Original Article
DOI: 10.22037/jds.v42i4.46141
ISSN 2645-4351

Comparison of the Effects of Requirement-Based and Test-Based Formative Assessment Methods on Pre-Clinical Endodontic Competence and Performance of Dental Students

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(Submitted: 4 September 2024 – Revised version received: 20 September 2024 – Accepted: 25 September 2024– Published online: Autumn 2024)

Abstract

Objectives: This study aimed to compare the effects of requirement-based and test-based formative assessment methods on pre-clinical endodontic competence and performance of dental students.

Methods: This interventional field study was conducted on dental students of Shahid Beheshti Dental School in the first and second semesters of 2021 academic year (third-year students), taking practical basic endodontics 1. After receiving theoretical instructions and practical demonstrations, the students in both groups were asked to perform root canal therapy for extracted maxillary anterior and mandibular/maxillary canine teeth as part of their requirement. Their errors were assessed and recorded by two calibrated instructors. Next, group 1 students performed root canal therapy for mandibular incisors and premolars as their requirement and returned the treated teeth on a specific date every 3 weeks. Group 2 students did not have a specific requirement and only participated in an examination which included endodontic treatment of the same group of teeth treated by group 1 students at the same designated dates. The treated teeth were assessed by instructors for errors. A final examination was held at the end of the semester for both groups. The two groups were compared by independent t-test, ANCOVA, Pearson Chi-square, and Mann-Whitney tests (alpha=0.05).

Results: No significant difference was found between the two groups in access cavity preparation, root canal instrumentation, or obturation (P>0.05).

Conclusion: Requirement-based and test-based formative assessment methods had similar effects on pre-clinical endodontic competence and performance of dental students.

Keywords: Endodontics; Process Assessment, Health Care; Students, Dental; Task Performance and Analysis

How to cite:
Gohari A, Alimadadi H, Nasseri M, Barikani M, Mehrabani M. Comparison of the Effects of Requirement-Based and Test-Based Formative Assessment Methods on Pre-Clinical Endodontic Competence and Performance of Dental Students. J Dent Sch 2024;42(4):164-170.

Introduction

Dental students acquire the required competence and skills through repeated practice. Novice dental students highly depend on their instructors to guide them and give them feedback regarding their performance. They also need step-by-step instructions to learn new techniques. [1]

In the field of education and training, assessment of students' performance is a valuable index for evaluation of the efficacy and quality of instruction.[2] Performance assessment is a fundamental step in the process of instruction and learning.[3] However, quality assessment is a challenge in medical fields since different types of assessments have their own inherent shortcomings. Also, students may have a limited attitude towards the goals and expected achievements in the assessment process.[2] Practical benefits of student assessments depend on the efficacy of examinations for promotion of educational activities.[1] In other words, examinations are highly important since they guide the process of instruction. Thus, quality promotion and standardization programs for the examinations are highly effective.[4] Accordingly, instructors can design programs to improve the assessment results and feedback of students.[1]

In usual academic programs, assessment of medical students is performed through summative assessment, which appraises the competency of students for promotion to a higher level of responsibility.[5] It also determines the scientific competence and clinical skills of students.[2] However, in this method, the students are not assessed during the process of learning.[5]

Leading institutions that follow innovative instruction-learning methodologies developed and implemented formative assessment in their educational programs after evaluation of different assessment methods that some of which included providing feedback to students. [5] In the recent years, formative assessment has attracted the attention of educational authorities.[6] Formative assessment provides timely feedback of the performance of students as well as suggestions for improvements aiming to enhance learning. Providing feedback has the greatest impact on learning achievements of students since it enables detection and resolution of weaknesses.[5] Formative assessment points to the strengths and weaknesses of learners and determines the level of learning of students and areas of weakness.[2] It also informs the instructors about the strengths and weaknesses of students.[7] By providing feedback, it helps the learners to develop an internal motivation to acquire knowledge and

skills, find their flaws and errors, decrease their anxiety level, and promote their creativity and self-esteem.[2,7-9]

