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Enhancing Operative Dentistry and Endodontics Education Through Telehealth: Integrating Digital Learning with Hands-On Training

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ABSTRACT

Objective: To evaluate the effectiveness of telehealth in dental education by identifying training gaps and proposing a blended learning model integrating digital education with hands-on clinical experience.

Study Design: Quasi-experimental study (Pre-post interventional study)

Place and Duration of Study: Department of Operative Dentistry and Endodontics, Armed Forces Institute of Dentistry Rawalpindi, Pakistan, from Apr to Oct 2024.

Methodology: A total of 80 dental professionals, postgraduate students and practicing dentists participated in a structured telehealth-based workshop covering diagnostic skills, case-based learning, and treatment planning. The Telehealth Educational Environment Measurement Tool (THEEM) assessed participants' perceptions, while pre- and post-intervention knowledge was measured using structured assessments. Paired t-tests were used to evaluate learning gains.

Results: The mean age of our participants was 32.52±4.69 years, with 61.25% males. Median THEEM scores showed domain-specific variation: Platform Usability remained stable, Internet Connectivity and Learning Engagement improved, while Instructor Support declined. Overall knowledge about THEEM significantly increased, with median pre-intervention scores of 114.25 (IQR 99.25–135.75) rising to 128.00 (IQR 110.00–147.50; p<0.001). Findings highlight notable gains in learning engagement and knowledge acquisition through telehealth.

Conclusion: Telehealth intervention significantly enhanced knowledge acquisition, confidence, and engagement in dental education. However, for clinical skill development, a hybrid model combining telehealth with hands-on training is essential. Addressing technical infrastructure and faculty training can further strengthen telehealth integration into dental curricula.

Keywords: Clinical Competency, Dental Education, Digital Health Training, Learning, Telehealth.

How to Cite This Article: *Ehsan HRU, Rana NA, Arif M, Naqvi SSEH, Mustafa MA, Maryum S. Enhancing Operative Dentistry and Endodontics Education Through Telehealth: Integrating Digital Learning with Hands-On Training. Pak Armed Forces Med J 2025; 75(5): 949-953. DOI: https://doi.org/10.51253/pafmj.v75i4.13255*

INTRODUCTION

"Telehealth" refers to the entirety of healthcare, health-related education, and health research activities that take place from a distance or remotely. It is the use of telecommunications technology to deliver health-related services and information including virtual consultations, treatment plans, remote monitoring, health education, counseling, second opinions, and follow-up care.[1] Telehealth is transforming dental education by expanding access to healthcare training, particularly in resource-limited regions. In Pakistan, telehealth has rapidly gained momentum, with 51 digital health initiatives identified, 55% of which leverage smartphones for medical and dental interventions.[2] Despite its growing adoption, over 60% of healthcare providers in developing regions, including Pakistan, lack formal training in utilizing telehealth tools effectively.[3] This underscores the urgent need for structured telehealth education to enhance provider competence and patient care. Traditionally, dental education has relied on in-person instruction, hands-on clinical training, and direct faculty supervision to develop essential competencies. However, with advancements in digital health and telemedicine, remote learning is becoming an integral component of professional education.[4,5]

Despite these advantages, telehealth alone cannot replace hands-on training, especially in skill-based disciplines such as surgery, operative dentistry, endodontics, and other procedural specialties.[6] These fields require manual dexterity, real-time supervision, and direct patient interaction, which telehealth cannot fully replicate.

Given the increasing importance of digital integration in healthcare, this study addresses a vital gap in dental education by examining how telehealth can be used to enhance traditional clinical training.[7,8]

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Received: 04 Mar 2025; revision received: 15 Aug 2025; accepted: 05 Sep 2025

By assessing the effectiveness of telehealth-based education in operative dentistry and endodontics, we aimed to provide insight into how a blended learning model, combining virtual and hands-on approaches, can improve clinical competency, increase confidence, and expand access to quality dental education.

METHODOLOGY

This Quasi-experimental study (Pre-post interventional study) was conducted at the Department of Operative Dentistry and Endodontics, Armed Forces Institute of Dentistry, Rawalpindi, Pakistan, from April 2024 to October 2024. The study received approval from the Institutional Ethical Review Board (IERB) of Armed Forces Institute of Dentistry, Rawalpindi (Letter No. 918/Trg/006/Jan/2024).

Inclusion Criteria: Adult postgraduate dental students enrolled in Operative Dentistry and Endodontics programs, as well as practicing dentists with 1–5 years of clinical experience were included.

Exclusion Criteria: Individuals who had not previously interacted with telehealth platforms were included.

