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Original Article

Effectiveness of Early Clinical Exposure Among Dental Students in Pre-Clinical Prosthodontics

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ABSTRACT

Clinical and theoretical knowledge are mostly kept apart in our dental education system in Pakistan. So, when students enter the clinical years of education, they become anxious and less confident when dealing with patients, even in the early years of clinical practice. **Objectives:** To find out the effectiveness of ECE on knowledge acquisition and application in pre-clinical prosthodontics among 2nd-year dental students. Pre- and post-intervention multiple-choice question (MCQ) scores were compared using Miller's Pyramid of Clinical Competence. **Methods:** A total of 512nd-year undergraduate dental students of the University of Lahore were included in the study. Candidates attended structured ECE sessions that covered specific stages of complete denture manufacture, mainly primary impression making and jaw relation procedures. Pre- and post-intervention MCQs based on Miller's Pyramid of Clinical Competence were utilized to assess "knowledge acquisition". Students' views about this intervention were then collected using a validated post-intervention questionnaire. **Results:** Post-intervention assessment showed overall improvement in student performance after ECE. Jaw relation procedure score of female students improved statistically significantly (p=0.002). Male students showed a significant reduction in higher-order (C2) errors during initial impression operations (p<0.001). The perception data also revealed that students, regardless of gender, stated better understanding and memory retention of the subject delivered, as well as increased confidence in applying theoretical knowledge in clinical settings. **Conclusions:** ECE was linked to better knowledge retention and application of pre-clinical prosthodontics. Students' perception data showed that ECE definitely improved their confidence in applying knowledge before entering practical training.

INTRODUCTION

Dental Education in Pakistan basically emphasizes theoretical learning in the initial years, with clinical training starting later. This usually makes students anxious and unprepared for independent clinical settings, especially in early years [1, 2]. Lack of confidence can severely affect patients' trust and care [3]. No early exposure to clinical settings also increases difficulty in reflecting theoretical knowledge gained in early years into clinical practice later years [4]. A structured pre-clinical environment incorporating patient interactions and clinical exposure in early years can help reduce this gap [5]. These controlled clinical experiences during early years of dental education can be provided through Early Clinical Exposures (ECE). Patient care, Communication skills, and students' motivation and familiarity with clinical settings are enhanced with ECE [6, 7]. Systematic reviews have shown the benefits of ECE as well, in developing professional attitudes, clinical reasoning, and in preparing the students for future clinical practice [8]. In the first two years of dental education, pre-clinical prosthodontics is taught, which mainly focuses on laboratory procedures for complete denture fabrication using edentulous models

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without any exposure to clinical procedures or patients [9]. ECE may help bridge this theory and practice gap by introducing students to patient care before formal clinical training [10, 11]. Other healthcare disciplines also support this ECE learning concept. Medical students who experienced autopsies demonstrated greater knowledge retention and preferred direct patient experience over simulations or written materials [12]. Dental interns also showed better communication and cultural awareness with direct patient interactions than those trained during lockdowns through online videos and lectures. [13]. Same results were reflected in reduced interest in neurosurgery because of limited clinical exposure [14]. This shows that ECE definitely influences students' interest in the subject, their knowledge retention and confidence in dealing with patients, as well as clinical competence. This research was based on Kolb's Experiential Learning Theory, which defines learning through reflective observations, abstract conceptualization, active experimentation, and concrete experience [15, 16]. Miller's Pyramid of Clinical Competence was used as guidance for assessment, focusing on "Knows" and "Knows How" levels through problem-solving and scenario-based MCQs [17].

Even with the stated benefits of ECE, its application in Pakistani dental education is still limited. This is a major concern when researchers talk about knowledge acquisition and retention, as well as its clinical application, in turns student's confidence. The purpose of this study was to address this gap: whether a structured ECE can effectively enhance theoretical learning with early clinical experience. Therefore, this study aimed to evaluate the effectiveness of ECE in pre-clinical prosthodontics by assessing changes in knowledge and its application, students' perceptions as well as confidence, with consideration of gender differences.

