and limited time, achieving the training objectives is challenging. The literature indicates that some students feel that the time allocated for preclinical and clinical training is insufficient to enable them to acquire the necessary skills and self-confidence, particularly for root canal treatments (RCTs) [2, 3]. Self-confidence is defined as the feeling of confidence that the person

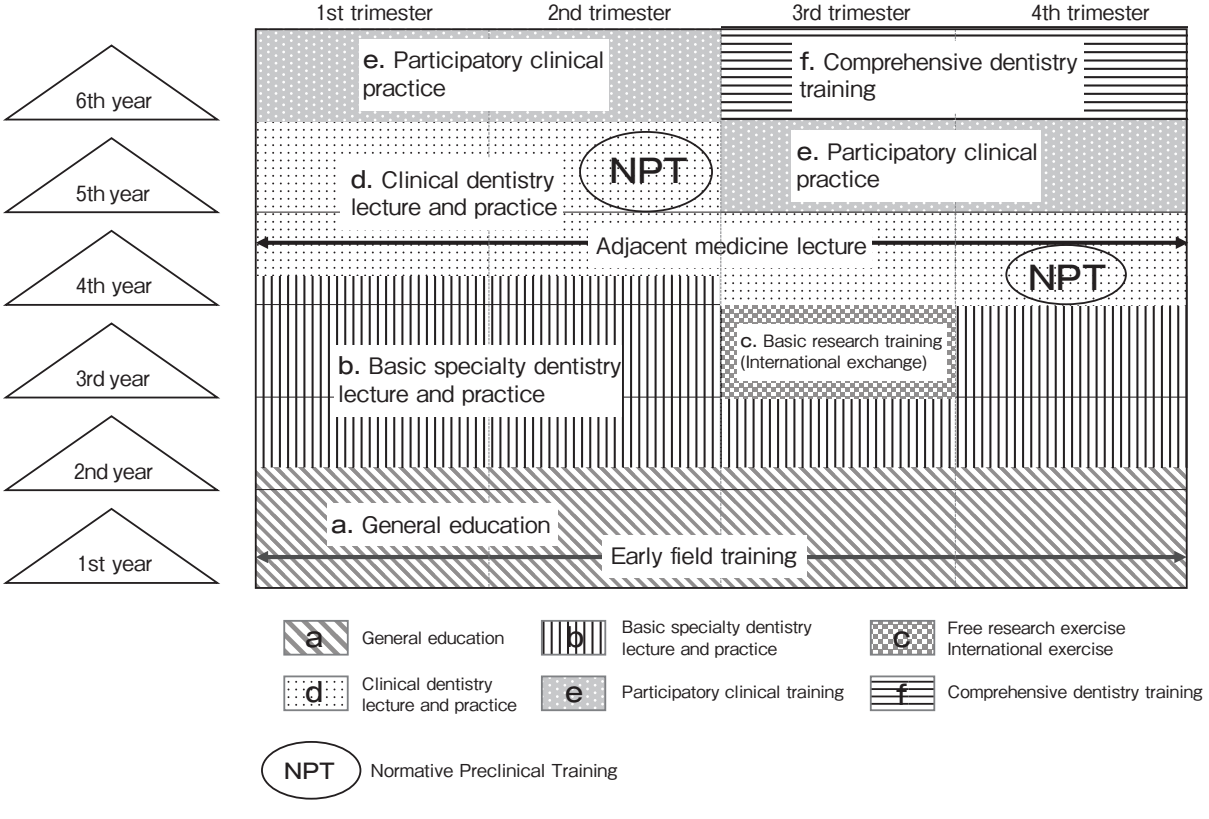

Fig. 1 Curriculum at the Dental School of Okayama University.

experiences about their own abilities, qualities, and judgments. In dental schools, students are trained to have a high level of self-confidence throughout the process of their undergraduate and postgraduate training to later continue with their already professional clinical practice [4]. There are studies indicating that detailed preclinical teaching has better outcomes than other teaching methods [5]. In another study, 71% of college students revealed that intensive preclinical training will ensure they manage patients with greater confidence [6]. Most of the undergraduate dental students perceive endodontics not only as interesting, but also as one of the specialties that they find the most difficult, stressful, and challenging [7, 8]. This perception affects self-confidence and self-efficacy and generates performance anxiety [9-11] and may be the result of insufficient didactic teaching in some dental schools. In addition to mastery of the concepts of dentistry, sufficient practice, based on detailed, up-to-date preclinical training, is critical to the development of the required confidence and competence before graduation [12-16]. There have been several studies reporting students' improvement of self-confidence, not only regarding knowledge but also about clinical skills when a small-group learning methodology was applied [17, 18].