A priori power analysis was conducted in G*Power (v3.1) for a paired-samples (one-sample) t-test, two-tailed, assuming a moderate standardized mean difference (dz = 0.50), α = 0.05, and power (1−β) = 0.80. The required minimum sample size came to 34. To safeguard against attrition and to enable subgroup analyses, we inflated the target by ≥15% (planned minimum ≈40) and ultimately enrolled 80 participants.[9] To capture both academic and clinical perspectives, participants were divided into two subgroups; 50 postgraduate students enrolled in operative dentistry and endodontics programs (representing formal academic training), and 30 practicing dentists with 1–5 years of experience (representing early-career professionals applying telehealth in real-world settings). This 50:30 ratio reflected the actual distribution of accessible and eligible participants during the study period.

Written informed consent was obtained from participants, and confidentiality was ensured through anonymized data collection and secure data handling procedures.Perceptions of the learning environment were measured with the Telehealth Educational Environment Measurement (THEEM) Tool, a validated 30-item instrument scored on a 5-point Likert scale (1 = Completely disagree to 5 = Completely agree). The tool was originally developed and validated by Arif *et al.*, following rigorous psychometric testing. THEEM comprises multiple domains that capture key aspects of telehealth education, including clinical decision-making, technology usability, communication and professionalism, patient safety, assessment and feedback, and faculty support. These domains were initially derived from literature review, expert consensus, and student feedback, and subsequently validated through factor analysis and reliability testing. THEEM comprises three major domains with the following item composition: (1) Quality & Accessibility of Educational Resources and Technology (items 1–7), (2) Instructor Support & Communication (items 8–13), and (3) Engagement & Support in Telehealth Learning Environment (items 14–30). The total score ranges from 30 to 150, with higher scores indicating a more favourable educational environment.[10] The survey was administered via Google Forms and distributed through email and WhatsApp platforms.

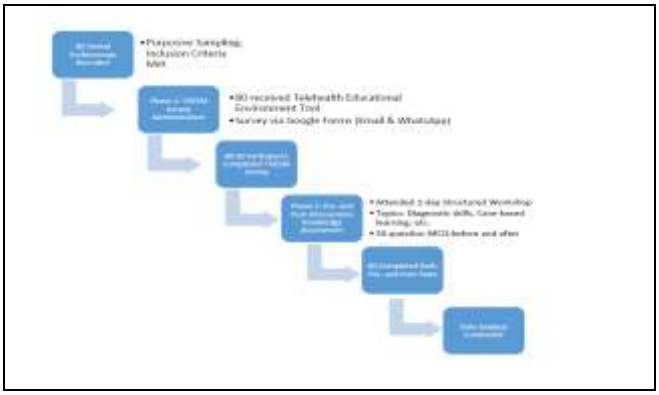

Figure: Flow of participants through the study (enrolment, assessment completion, analysis set)

Participants attended a one-day structured workshop covering key concepts in Operative Dentistry and Endodontics. A 30-question multiple-choice assessment (MCQ test) was Administered before and after the workshop to assess baseline knowledge and to measure learning gains respectively. While the one-day workshop was not designed to confer full clinical competency, it served as a focused theoretical intervention aimed at strengthening participants' foundational knowledge in operative dentistry and endodontics. The workshop emphasized diagnostic reasoning, treatment planning, and case-based learning through structured content delivery. A significant improvement in post-test scores would be taken as a reflection of cognitive gains in knowledge acquisition, but not of skill. Therefore, this workshop

was conceptualized as a component within a broader blended learning model, where telehealth education complements but does not replace practical clinical training.

Quantitative data were analyzed in Statistical Package for the Social Sciences version 25. Medians and interquartile ranges (IQRs) summarized THEEM domain and knowledge scores. Wilcoxon rank test was used to compare pre- and post-intervention knowledge scores, with a *p*-value of <0.05 being considered statistically significant.

RESULTS

A total of 80 dentists and dental students were included in this study; their mean age was 32.52±4.69 years. Out of 80 participants 49(61.25%) were males and 31(38.75%) females. Table-I presents the median and interquartile range (IQR) values of pre- and post-intervention Telehealth Educational Environment Measurement (THEEM) scores across five domains. In the domain of Platform Usability, the median score remained constant at 24.00, while the IQR narrowed slightly from (20.00–28.00) to (19.00–27.00), indicating a minor reduction in score variability following the intervention. Internet Connectivity showed an improvement in the median from 21.00 to 24.00, suggesting better perceived connectivity, with a slight widening of the IQR. Technical Support maintained a stable median of 24.00, though the shift in IQR implies some change in the distribution of responses. Notably, Instructor Support experienced a decline in the median from 25.00 to 20.00, with a corresponding downward shift in the IQR, indicating a reduction in participant satisfaction in this domain. In contrast, the Learning Engagement domain showed the most substantial improvement, with the median increasing from 20.00 to 28.00 and the IQR expanding from (17.00–24.00) to (25.00–33.00), reflecting a strong positive impact of the intervention. Overall, these results suggest domain-specific variations in response to the intervention. Table-II presents a comparison of pre- and post-intervention knowledge scores related to THEEM among 80 participants. The median pre-intervention score was 114.25 with an interquartile range (IQR) of 99.25 to 135.75, while the median post-intervention score increased to 128.00 with an IQR of 110.00 to 147.50. The observed difference was statistically significant, with a *p*-value of less than 0.001.