METHODS

This non-randomized educational interventional study was conducted at the Department of Prosthodontics, University College of Dentistry, The University of Lahore, following ethical approval from the institutional review board (Ref No: UCD/ERCA/24/1577 dated 13 December 2024). The duration of the study was 4 months, from 1st January, 2025 to 30th April, 2025. Fifty-one second-year BDS students were recruited through convenience sampling. Baseline demographic data, including gender, were collected using a structured form. Written informed consent was obtained from all participants before enrolment. The sample size was estimated using G*Power software (version 3.1) for a paired-sample test. The calculation was based on the formula for power analysis in paired designs: $n = (Z_{1-\alpha/2} + Z_{1-\beta})^2 \sigma^2 / d^2$, where d represents the expected mean difference, σ is the standard deviation of the paired differences, α is the significance level, and β is the type II error. A medium effect size (Cohen's d = 0.5), a significance level of 0.05, and a power of 80% were assumed, resulting in a minimum required sample size of 34 participants. The standard deviation of differences (σ) was assumed to be 1.5 based on similar MCQ-based educational interventions in dental education [18]. The final sample size of 51 participants exceeded this threshold, ensuring sufficient statistical power and alignment with established educational research standards [1, 18]. Written informed consent was obtained from all participants. Students were randomly allocated into five groups (four groups of 10 and one of 11) and supervised by two subject specialists, including the principal investigator, to ensure consistency. Inclusion criteria were 2nd-year BDS students who were able to attend all sessions and provided consent. Exclusion criteria were any prior direct clinical exposure to primary impression-making and jaw relation procedures, and those who declined to participate. Edentulous patients who were getting complete dentures in our department and were able to come for multiple visits were included in the study with informed consent. This study intervention focused on two stages of complete denture fabrication: primary impressions and jaw relations. The instructional process included four segments: 1: To assess the baseline knowledge, a 20-item MCQ test was conducted after a theoretical lecture on two selected procedures (pre-intervention). 2: Students then attended structured ECE sessions under faculty supervision. 3: The same 20-item MCQs were then administered again to evaluate changes after ECE (Post-intervention). 4: Students' perceptions of ECE were assessed using a structured questionnaire (post-intervention survey). Each correct MCQ was scored one mark, with scores ranging from 0-20 per topic and no penalty for incorrect responses. Higher scores indicated better understanding and application. Assessment focused on the "Knows" (C1) and "Knows How" (C2) levels of Miller's Pyramid [15, 19]. To assess knowledge retention and clinical application, curriculum-aligned, criterion-referenced MCQ tests were developed. The researchers didn't focus on score-based ranking, but on mastery of predefined learning outcomes; that is why Cronbach's alpha was not considered essential for this purpose [20, 21]. Before administration of MCQs, three expert clinical professors with more than 10 years of experience reviewed the MCQs independently to ensure content validity. They assessed the content coverage, item relevance, and adherence to standard MCQ construction guidelines [19, 20]. Student feedback was recorded in a post-intervention survey, which was conducted through an anonymous, self-administered questionnaire. This survey had 14 questions rated on a 5-point Likert scale (1 = Strongly Disagree to 5 =

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Strongly Agree). The items were developed based on a literature review and expert consultation. Baseline gender data were collected using a structured form. Knowledge was assessed through pre- and post-intervention MCQs, while perceptions were measured using the self-administered 5-point Likert-scale questionnaire.

Data were analyzed in SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Knowledge scores were summarized as mean ± SD, while ordinal perception data were reported as median (IQR) [22]. Normality was assessed using the Shapiro–Wilk test. A paired-samples t-test was used for normally distributed MCQ scores, while the Wilcoxon signed-rank test was applied to non-normally distributed or ordinal data. Gender-based categorical perception responses were compared using the Chi-square test. Statistical significance was set at p-value<0.05.

RESULTS

A total of 51 second-year BDS students participated in this study, with 32 males (63.7%) and 19 females (37.3%). All participants completed the pre-test, post-test, and post-intervention perception questionnaire. The mean pre- and post-intervention MCQ scores for primary impression and jaw relation were compared separately for male and female students to assess the effect of Early Clinical Exposure. Among male students, post-test scores showed a slight improvement for both topics; however, these differences were not statistically significant (primary impression: p=0.317; jaw relation: p=0.179). In contrast, female students demonstrated a statistically significant improvement in jaw relation scores following ECE (p=0.002), while the improvement in primary impression scores did not reach statistical significance (Table 1).