Because of these issues, in 2019, the Department of Pathophysiology, Periodontal Science and Endodontics at Okayama University implemented an innovative personalized preclinical training (PPT) pilot study for the 5th year students to improve their skills, knowledge in dental ergonomics (body posture and indirect vision) and endodontics, in which one instructor worked with only 2 trainees at a time. Regarding dental ergonomics, the students were trained on working in confined spaces, correct working postures, and effective use of the dental mirror for an indirect vision of the oral cavity [19] to prevent future injuries from poor ergonomic practice [20-21]. For the endodontic training, they were taught to perform, in detail, each step of the manual root canal preparation (RCP) starting with rubber dam isolation, cavity access, root canal location, working length measure, standard root canal preparation (RCP) and root canal filling (RCF) procedures. Using two dental units, two students were trained at the same time by one instructor for three one-hour sessions.

The purpose of this pilot study was to evaluate the effectiveness of PPT at increasing student knowledge and future clinical skills regarding dental ergonomics (body posture and indirect vision) and endodontics in 5th year undergraduate students at the Department of Pathophysiology and Periodontal Sciences at the Dental School of Okayama University.

Materials and Methods

A quasi-experimental interrupted time-series study design was applied to the 5th year students (n = 51) before and after the PPT. Ethics approval was obtained from the University Ethics Board (No. 2105-041).

Participants (inclusion and exclusion criteria). The population was a convenience sample of 51 undergraduate dental students (female n = 24, male n = 27) at the Department of Pathophysiology, Periodontal Science, and Endodontics at Okayama University. As noted above, the intervention entailed PPT in dental ergonomics (body posture and indirect vision) and Endodontics.

Inclusion criteria.

- Students who had attended the entire class of normative preclinical training (NPT) included in the curriculum of the 5th year of the 2019 academic period.
- Students who had attended the personalized preclinical training (PPT) in dental ergonomics (body posture and indirect vision) and endodontics.
- Students who had taken the pre- and post-attending examination tests during the PPT.
- Students who had completed the questionnaire regarding the perceived benefit of PPT at the end of this training and who had chosen only one answer for each question in this multiple-choice questionnaire.

Exclusion criteria.

- Students who did not attend the whole-class (NPT) on endodontics included in the curricula of the 5th year of the 2019 academic period.
- Students who did not participate in the PPT in dental ergonomics (body posture and indirect vision) and endodontics.
- Students who did not take the pre- and post-attending examination tests during the PPT.
- Students who did not complete the questionnaire regarding the PPT perceived benefit at the end of this training or who chose more than one answer to the questions on this multiple-choice question-

naire.

Of the 51 students, only 50 were included because one of them chose more than one answer to question 4 of the perceived benefit questionnaires given at the end of the PPT.

Intervention.

1. Personalized preclinical training (PPT). Two students (each using one dental training unit) were trained by one instructor for three one-hour sessions. The students used a Phantom DR-11 type CB (Morita, Osaka, Japan) and a plastic upper right molar #16 (A12A-500) (Morita) for the root canal treatment (RCT).

2. Dental Ergonomics (body posture and indirect vision) and root canal treatment training. The dental ergonomics training included two tasks to be taught: body posture and indirect vision. Following Rahim's study [22], the students in this study were taught to raise the level of the phantom's mouth and hold their arms up, positioning their forearms at 30° from the horizontal axis, thereby eliminating the need for the operators to bend their head back to see the narrow operating field where they worked. For the indirect vision teaching–learning process, a plastic upper right molar #16 (A12A-500) (Morita) was attached to a phantom for basic training DST (Morita), and the students were instructed that their eyes should be 35-40 cm from the working field using a dental mirror [23]. After rubber dam isolation, the following steps were done to perform the manual RCT: cavity access, root canal location, working length establishment, RCP, and RCF. For the RCP, students used manual stainless-steel k-files 25 mm (MANI, Tochigi, Japan), a step-back technique for mesial buccal and distal buccal root canals, and a standardized technique for the palatal RC. Regarding the RCF technique, they applied the lateral condensation technique using a manual spreader 0,25 (MANI) and Zipperer gutta-percha points (United Dental Manufacturers Inc., Tulsa, OK, USA).

Endodontics multiple choice questions (MCQs), questionnaire, and statistics.