Despite the positive effects of formative assessment on the attitude and quality of learning of students, medical and dental schools are reluctant to include formative assessments in their educational curricula.[2] Some types of formative assessments give immediate feedback to students that increase their motivation and interactions. Nonetheless, some other types such as tests and self-assessments may not have a sufficiently high educational efficacy since the provided data are indefinite and controversial. Such assessments have several limitations in gathering the students together, supervising the examination, and providing individual feedback since they all require time and human resources.[2,5] Nonetheless, formative assessment has gained popularity among clinical medical and dental students although its role as an efficient tool for þ of the final outcome has not yet been clearly elucidated, and innovative assessment models need to be designed to create an attractive, yet challenging, learning experience for medical and dental students.[5] Formative assessment enhances the motivation, commitment, learning, and understanding of students, improves their skills, clinical competence, cooperation, communication, self-confidence, and practical skills, promotes critical thinking in complex cases, and decreases their anxiety.[10-18] On the other hand, summative assessment has advantages such as increasing precision and concentration, improvement of time management skills, promoting decision making skills, and enhancement of deep learning and self-efficiency.[13,15,19-21] Considering the increasing interest in a shift from summative to formative assessment and scarcity of studies comparing these two assessment methods, this study aimed to compare the effects of requirement-based and test-based formative assessment methods on pre-clinical endodontic competence and performance of dental students.

Methods

This interventional field study was conducted on all dental students of Shahid Beheshti Dental School in the first and second semesters of 2021 academic year (third-year students) taking preclinical endodontics 1. Students who could not attend the tests or did not return the requirements at the designated times were excluded.

Students in the first semester (n=46) were assigned to the requirement-based formative assessment group, and students in the second semester (n=38) were assigned to the practical test-based formative assessment group. The study protocol was approved by the ethics committee of the university (IR.SBMU.DRC.REC.1401.127).

Both groups initially received instructions regarding the basic principles of endodontics in the form of lectures, PowerPoint presentations, demonstrations, and question and answer sessions, with special emphasis on the principles of practical work. The educational content and the instructors were the same in both groups. The educational content included familiarity with endodontic instruments, principles and goals of access cavity preparation in single-rooted single-canal teeth for maxillary and mandibular anterior teeth, and mandibular single-rooted single-canal premolars, working length determination, principles and goals of root canal cleaning and shaping and obturation, common procedural errors during different steps of root canal treatment, and measures to prevent iatrogenic errors.

For initial (baseline) assessment of performance, students in both groups were asked to perform root canal therapy on extracted human maxillary central and lateral incisors and maxillary or mandibular canine teeth mounted in typodonts in a head phantom under the supervision of two previously calibrated instructors. After completion of treatment, the teeth and radiographs were inspected by the instructors, and errors in access cavity preparation (gouging, overextension, under-extension, perforation), errors in root canal instrumentation (transportation, ledge formation, perforation, apical zipping, over flaring, under flaring) and errors in obturation (voids, tip to tip, under filling, over filling, inappropriate cutting, poor apical seal) were recorded.

Next, all students in group 1 were asked to prepare 4 access cavities on extracted human mandibular incisors and mandibular premolars and perform complete root canal therapy for 3 teeth, and then return the treated teeth as part of their requirement at the designated time points (every 3 weeks for each tooth type). All teeth and related radiographs were then inspected by the aforementioned calibrated instructors, and procedural errors were recorded and feedback was given to students.

Students in group 2 did not have a specific requirement and had no minimum number of treated teeth as requirement. Each student practiced on extracted teeth depending on his/her own needs so that he/she could acquire the required competency for performing a complete root canal therapy without the guidance of instructors at the time of examination. In this group, each student had to appraise his/her own performance during the practice sessions, and the required level of practice of students was determined by themselves. On the examination day, the treated teeth and related radiographs were precisely assessed by the aforementioned instructors, procedural errors were recorded, and students received feedbacks in this regard.

In both groups, students were free to ask for help from their instructors in case of a problem, find their errors, and learn how to correct them. At the end of the semester, both groups participated in a final standard examination for final assessment, which was the same for both groups (entire root canal therapy of extracted maxillary central or lateral incisors with the same level of difficulty mounted in acrylic resin).

The timing and all test parameters were the same for both groups. The treated teeth were inspected by the instructors, and iatrogenic errors during access cavity preparation, root canal instrumentation, and obturation were recorded for the two groups.

It should be noted that all treated teeth were disinfected with 1% sodium hypochlorite prior to the procedure, and were assessed by the instructors in terms of level of difficulty for root canal therapy (pulp chamber depth, canal calcification, etc.) for the purpose of standardization. Also, all radiographs at all phases of the study in both groups were taken by the same X-ray unit.

The normality of data distribution was assessed by the Kolmogorov-Smirnov test, and homogeneity of the variances was analyzed by the Levene's test. The frequency and type of errors in the final examination were compared between the two groups by independent t-test (after ensuring absence of a significant difference in the baseline competence level of the two groups). ANCOVA, Pearson Chi-square test, and Mann-Whitney test were also applied to compare the efficacy of the two formative assessment methods. All statistical analyses were performed using SPSS 20 (SPSS Inc., IL, USA). Level of statistical significance was set at 0.05.

