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Effectiveness of a Banana Peel-Based Simulation Model for Teaching Basic Suturing Skills among Undergraduate Medical Students: A Prospective Interventional Study

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ABSTRACT

Introduction: Basic suturing is a fundamental procedural competency expected of every medical graduate. However, opportunities for supervised practice are often limited in resource-constrained medical institutions because of restricted access to commercial simulation models. Simple, inexpensive simulation tools may offer an effective alternative for early skill acquisition.

Aim: To evaluate the effectiveness of a structured banana peel-based simulation module for teaching basic suturing skills to Phase III Part II MBBS students and to assess learner competency and participant perceptions.

Materials and Methods: A prospective interventional educational study was conducted over three months in the Department of General Surgery at a government medical college. Sixty Phase III Part II MBBS students underwent a structured training programme comprising interactive teaching, video-assisted learning, faculty demonstration, and supervised hands-on suturing practice using banana peel. Competency was assessed using a Direct Observation of Procedural Skills (DOPS) checklist with a predefined benchmark. Student, faculty, and senior resident perceptions were evaluated using pre-validated Likert-scale questionnaires. Quantitative data were analysed using descriptive statistics, while qualitative feedback was analysed using a Strengths, Weaknesses, Opportunities, and Challenges (SWOC) framework.

Results: All 60 students completed the training programme. More than 85% achieved the predefined competency benchmark on DOPS assessment. Student feedback was highly favourable, with 98.3% finding the sessions engaging, 96.6% reporting improved confidence in suturing, and 78.3% preferring banana peel as the simulation model. Faculty and senior residents consistently rated the module as feasible, safe, cost-effective, and educationally valuable.

Conclusion: A structured banana peel-based suturing programme is an inexpensive, practical, and effective method for teaching basic suturing skills and may be incorporated into undergraduate surgical training, particularly in resource-limited settings.

Keywords: *Basic suturing; Banana peel; Competency-based medical education; Simulation-based medical education; Surgical skills; Undergraduate medical education.*

INTRODUCTION

Basic skin suturing is a fundamental procedural competency that every medical graduate should be able to perform safely and effectively. Early, structured training enables students to develop technical proficiency, improve self-confidence, and enhance patient safety compared with learning solely through opportunistic clinical exposure [1–4]. Nevertheless, undergraduate suturing training often varies considerably between institutions and is largely influenced by the availability of suitable clinical cases, resulting in limited opportunities for supervised hands-on practice.

The National Medical Commission introduced Competency-Based Medical Education (CBME), under which basic suturing is recognised as a certifiable psychomotor skill that undergraduate medical students must acquire before graduation. Although this curriculum emphasises competency-based learning, implementation remains challenging in many government medical colleges because of large student cohorts, limited faculty time, and inadequate access to dedicated skills laboratories and commercial simulation models [5,6].

Simulation-based medical education provides a safe environment in which learners can repeatedly practise procedural skills, receive constructive feedback, and undergo objective assessment before performing procedures on patients. While high-fidelity simulators offer excellent tissue realism, their high cost and maintenance requirements limit routine use in resource-constrained settings. Consequently, low-fidelity simulation models have gained increasing attention as affordable educational alternatives for early procedural training. Several fruit- and vegetable-based models, including banana peel, have demonstrated favourable educational outcomes and learner acceptability for introductory suturing practice [7–15].

Despite these encouraging findings, evidence regarding the structured incorporation and educational evaluation of banana peel-based simulation within undergraduate CBME programmes remains limited, particularly in resource-constrained medical colleges. The present study was therefore undertaken to develop and implement a structured banana peel-based suturing module and to evaluate its effectiveness in improving technical competency and learner perceptions among Phase III Part II undergraduate medical students.

MATERIALS AND METHODS

Study Design and Setting

A prospective interventional educational study was conducted over a three-month period (May 2024- July 2024) in the Department of General Surgery at Government Medical College (GMC), Patiala, Punjab, India.