1. Multiple choice questions (MCQs). To establish a baseline and compare levels of knowledge of endodontic treatment acquired during the whole-class normative preclinical training (NPT) to the knowledge achieved after this innovative personalized pre-clinical training (PPT), a test blueprint was made consisting of the same MCQs that were given to this group of students before and after PPT. To validate this examination, the questions were taken from the theoretical lectures given to the students at the beginning of every Endodontics NPT session containing all the basic knowledge required to perform the preclinical training; the same explanations were given to the students before the corresponding PPT sessions. The content of this test blueprint was taken from curriculum lectures whose reference was a classic book about endodontics [24]. The written exam was a multiple-choice test consisting of 10 questions. Questions No 1,2,3,4,5,6,9 and 10 had only one answer. Questions 7 and 8 had 2 possible answers. Each question was worth 10 points, and the maximum grade was 100 (Table 1).

The content of the MCQs was related to the sequence of steps to perform root canal treatment with the aim that students follow that sequence, so the questions were divided into groups: a) cavity access (#1), b) location of the root canals (#2,3), c) working length determination (#4), d) rectification of the canal entrances (#5), e) RCP (#6,7,8), and f) RCF (#9,10). The PPT instructor was the test author. To validate whether the level of difficulty was acceptable, and to confirm that the content was related to the curricula and that it was a reliable tool to measure the students' learning objective (SLOs), two other department staff members reviewed the MCQs. Regarding the test blueprint weighting, the number of questions for each item was adjusted considering the importance and the time that each step takes to complete during RCT. Details containing the student learning objectives (SLOs) as well as statistics for each question are given in Table 2. The whole-class NPT was given to this group of students during April and May 2019. The pre-MCQs were administered in December 2019; PPT occurred from December 2019 to August 2020; and the post-MCQs were administered in November 2020.

2. Questionnaire. A questionnaire was circulated after the PPT to obtain information on the students' reported levels of understanding obtained during the whole-class normative preclinical training (NPT) and the perception of improvement for future clinical skills after PPT regarding the following procedures: keeping the right body posture, indirect vision, use of rubber dam isolation, cavity access, RCP, and RCF. There were 14 questions divided in 2 sections. The first section (n = 12) was related to student's perception of level of understanding regarding the NPT and whether they felt the PPT would improve their future

Table 1 Multiple choice questions (MCQs)

Question No	Question	Multiple choice
1.	The shape of the opening cavity for a tooth #16 would be	a. Triangle with the base towards mesial
		b. Triangle with the base towards the buccal surface closer to the mesial surface than to the distal surface
		c. Square surrounding the middle of the tooth
		d. Triangle with the base towards the buccal surface closer to the distal surface than to the mesial surface
2.	What is the difference between the roof chamber and the furcation?	a. The furcation dentine colour is darker that the roof chamber's dentin
		b. The roof chamber is darker than the furcation
		c. The furcation is brighter than the roof chamber
		d. Furcation and roof chamber dentine are the same colour
3.	Indicate the location of the root canals on the furcation in tooth # 16	a. One orifice next to the palatal site, 2 orifices next to the mesial site
		b. 1 orifice next to the palatal site, 1 orifice next to the buccal site
		c. 1 orifice next to the palatal site, 1 orifice next to the mesiobuccal angle, 1 orifice next to the distobuccal angle
		d. 1 orifice next to the palatal site, 1 orifice next to the mesiobuccal angle, 1 orifice next to the palatal distal angle
4.	Is there any anatomical location difference between the anatomic apex and the apical constriction?	a. There is no difference both are located in the same anatomical location
		b. The anatomical apex is where the root tip is located, the apical constriction is around 0.5 to 1.5 mm more coronal than the anatomical apex
		c. The anatomical apex is 10 mm more coronal than the apical constriction
		d. The apical constriction is at the furcation while the anatomical apex is at the tip of the root
5.	Choose the right statements about peeso files and gates gliden burs	a. Peeso files are used to make orifices into the furcation
		b. Peeso files and Gates Glidden burs are used for the step back technique
		c. Peeso files or Gates Glidden burs are used to rectify the opening of the root canal access
		d. None of the choice is correct
6.	During the root canal (RC) preparation, there are safety and dangerous zones so we should file the RC towards the safety zone. From the following statements, choose the correct one	a. The dangerous zone is located towards the inner wall of the root canal
		b. Inner and outer walls are dangerous zones
		c. The outer walls are dangerous zone while the inner walls are the safety zones
		d. None of the choice is correct
7.	Why is it important to use an irrigating solution during the root canal preparation?	a. It is not important since doing the filing, all the debridement will be removed
		b. The irrigating solution helps the file to enter smoothly into the root canal
		c. The irrigating solution makes easier to remove all the debridement
		d. None of the above is correct
8.	Select the right statements about RC preparation techniques	a. The crown down technique is used for calcified root canals
		b. The step-back technique is used for curved root canals
		c. The step-back technique is used for wide diameter root canals
		d. None of the choice is correct
9.	How do you choose the master cone?	a. It should be one diameter smaller than the last file used for RC preparation
		b. It should be one diameter bigger than the last file used for RC preparation
		c. It should have a tug-back or a resistance to the apex, should be the same diameter or bigger than the last file used for mechanical preparation
		d. It should have any diameter, depending on the operator's criteria
10.	Regarding the root canal filling, what is the next step after inserting the master cone into the root canal?	a. Cut the master cone with a plugger, then perform vertical condensation and finish the root canal filling
		b. A spreader should be inserted, and a space should be made so after that the accessory points will be inserted
		c. The rest of the root canal should be filled using root canal sealer
		d. None of the choice is correct