Results

A total of 84 students were evaluated in two groups of requirement-based (n=46) and practical test-based formative assessment (n=38). Assessments were made on 1000 teeth. Access cavities were prepared in all 1000 teeth but complete root canal therapy was performed for 748 teeth. Thus, assessments were made on 1000 access cavities (506 teeth in group 1 and 494 teeth in group 2), and 748 endodontically treated teeth (368 teeth in group 1 and 380 teeth in group 2). The frequency and percentage of errors in access cavity preparation, root canal instrumentation, and obturation in the two groups at baseline and final assessment are presented in Tables 1-3, respectively.

Table 1- Frequency and percentage of errors in access cavity preparation in the two groups in baseline and final assessments

		Access cavity preparation errors					
		Flawless	Perforation	Under-extension	Overextension	Gouging	Total
Baseline	Requirement-based	183(39%)	0 (0%)	119 (25%)	90 (19%)	83 (17%)	460(2 errors in 15 teeth)
	Test-based	333(73%)	4 (1%)	22 (5%)	28 (6%)	70(15%)	456(2 errors in 3 teeth)
Final	Requirement-based	5 (9%)	0 (0%)	35 (60%)	6 (10%)	12 (21%)	46(2 errors in 12 teeth)
	Test-based	5 (12%)	0 (0%)	18 (43%)	6 (14%)	13 (31%)	38(2 errors in 6 teeth)

*Since more than one error was detected in some teeth, the total number of errors is not the same as the total number of teeth.

Table 2- Frequency and percentage of errors in root canal instrumentation in the two groups in baseline and final assessments

		Root canal instrumentation errors								
		Flawless	Over-flaring	Under-flaring	Irregular tapering	File Fracture	Ledge	Apical zipping	Transportation	Total
Baseline	Requirement-based	259 (80%)	5 (2%)	53 (17%)	3 (1%)	0 (0%)	1 (03/0%)	1 (03/0%)	1 (03/0%)	322 (2 errors in 1 tooth)
	Test-based	281 (82%)	11 (3%)	37 (11%)	7 (2%)	1 (03/0%)	4 (1%)	1 (03/0%)	1 (03/0%)	342 (2 errors in 1 tooth)
Final	Requirement-based	39 (85%)	0 (0%)	6 (13%)	1 (2%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	6
	Test-based	30 (79%)	1 (3%)	7 (18%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	38

*Since more than one error was detected in some teeth, the total number of errors is not the same as the total number of teeth.

Table 3- Frequency and percentage of errors in root canal obturation in the two groups in baseline and final assessments

		Access cavity preparation errors							
		Flawless	Over-filling	Under-filling	Tip to tip	Poor apical obturation	Void	inappropriate cutting	Total
Baseline	Requirement-based	231 (69%)	1 (0%)	35 (10%)	16 (5%)	8 (2%)	29 (9%)	15 (5%)	322(2 errors in 13 teeth)
	Test-based	232 (65%)	4(0%)	17(5%)	1(3%)	22 (6%)	52 (15%)	22 (6%)	342(2 errors in 17 teeth)
Final	Requirement-based	21 (40%)	1 (2%)	2 (4%)	2 (4%)	12 (23%)	11 (21%)	3(3%)	46(2 errors in 6 teeth)
	Test-based	15 (32%)	2 (8%)	1 (4%)	7 (16%)	4 (9%)	8 (18%)	6 (13%)	38(2 errors in 5 teeth)

*Since more than one error was detected in some teeth, the total number of errors is not the same as the total number of teeth.

Figure 1 shows the mean percentage of errors in access cavity preparation, root canal instrumentation, and obturation in the two groups in baseline and final assessments. As shown, the mean frequency of errors was the highest in access cavity preparation (48.5%), and the lowest in root canal instrumentation (14.75%).

Baseline comparison of the two groups revealed no significant difference in root canal instrumentation (P=0.472) and obturation (P=0.405). However, the difference in access cavity preparation was significant between the two groups (P=0.00), and the requirement-based group acquired a higher score. Thus, in order to control for the baseline difference between the two groups in comparison of final assessment, ANCOVA was applied. ANCOVA showed no significant difference between the two groups in final assessment of access cavity preparation (P=0.185), root canal instrumentation (P=0.375), and obturation (P=0.768).