Table 1: Baseline Clinical and Biochemical Characteristics According to In-Hospital Adverse-Event Status

Variables		Test Type	Mean Score ± SD	p-value
Male	Primary Impression	Pre-Test	15.316 ± 2.4279	0.317
		Post-Test	15.474 ± 2.4351	
	Jaw Relation	Pre-Test	13.316 ± 4.5953	0.179
		Post-Test	14.737 ± 2.5131	
Female	Primary Impression	Pre-Test	15.531 ± 1.6845	0.090
		Post-Test	15.969 ± 1.1496	
	Jaw Relation	Pre-Test	12.438 ± 4.2498	0.002*
		Post-Test	14.281 ± 2.4526	

Errors at the "Knows" (C1) and "Knows How" (C2) levels of Miller's Pyramid were compared before and after the intervention. Among male students, C2-level errors in primary impressions decreased significantly after ECE (p<0.001). Among female students, C1 and C2 errors in primary impressions and C1 errors in jaw relations also decreased significantly (p=0.001), indicating improved conceptual understanding. Other changes were not statistically significant (Table 2).

Table 2: Gender-Based Comparison of Incorrect Responses by Cognitive Level (C1 and C2) Before and After ECE Using the Wilcoxon Signed-Rank Test

Gender	Topic	Cognitive Level	Pre ECE	Post ECE	p-value
Male	Primary Impression	C1	2.947 ± 1.68	2.842 ± 1.67	0.317
		C2	3.947 ± 1.68	1.684 ± 1.16	0.001
	Jaw Relation	C1	4.421 ± 2.95	3.421 ± 1.74	0.143
		C2	2.263 ± 1.99	1.842 ± 1.57	0.167
Female	Primary Impression	C1	2.688 ± 1.35	2.156 ± 0.81	0.019*
		C2	3.688 ± 1.35	1.875 ± 0.91	0.001
	Jaw Relation	C1	5.063 ± 3.07	3.250 ± 1.36	0.001*
		C2	2.438 ± 1.72	2.344 ± 1.68	0.686

*Indicates a statistically significant difference with a p-value ≤0.05

A Likert-scale questionnaire assessed students' perceptions of ECE by gender. No significant gender-based differences were observed for most items. Overall, most students agreed or strongly agreed that ECE improved their understanding and retention of prosthodontic concepts, increased pre-clinical confidence, and supported the application of theoretical knowledge in clinical settings (Table 3).

Table 3: Gender-Based Comparison of Students' Perceptions of ECE Using the Chi-Square Test

Questions	Gender	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	p-value
This method of teaching has stimulated interest in the subject.	Female	5	24	2	0	1	0.767
	Male	4	13	2	0	0	
After the discussions in ECE, a better understanding of the complete denture procedures is made possible.	Female	5	24	2	0	1	0.426
	Male	6	11	2	0	0	
ECE has enhanced your knowledge of the subject more than it was previously.	Female	7	11	14	0	0	0.246
	Male	5	10	4	0	0	
ECE has allowed better comprehension of the acquired knowledge	Female	5	23	3	1	0	0.448
	Male	4	15	0	0	0	
ECE will help in better retention of the topics as compared to the traditional curriculum	Female	4	16	11	1	0	0.454
	Male	5	10	4	0	0	

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ECE will help you to effectively apply basic theoretical knowledge in a clinical context	Female	4	25	3	0	0	0.932
	Male	3	14	2	0	0	
ECE will help in better recall of the topics as compared to the traditional curriculum	Female	7	11	13	1	0	0.480
	Male	2	10	7	0	0	
ECE has motivated you to learn more about complete denture prosthodontics	Female	5	15	12	0	0	0.444
	Male	3	12	4	0	0	
ECE has raised your confidence before clinical exposure in the third year.	Female	4	14	14	0	0	0.441
	Male	4	8	6	1	0	
ECE will enable you to communicate with patients in the future.	Female	4	24	4	0	0	0.717
	Male	4	13	2	0	0	
The interaction between the students and the faculty was good in ECE.	Female	5	16	2	9	0	0.529
	Male	6	9	1	3	0	
ECE is enjoyable, and you are happy with this way of teaching ECE.	Female	4	25	3	0	0	0.576
	Male	2	15	1	1	0	
This approach to teaching would be preferred to be incorporated into pre-clinical prosthodontics.	Female	4	25	3	0	0	0.311
	Male	4	15	0	0	0	
You want to know about other topics in the field of prosthodontics, other than those covered in ECE.	Female	6	22	4	0	0	0.256
	Male	5	14	0	0	0	

Note: The Chi-square test was applied to assess the differences in perception responses between male and female students. * Indicates a statistically significant difference with a p-value ≤ 0.05