Table 2 Students learning objective (SLO), taxonomy and questions' weight of the test blueprint

Item	Students learning objectives (SLO)	Percentage of test dedicated to measuring SLO	Type of test items to measure the SLO	Number of Questions for each Item type & item Weight	Indicate level of cognition	List Question numbers for each SLO
1	Cavity access	10%	Multiple choice	10 (10 points each)	Knowledge	1
2	Location of the root canals	20%	Multiple choice	20 (10 points each)	Knowledge	2,3
3	Working length establishment	10%	Multiple choice	10 (10 points each)	Knowledge	4
4	Canal entrance rectification	10%	Multiple choice	10 (10 points each)	Knowledge	5
5	RCP	30%	Multiple choice	30 (10 points each)	Knowledge	6,7,8
6	RCF	20%	Multiple choice	20 (10 points each)	Knowledge	9,10

*Column indicates objectives and taxonomy.
**Rows provide details of objectives as well as statistics on proportion of each question.

Table 3 Questionnaire

A. Please tell us about your prior preclinical training (NPC), how well you understood that training, and whether you felt the personalized training (PPT) will improve your future clinical skills.

Please choose only one response/question: *e.g.* ○○○●○	**A.1** Before the Preclinical training at Muscat Cube (PPT) did you have any training for the following procedures:			**A.2** Do you think this PPT will help you improve your future clinical skills regarding the following procedures?		
	Yes, I have been trained before	Yes, but I couldn't understand it well	I have never been trained before	Not at all	Somewhat	A lot
1. Keeping the **right body posture on the dental unit**	○	○	○	○	○	○
2. **Indirect vision** (using the mirror) for dental treatment?	○	○	○	○	○	○
3. **Rubber dam isolation**	○	○	○	○	○	○
4. **Indirect vision for cavity access**	○	○	○	○	○	○
5. Root canal **preparation**	○	○	○	○	○	○
6. Root canal **filling**	○	○	○	○	○	○

B. Please rate the personalized training against normative preclinical training (NPT):

1. What is the main advantage of the PPT in comparison to the normative preclinical training you received before	I feel that PPT was more personalized because we received a detailed explanation about **performing RCT keeping the right body posture** on the dental unit	Either of the trainings were the same, no difference at all
Please choose one response	○	○
2. If you have the **chance to engage in future personalized preclinical training**, would you join?	YES ○	NO ○

clinical skills. The second section (n = 2) was about the personal assessment of the PPC against the NPT. The results of the questionnaire were descriptively analyzed (Table 3).

3. Statistics. The null hypothesis was used as the comparator: *i.e.*, actual outcomes were compared with the hypothesis that student scores and perception of improvement of future clinical skills would be unchanged by participating in the PPT. The results of pre- and post-training tests were analyzed using the Wilcoxon signed rank test. Statistical significance level was set at $p < 0.05$.

Table 4 Descriptive statistics for MCQs

	Before	After Training
Mean	73.8	90.3
Mode	70	90
Standard Deviation	14.1	8.8
Minimum	50	70
Maximum	100	100
Count (n)	50	50

Scores are out of 100 possible marks.
Statistical Analysis results of the test before and after the personalized pre-clinical training.

Results

Students' level of knowledge in endodontics. Students' level of knowledge in endodontics, measured by their MCQs grades after PPT, was significantly higher (M = 90.3, SD = 8.8) than before the PPT (M = 73.8, SD = 14.1), t (49) = 8.0, $p < .001$ (Table 4).

Notably, the average score after PPT was 16.5 points, and the raw scores were more tightly clustered at the high end of the scale in comparison to the average scores before PPT.