To ensure the accuracy of analyses, the final assessment of the two groups was once again compared by using the Pearson Chi-square test, which revealed no significant difference between the two groups in access cavity preparation (P=0.390), root canal instrumentation (P=0.487) and obturation (P=0.836). The results were confirmed by the Mann-Whitney test as well (P=0.172, P=0.490, and P=0.640, respectively).

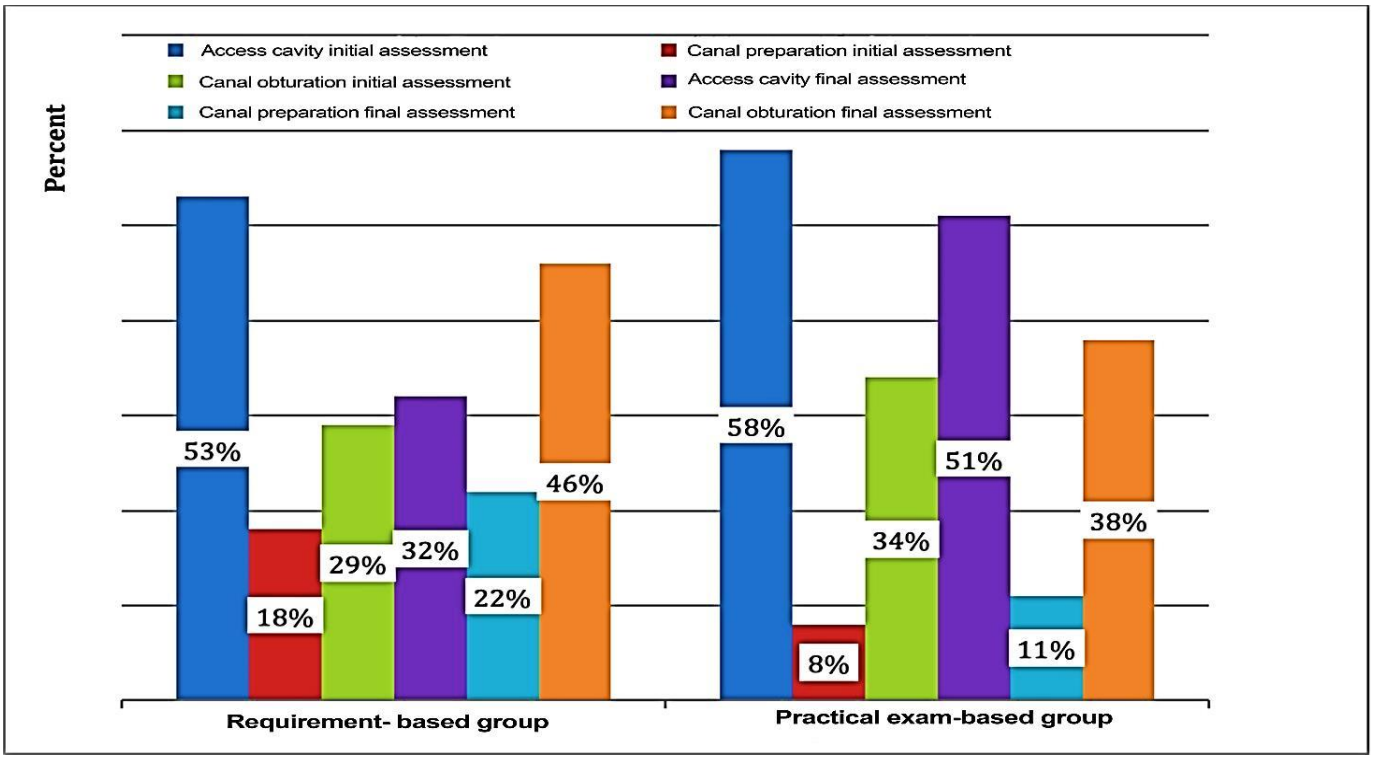

Figure 1: mean percentage of errors in access cavity preparation, root canal instrumentation, and obturation in the two groups in baseline and final assessments

Discussion

This study compared the effects of requirement-based and test-based formative assessment methods on pre-clinical endodontic competence and performance of dental students. In the present study, the teeth were mounted in typodonts in a head phantom since the efficacy of typodont mounting [22] and head phantoms[23] for instruction of clinical skills to dental students has been previously confirmed. Also, both types of formative assessment (during the semester) and summative assessment (final examination at the end of the semester) were used in the present study to benefit from the advantages of both methods. Moreover, it has been demonstrated that summative assessment cannot be eliminated and replaced with formative assessment, and in case of frequent formative assessments in an educational course, number of assessors should be limited and they must be calibrated.[24] In the present study, the final score of students was the sum of their formative assessment scores during the course and the score of their final summative assessment. Also, the assessors had been previously calibrated. The results showed no significant difference between the two groups in access cavity preparation, root canal instrumentation, and obturation.