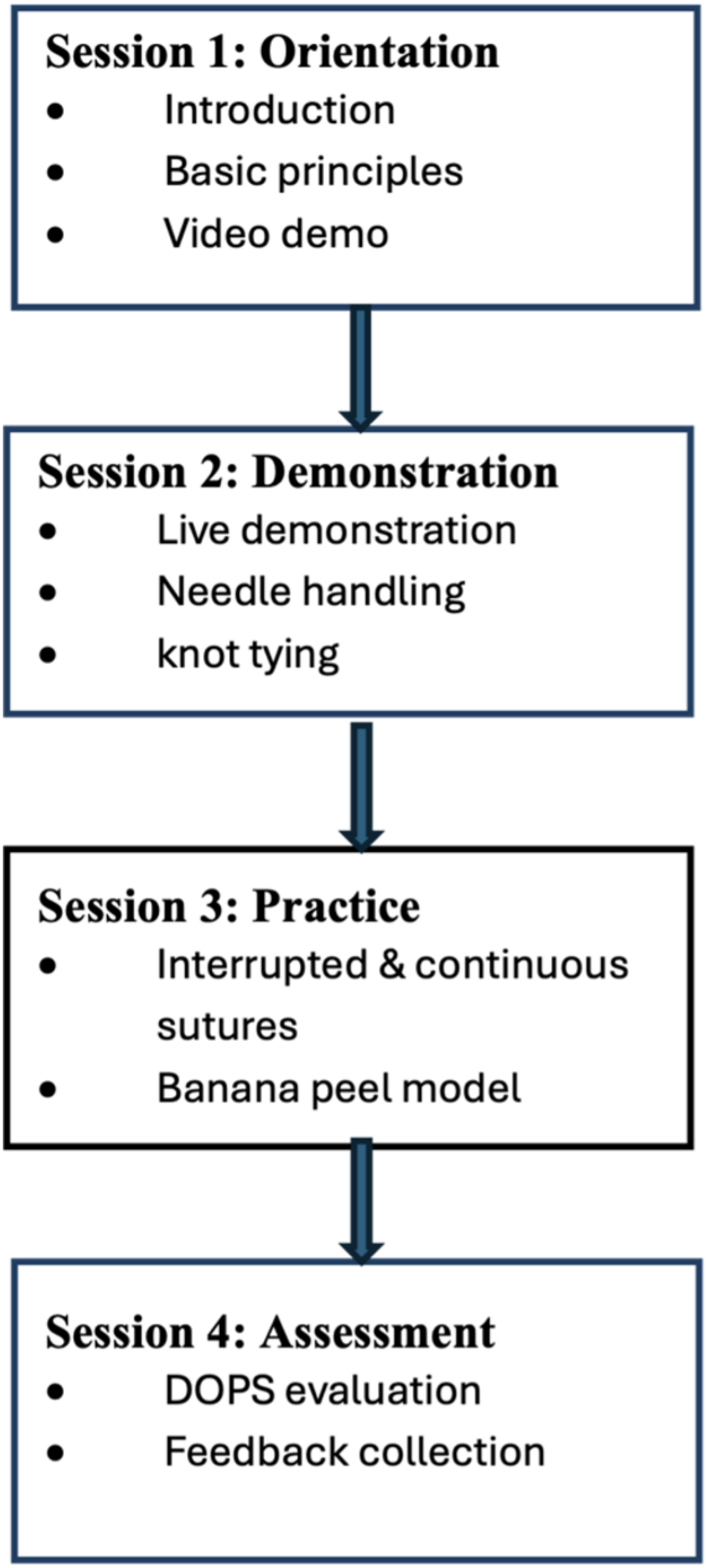
Participants

All Phase III Part II MBBS students posted in the Department of General Surgery during the study period were invited to participate. Students who provided written informed consent and attended all training sessions were enrolled in the study. Faculty members and senior residents involved in conducting the training and assessment constituted the instructor group. The final study population comprised 60 undergraduate students (23 males and 37 females) and six instructors (three faculty members and three senior residents). As the intervention included a complete batch of eligible students, a formal sample size calculation was not performed.

Educational Intervention

Basic suturing skills were taught in the surgical skills laboratory using banana peel as a low-cost simulation model. The training programme consisted of four sequential sessions: (i) orientation with interactive teaching and video demonstration of basic suturing principles, (ii) live faculty demonstration of interrupted and continuous suturing techniques, (iii) supervised hands-on practice on standardised 10-cm banana peel segments using No. 1 silk mounted on a curved cutting needle, and (iv) competency assessment followed by structured feedback [Figure1]. During practical sessions, students received individual guidance and corrective feedback to reinforce proper technique.

[Figure1]: Structured four-session banana peel suturing training module.



Simulation Materials

Fresh, undamaged banana peels of comparable size and thickness were used throughout the training to provide a consistent simulation surface with tissue characteristics suitable for practising basic skin suturing. Standard surgical instruments, including needle holders, toothed forceps, scissors, and No. 1 silk sutures with curved cutting needles, were used for all practical sessions.