The lowest-scoring students (pre-training scores of 50-59/100, n = 4) improved the most, by an average of 35 points in the post-training test, an improvement of 70.0% on their original score. Those who scored 60-69/100 (n = 10) in the pre-training test improved by an average of 29.5 points (49.2% improvement). Where the test score before training was higher, there was less scope for improvement. Diminishing improvement was observed in the cohorts who initially scored 70/100 and above. Interestingly, for students who scored highest in the pre-training test (100/100, n = 4), the average post-training test result was 8 points lower (−7.5%) (Fig. 2).

The Wilcoxon signed rank test had a p score of less than < 0.0001, proving that there was a strong statistical significance between the pre and post MCQ test scores (Fig. 3).

Students' perception of future clinical skill perfor-

Fig. 2 Mean improvement in MCQs scores after training compared before training.

mance. Regarding the answers to the questionnaire, overall, 87.7% of the students felt the PPT would significantly improve their future clinical skill performance. A further 11.7% felt it would somewhat improve their performance, and just 0.7% felt that this PPT would not improve their performance at all (Fig. 4, Table 3 A.2).

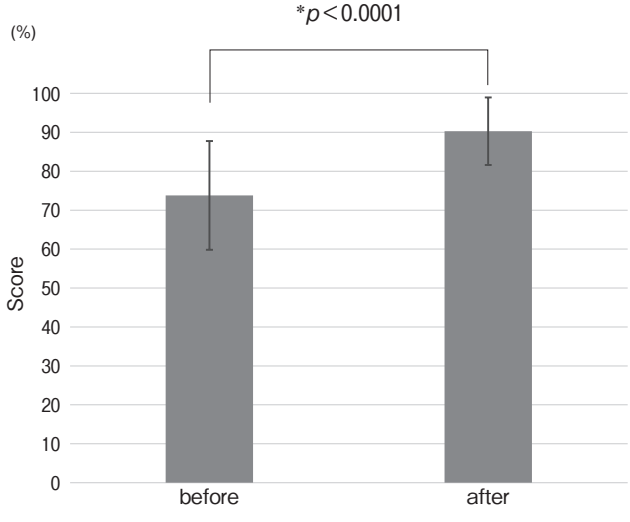

Fig. 3 Comparison of MCQs mean scores before and after PPT (Wilcoxon signed rank test).

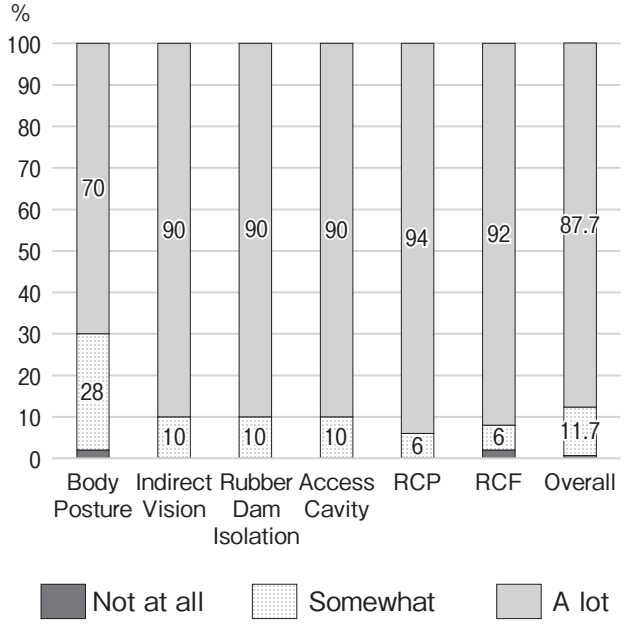

Fig. 4 Self-assessment chart of student's perception of how PPT will improve their future clinical performance.

Interestingly the highest areas of perception of improvement of future clinical performance were RCP (94%), RCF (92%), indirect vision, performing rubber dam isolation, and cavity access (90% in each of these areas) followed by body posture (only 70% anticipated significant improvement) (Fig. 4).

When stratified by the whole-class normative prior training received (NPT) (no prior training, some prior training but not well understood, and well understood prior training), students who reported the least prior training felt that the PPT would improve their abilities the most (95%) (Fig. 5C), followed by students who had received and understood prior training (87%) (Fig. 5A), and students who had received training but did not understand it well (81%) (Fig. 5B). For some education areas, such as RCF and RCP, there were no students who reported having no prior training, reducing the number of education areas reported in the figure for this stratification group (Fig. 5C).

All the students indicated that they had received and understood previous training in rubber dam isolation, but the additional personalized training reinforced their confidence and belief in their future ability; 90% felt that the personalized training would significantly improve their ability to perform rubber dam isolation (Fig. 5A Rubber dam isolation).