Weurlander et al. [25] compared three formative assessment methods of direct feedback, practice and classroom activities, and feedback questionnaire and forms for medical students. They reported that all three assessment methods improved the performance of students and they may be used individually or in combination depending on the conditions and goals. Their results were in agreement with the present findings. Baghdadi [26] compared two formative assessment methods including short tests and homework, and personal interviews for instruction and learning and showed that both methods had a positive effect and may be used alone or in combination depending on the conditions and limitations. Their results were in line with the current findings. Medley-Mark and Weston [27] compared three formative assessment methods of written feedback forms, personal interviews, and online feedback forms for medical students. They discussed the advantages and disadvantages of each method, and stated that a suitable method should be selected depending on conditions, which was consistent with the present findings. Khalili et al.[28] compared self-assessment and peer-assessment as two formative assessment methods regarding learning clinical skills and satisfaction of nursing students. They found equal efficacy of both methods in one parameter. However, a significant difference existed between the two methods in the other procedure, probably due to different nature of the tested procedures. Nonetheless, both techniques were satisfactory according to the opinion of students. Nikanmehr et al. [29] compared the effects of two formative assessment techniques (pre-test and post-test assessment, and quizzes and mid-term exams during the course) on learning and satisfaction of pharmaceutical students. Unlike the present study, a significant difference was found between the two methods, and the pre-test and post-test method was superior to the other in terms of quality of learning and satisfaction level of students. This difference may be attributed to different nature of the taught topics.

Consistent with the present results, a previous study found no significant association between formative and summative scores of students. They attributed this finding to the anxiety of students in the summative test, which can adversely affect their final performance. Also, the summative test often has a complete checklist that addresses all the taught topics while formative tests are briefer and assess a particular skill. [24] Some other studies indicated that formative assessment can positively affect final summative assessment.[30,31] To maximize the efficacy of instruction and formative assessment, the authors of the present study attempted to make the formative assessment scoring checklist in both groups similar to the scoring checklist of the final summative test. Nonetheless, this study did not have a control group (without formative assessment); thus, the effect of presence versus absence of formative assessment on the final summative score of students could not be assessed.

The present results showed that test-based formative assessment was as effective as the requirement-based formative assessment. Nonetheless, in requirement-based assessment, 3 teeth for obturation, and 4 teeth for access cavity preparation were used from each tooth group while in the test-based assessment, one access cavity preparation and one complete endodontic treatment were performed for each tooth group. Thus, in the latter group, less time was devoted to assessment and more time was allocated to give feedback to students. Also, the latter method decreased the stress of students related to finding extracted teeth to complete their requirement. Moreover, in requirement-based assessment, instructors cannot directly supervise all the steps of treatment while in test-based assessment, all steps of treatment are supervised by the instructors at the examination time, and this method has less bias due to lower likelihood of cheating.

According to the present results, the frequency of errors related to instrument fracture, zipping, transportation, and ledge formation decreased to zero compared to baseline. However, the frequency of under-extension error increased in the final examination, indicating that the students became more conservative, and probably under-extended the root fillings to prevent gauging and over-extension. The number of sound access cavities also decreased in the final examination in both groups.

It should be noted that this study only assessed the short-term performance of students. Future studies are required to assess the effect of the two formative assessment methods on the

long-term performance of students, knowledge retention, and their anxiety level in different dental departments and in the clinical courses. Also, human resources, number of instructors, number of students, and time should be taken into account in selection of assessment method.

Conclusion

Requirement-based and test-based formative assessment methods had similar effects on pre-clinical endodontic competence and performance of dental students including access cavity preparation, root canal instrumentation, and obturation.

Acknowledgements: Not declared.
Author Contributions:
A.G. and H.A. and M.N. Conceptualization; A.G. and H.A. and M.B. Implementation, Methodology, M.M. wrote the manuscript M.B. analyzed the data
Funding: No funding was received for this research.
Ethical Approval Code:
The study protocol was approved by the ethics committee of the university (IR.SBMU.DRC.REC.1401.127).
Informed Consent Statement: Not applicable
Data Availability Statement: No new data were created or analyzed in this study
Conflict of Interest: No Conflict of Interest Declared ■

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