DISCUSSION

This study was conducted at the University College of Dentistry, University of Lahore, after ethical approval. 51 2nd year pre-clinical Prosthodontics students were included in the study as per our inclusion criteria. The current study showed that ECE definitely improved the knowledge retention and application in the students. Post-intervention MCS scores were visibly improved in both primary impressions and jaw-relations procedures, especially at "Knows (C1)" AND "Knows How (C2)" levels of the Miller Pyramid. Similar results were seen in studies conducted in medical and dental specialties reporting that ECE improved the overall learning experience and satisfaction of students [8, 15]. Around 70% of students reported better concept grasping, understanding, and retention of knowledge. They also reported developing interest in prosthodontics and that this intervention definitely prepared them for future patient interactions and better application of theoretical knowledge in clinical settings. Over half of the participants stated greater motivation in learning complete dentures. These results suggest that exposure and individual learning experience influence the ECE outcomes. A study conducted by Maheshwari *et al.* reported the same findings i.e., an increase in mean scores from 21.48 ± 5.50 to 27.04 ± 5.04 following ECE, with higher satisfaction across most domains [1]. They basically used 40 MCQs compared to 20 in the present study, which may have resulted in a larger improvement score. Another study by Shigli *et al.* reported a similar increase in post-intervention scores from 12.78 ± 2.70 to 14.51 ± 2.03 following lectures supplemented with video demonstrations [5]. Dehghan *et al.* also stated improvements in motivation, knowledge integration, and satisfaction after ECE [8]. Together, these findings support the educational value of early clinical experiences. No significant gender differences were found in perceptions, although female students demonstrated greater academic improvement. Specifically, female students showed a significant improvement in jaw relation scores (p=0.002), while male students demonstrated a significant reduction in C2-level errors related to primary impressions (p<0.001). Previous research among female medical trainees in Pakistan identified limited clinical exposure as a barrier to neurosurgical training and career interest [14]. This suggests that structured early exposure may have implications beyond academic learning, including confidence and career development. The value of direct clinical exposure was also evident during COVID-19. Students trained without patient demonstrations had lower communication and cultural intelligence scores than those receiving direct patient exposure [13]. This supports the potential of ECE to strengthen patient-related understanding and clinical reasoning. Similarly, incorporating structured ECE alongside conventional teaching may improve competence, confidence, and clinical preparedness, particularly in complex areas such as complete denture prosthodontics [23]. ECE may also encourage metacognitive development. Planning, monitoring, and evaluating one's learning contribute to clinical decision-making and are more developed among experienced dentists [24]. Early case discussions and patient observation can encourage students to reflect on their knowledge and its clinical application, supporting the development of self-directed learning habits. The findings are consistent with Kolb's Experiential Learning Theory,

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which emphasizes learning through active experience and reflection. Previous studies have likewise reported improved reflection, confidence, and preparedness following experiential clinical learning [25]. Overall, ECE appears to be a useful adjunct to conventional pre-clinical prosthodontic teaching. It can support knowledge application, engagement, and clinical preparedness while helping students connect theoretical learning with patient care.

However, the present study has limitations, including its non-randomized design, convenience sampling, single-institution setting, relatively small sample, and short follow-up period. The findings may therefore have limited generalizability, and improvements in MCQ performance may not necessarily reflect long-term clinical competence. Future studies should use larger multi-center samples, randomized designs, and longer follow-up to assess whether ECE produces sustained improvements in clinical competence and patient-care outcomes.

CONCLUSIONS

The study concluded that ECE improved students' understanding of pre-clinical prosthodontic concepts, particularly at the "Knows" (C1) and "Knows How" (C2) levels of Miller's Pyramid significantly. Female students reported greater improvement in knowledge application as compared to male students, but this is totally based on individual preferences and exposure. Students perceived that ECE helped them link theoretical knowledge with clinical application, which improved knowledge retention. These findings support the idea that integrating structured ECE into the dental curriculum will definitely enhance students' clinical preparedness.

Authors' Contribution

Conceptualization: RA, MAA
Methodology: RA, MAA, SA
Formal analysis: RA, NUD, SA, TA, AN
Writing and Drafting: NUD, MAA, HAS, TA, UR
Review and Editing: RA, NUD, MAA, HAS, SA, TA, UR, AN

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflict of Interest

All the authors declare no conflict of interest.

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