All the students had also been trained in RCP and RCF, but 6% and 4% respectively felt they had not understood the training well (Fig. 6, Table 3 A.1). Personalized training redressed existing misunderstandings in these areas. All students who felt that they had not understood the previous training in these areas (Fig. 5B RCP, RCF), as well as 94% and 92% of those who felt that they had understood the previous training felt that the PPT would improve their abilities in these fields (Fig. 5A RCP, RCF). A few students felt that the PPT would only improve their ability in these areas slightly (6%), and 2% reported feeling that it would not improve their work in RCF at all (Fig. 5A RCF black).

Given the importance to their own well-being in good dental ergonomics practice, it is interesting that 2% of the students reported not having any prior training in body posture, (Fig. 6). All but 2% of the students indicated that the PPT would help them improve their good-body-posture practice significantly, regardless of their level of understanding of the NPT (Fig. 5C Body posture).

Implications for teaching and training arise from

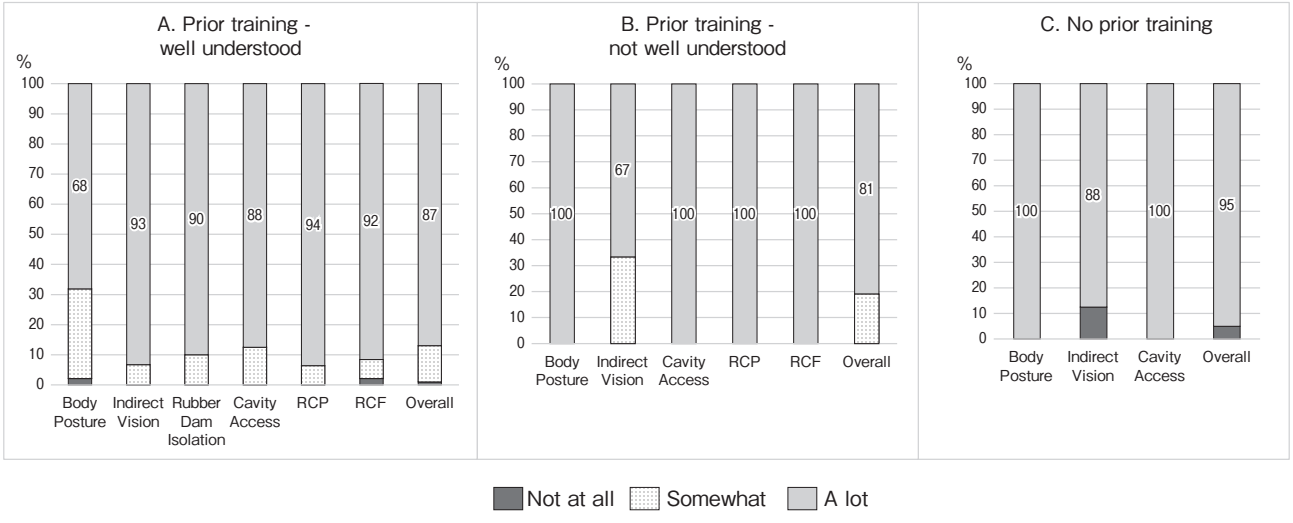

Fig. 5 Perceived impact on performance stratified by self-reported level of prior PPT.

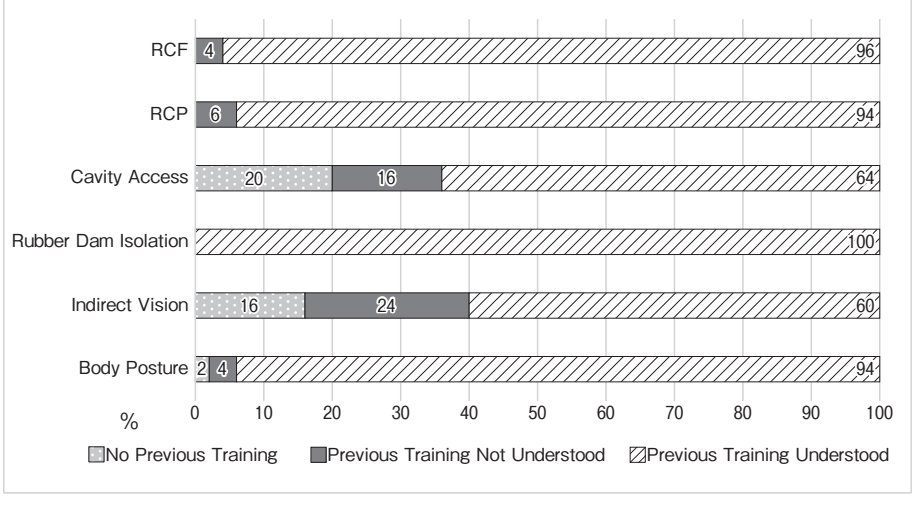

Fig. 6 Students' report regarding having received and level of understanding of prior training by education area.

areas of least understanding and confidence: indirect vision and cavity access. Only 60% of the students reported they had received and understood prior NPT in using indirect vision; 24% — approximately a quarter — felt that they had not understood the NPT; and 16% reported no previous training in this area (Fig. 6). Interestingly, 12% of the students who reported no having prior training in indirect vision felt that PPT would not help them at all to improve their skills in that area.