DISCUSSION

The findings of this study indicate a favourable telehealth educational environment with the strongest ratings in engagement and instructor support and lower ratings for internet reliability/technical support, a pattern reported across regional telehealth implementations. The +3.9-point gain in knowledge confirms short-term learning effectiveness of a telehealth-enabled workshop; however, given the procedural nature of operative dentistry and endodontics, sustained hands-on training and supervised practice remain essential[11]. Priorities include strengthening infrastructure, developing faculty capability in digital pedagogy, and embedding telehealth within a blended curriculum to translate cognitive gains into clinical competence.[12,13]

While telehealth provides valuable theoretical knowledge and enhances clinical reasoning, its effectiveness is maximized when integrated with hands-on training.[14] The hybrid learning model, combining telehealth education with structured in-person workshops, addresses the gap in skill acquisition.[15] This aligns with existing literature emphasizing that blended learning models improve competency development in medical and dental education.

Table-I: Median of Pre and Post Telehealth Educational Environment Measurement (THEEM) score of each domain (n=80)

THEEM Domain	Pre Knowledge Median (IQR)	Post Knowledge Median (IQR)
Platform Usability	20.00(24.00 – 28.00)	24.00(27.00 – 19.00)
Internet Connectivity	21.0(25.75-20.00)	24.0(28.75-19.00)
Technical Support	24.00(29.00 – 19.25)	24.00(28.75 – 20.25)
Instructor Support	25.00(23.00 –29.00)	20.0(24.00 – 17.00)
Learning Engagement	20.00(24.00 – 17.00)	28.00(33.00 – 25.00)

Table-II: Comparison of Pre and Post Knowledge about Telehealth Educational Environment Measurement (THEEM)

	Pre Knowledge	Post Knowledge	*p*-value
THEEM	114.25 (99.25 – 135.75)	128.00 (147.50 – 110.00)	< 0.001

For instance, a study by Maynard *et al.* on the effectiveness of blended learning in conservative dentistry and endodontics found significant improvement in students' theoretical knowledge and confidence, similar to the post-test gains observed in

our cohort.[15] Likewise, a study conducted by Kruse *et al.* reported that blended learning increased student engagement and perceived learning quality in dental education, aligning closely with the high engagement and motivation scores seen in this study.[16] From a local perspective, a recent study in Pakistan by Amin *et al.* underscored the value of tele-dentistry in underserved rural areas, revealing a strong demand for structured telehealth training and reporting improvements in educational access and digital skill development, echoing the rationale and positive outcomes seen in our intervention.[17] Moreover, a large-scale study in the United States by Lawrence *et al.* found that integrating telehealth into dental curricula during the COVID-19 pandemic helped sustain clinical reasoning and diagnostic skills, highlighting telehealth's role as an effective supplement to practical education across different healthcare systems.[18]

Despite the benefits, barriers such as technical difficulties, internet connectivity issues, and the need for faculty training in telehealth methodologies were noted.[19] To optimize telehealth integration in dental education, certain recommendations are proposed, including enhancing telehealth infrastructure by making investments in stable internet connectivity, user friendly platforms, and better technical support can improve learning outcomes; faculty training and development by training educators in digital pedagogy and telehealth tools can enhance instructional quality; using a hybrid learning approach by combining telehealth-based education with hands-on workshops can ensure comprehensive skill development, and enhancing student engagement strategies by increasing interactive elements such as virtual case discussions, AI-assisted decision-making tools, and live mentorship sessions can further improve engagement.[20]

By addressing these challenges and implementing the recommended strategies, dental education institutions can enhance the effectiveness of telehealth in their curricula, leading to improved competency and confidence among dental professionals.

LIMITATION OF THE STUDY

While this study demonstrates the effectiveness of telehealth education, it has some limitations. The research focuses on short-term learning gains, without assessing long-term knowledge retention or clinical skill application. Additionally, infrastructure challenges such as internet connectivity and technical support could have influenced participants' experiences. Lastly, the study primarily focused on operative dentistry and endodontics, which may limit its applicability to other dental specialties requiring hands-on training, such as prosthodontics or oral surgery.

CONCLUSION

This study underscores the effectiveness of telehealth in dental education, demonstrating its ability to enhance knowledge acquisition, confidence, and engagement. However, for procedural disciplines like operative dentistry and endodontics, telehealth should be integrated with practical, hands-on training to ensure comprehensive learning.

Conflict of Interest: None.

Funding Source: None.

Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

HRUE & NAR: Data acquisition, data analysis, critical review, approval of the final version to be published.

MA & SSEHN: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

MAM & SM: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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