This means that 40% of the 5th year dental students were not knowledgeable or confident in the use of indirect vision — a skill in which good practice is critical both to good treatment and practitioner well-being. Figure 6 also shows that only 64% of the students felt they had understood NPT in cavity access, with 20% never having been trained in this area before the PPT while 16% had received but not understood the NPT in this area. This means that over one-third (36%) of the 5th year students do not have confidence in their abilities in this area. This could result in higher referral rates to specialists along with delays in treatment arising from onward referrals.

Discussion

This pilot study provides empirical evidence of the value of personalized preclinical training in the curriculum for undergraduate dental students, especially in the context of growing emphasis on personalized medicine and dentistry for the client/patient [25,26]. A nationwide survey on Endodontic practice at Dental Schools reported that in 2008, the number of students per instructor in the NPT ranged from 5 to 10 [27]. NPT in this Department lasts 18 h, with an 8 : 1 student/instructor ratio. A recent study performed in a Japanese Dental School that sought to measure the learning achievements during preclinical training of root canal treatment, in which one instructor taught one student, showed that this personalized preclinical training helped to verify the students' root canal treatment abilities more effectively than the normative preclinical training. Like the present study a questionnaire about the training was distributed after it was finished, and most of the students responded that this practice was extremely helpful to improve their endodontics skills. Regarding the feedback received from the instructors, most of the students expressed that it was very appropriate. Like the present study, the abovementioned training allowed feedback to be provided to each individual student [28]. Other studies reported that during preclinical training, students prefer smaller group size since they can have active participation improving their skill acquisition [18]. Furthermore, some researchers found that the step-by-step teaching method improves the student's achievements during dental skills preclinical training [5]. Much of the literature recognizes the benefit of the personalization of treatment, procedure, equipment, materials for the patient or client, or focuses on cost benefits for the health system [25,26]. Some articles have reported that improved endodontic preclinical teaching models influence the quality of clinical root canal treatments [29,30], including virtual learning that has been necessary during the COVID-19 pandemic [31] and the incorporation of artificial intelligence [32], equipment, and materials [33] for education and training [34]. However, there is growing awareness of practitioner skill, knowledge, and ability benefits that are enhanced by personalization in education and training in medical and dental fields. In a study in which clinical root canal treatments performed by undergraduate students were evaluated, it was found that 70% of those treatments had low quality. Furthermore, preclinical training at that dental school lasted 56 h, longer than the present study, with an instructor-to-student ratio of 1 : 15, much lower than in the present study; in their evaluation, the researchers recommended that increased direct supervision, *i.e.*, more personalized, and longer training hours may be the key to improving the quality of future endodontic clinical treatments [35]. In addition, in another similar study, only 24.2% of root canal treatments were found to have good quality, and it was concluded that the main reasons for this result it was the insufficient preclinical training in endodontic treatment the students had received [36]. The frequency, earliness, and quantity of time to be invested in personalized education in the curriculum is a matter that is up for debate [37]. It is probable that variability (or contextual flexibility) will persist depending on the students' existing skill and levels of understanding and the ability and inclination of the educational institution to invest. A high level of supervisor time and clinic or simulation laboratory time and infrastructure must be balanced against the perceived or measured improvement in students' performance prior to graduation, as well as what level of competence and confidence is considered sufficient for a graduate of that dental school [38]. Whenever educational planning for health care professions is performed, some important factors must be taken into consideration such as number of students, the emphasis in learning skills and competence. There are some studies that found that when skill performance was tested, small-group discussion scored higher than traditional lectures [39]. Relevant factors influencing the implementation of personalized training and its place in the curriculum include the philosophy of the educational institution, its public or privately funded nature, access to initial and ongoing funding, and the value placed on institutional reputation [40]. Evidence of beneficial effects is likely to be required for such investments to be prioritized. To achieve the preclinical endodontic training objectives during this PPT, a detailed explanation of the root canal treatment steps was given to the students, so that theoretical and hands-on learning occurred in the same time frame. In addition, individual feedback from the instructor was given after each session. During this feedback the student's strengths were highlighted, and advice was given on how to improve their weak points.

Interestingly, in the present study, a decline in scores was observed among the students who performed best on the pre-training test, this may reflect chance (where answers guessed in the pre-test happened to be correct and answers guessed in the post-test happened to be incorrect). The decline also may have been affected by the deterioration of details in the memory by the time of the post-test (recency effects) or by the increased awareness of complexity and nuances in endodontic treatment arising from the training, causing them to overthink and question their existing, more superficial knowledge, thereby temporarily reducing their confidence and test scores [https: //dx.doi.org/10.2991/ictppfms-18.2018.10].

Regarding the students (12%) who reported not having prior training in indirect vision and who felt that PPT would not help them at all to improve their skills in this area, we think that they may not have recognised the term "indirect vision" although this is a standard term used in this school. This gap in understanding could be possible due to the following situations:

1. They came from different training environments where a different term is used.
2. They joined the dental program at a point after the standard first training in indirect vision occurred (for instance transferring from other medical studies).
3. A different term was used at the time they received this training.
4. Despite being in the program and receiving training, they did not remember this terminology – which would be more concerning.

These issues could be addressed in the future by indicating in the questionnaire alternative terms used for indirect vision, so that students can then answer these questions without doubt. As the student results were de-identified, it is not possible to investigate the pathways into this dental program taken by the students whose answers followed the above pattern.

In conclusion, the present pilot study contributes to a small but growing evidence base that individualized personalized preclinical training is helpful in supporting decision-making and enhancing the competence and confidence of students as they progress into their profession as clinicians.

Limitations of this study. The major limitation of this study is that we did not have a control group of students who participated only in the whole-class normative preclinical course to compare with the results of the present customized training. However, the knowledge regarding endodontics acquired before this personalized preclinical training (PPT) was what the students received in the whole NPT class, so to establish a baseline, the students took the same knowledge test before and after this customized training. An analogous study was carried out in a pre-clinical periodontics training, with results like those of the present pilot study [41]. Furthermore, we consider that it would have been unfair to conduct a randomized controlled trial when subjects assigned to a control group would not receive the intervention (personalized preclinical training) and its potential benefits. Other limitations of this pilot study could be the sample size (n = 51). Future applied studies conducted in larger dental schools could offer this opportunity. Another limitation is the pragmatic nature of subject selection, which aimed to improve the level of understanding and future clinical skills of existing students. Another drawback of this study is that the instructor did not objectively assess the students' abilities. Future studies that include the evaluation of the student's performance given by the instructor will be more valuable. Regarding the questionnaire, interestingly, although all students included in this study participated in the NPT, some students stated that they had no previous training on body posture, indirect vision and cavity access (Fig. 5C and Fig. 6); the reason could be that during the NPT, due to the large number of students, they were not given a detailed explanation of these steps, so that they were not aware of having learned these topics.

The quasi-experimental interrupted time series was the most robust and appropriate research design for the circumstances of this study. Any bias that might arise from the students' knowledge in their dental school setting has been minimized by the data analysis performed by a remote researcher team member who had no contact with students at the university. Recency may have affected the level of knowledge reflected in the post-training test and the perceived benefits of the training. Although impossible during this initiative, future research would benefit from repeat post-training assessment of knowledge, skills, and confidence at one or two post-training periods to determine whether the improvement in confidence, ability, and knowledge is sustained.

It would also be beneficial to assess the iterations of

this study in the future, the potential benefit of a short refresher practical session on the sustained level of understanding, skill, and confidence. For the future repetition of this study, a revision of the questionnaire to allow Likert scale responses would enable examination of the correlations with pre- and post-training test results in greater detail to determine the direction and magnitude of the effects on skills the students perceived themselves attaining from the personalized training, so that a significant difference analysis could be applied.

The results obtained in this pilot study show that the personalized preclinical training positively affects student confidence regarding the application of the basic principles of dental ergonomics (body posture and indirect vision) and practical endodontic treatment regardless of their level and understanding of their previous training. Students who had no previous training perceived the initiative as most beneficial, although high percentages of students from all levels of prior knowledge acquisition perceived that the personalized training had significantly improved their ability at the time of filling out the questionnaire.

In conclusion we conclude that this personalized preclinical training pilot study increased student knowledge and perception of future clinical skills improvement within this convenience sample and setting. As preclinical training forms the foundation for future learning and clinical practice, investment in a future personalized approach with 5th year students is likely to enhance students' understanding, and their future performance of clinical treatments, thus leading to improved clinical treatment outcomes for patients.

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Data Availability Statement. The authors confirm that the data supporting the findings of this study are available within the article.

The statistical analysis data is available to Peer Reviewers.

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