Outcome Assessment

Technical competency was assessed using a Direct Observation of Procedural Skills (DOPS) checklist comprising nine essential steps of basic skin suturing (Annexure 1). Each step was scored using a three-point rating scale (0 = not performed/incorrect, 1 = partially correct, and 2 = performed correctly), giving a maximum possible score of 18. A score of ≥12 was predetermined by faculty consensus as the minimum competency benchmark expected from undergraduate trainees. The checklist was developed from standard surgical skills teaching protocols and reviewed by experienced faculty members to establish content validity.

Student perceptions were evaluated using a pre-validated five-point Likert-scale questionnaire (1 = strongly disagree to 5 = strongly agree) covering interest, satisfaction, perceived usefulness, confidence, and safety. Faculty members and senior residents completed similar questionnaires containing both Likert-scale items and open-ended questions. The questionnaires were reviewed by the Medical Education Unit (MEU) for content validity and pilot-tested before implementation to ensure clarity and relevance.

Data Analysis

Data were entered into Microsoft Excel (Microsoft Corporation, Redmond, WA, USA; 2024 version) and analysed using descriptive statistics. Categorical variables and Likert-scale responses were summarised as frequencies and percentages. For ease of interpretation, Likert-scale responses were grouped into three categories: agreement (agree/strongly agree), neutral, and disagreement (disagree/strongly disagree).

Inferential statistical analysis was not performed because the primary objectives of the study were to evaluate the feasibility of the educational intervention, learner competency, and participant perceptions within a single-group design.
Responses to open-ended questionnaire items were analysed using thematic analysis and subsequently organised into the Strengths, Weaknesses, Opportunities, and Challenges (SWOC) framework.

Ethical Considerations

The study received approval from the Institutional Ethics Committee, Government Medical College, Patiala (Reference No. Trg.9(310)2024/13209; dated 03 May 2024). All procedures were conducted in accordance with the ethical principles of the Declaration of Helsinki (1975, revised in 2013). Written informed consent was obtained from all participants before enrolment. Participation was voluntary, confidentiality was maintained throughout the study, and all findings are reported in aggregate form to ensure participant anonymity.

RESULTS

Participant Characteristics

All 60 Phase III Part II MBBS students (23 males and 37 females) completed the structured training programme and post-training assessment. All six instructors (three faculty members and three senior residents) also completed the feedback process. No participant was lost to follow-up during the study.

Student Performance (DOPS Assessment)

Following completion of the training programme, 51 of the 60 students (85.0%) achieved the predefined competency benchmark (DOPS score ≥12), demonstrating satisfactory acquisition of basic suturing skills. The remaining nine students (15.0%) scored below the competency threshold.
The distribution of post-training DOPS scores is presented in [Table 1].

[Table 1]: Distribution of post-training DOPS scores.

DOPS Performance	Students n (%)
Competent (≥12)	51 (85.0)
Below competency (<12)	9 (15.0)

Student Perceptions of the Suturing Module

Student responses indicated a high level of acceptance of the training programme, with predominantly positive ratings across all questionnaire domains. Nearly all participants (98.3%) considered the training sessions interesting, while 96.7% reported increased confidence in performing basic suturing following the intervention. All students agreed that the module improved their suturing skills, and 95.0% believed that simulation-based practice enhanced patient safety.

Repeated practice using the simulation model was considered beneficial by 88.3% of participants. Almost all students (98.3%) preferred simulation-based practice over video-based learning alone, and every participant agreed that the module

provided a safe environment for skill development. When asked about their preferred simulation substrate, 78.3% selected banana peel as the most suitable low-cost model for practising basic suturing.
The detailed distribution of student responses is presented in [Table 2] and [Table 3].

[Table 2]:Student Likert responses.

S No.	Item	SD n (%)	D n (%)	N n (%)	A n (%)	SA n (%)	A +SA n(%)
1	Suturing session was interesting	0 (0.0)	0 (0.0)	1 (1.7)	12 (20.0)	47 (78.3)	59 (98.3)
2	Banana peel model satisfactory	0 (0.0)	0 (0.0)	2 (3.3)	26 (43.3)	32 (53.3)	58 (96.7)
3	Simulation better than real patients	0 (0.0)	4 (6.7)	14 (23.3)	19 (31.7)	23 (38.3)	42 (70.0)
4	Improves suturing skills	0 (0.0)	0 (0.0)	0 (0.0)	29 (48.3)	31 (51.7)	60 (100.0)
5	Allows repeated practice	0 (0.0)	2 (3.3)	5 (8.3)	28 (46.7)	25 (41.7)	53 (88.3)
6	Improves performance	0 (0.0)	0 (0.0)	2 (3.3)	27 (45.0)	31 (51.7)	58 (96.7)
7	Enhances patient safety	0 (0.0)	1 (1.7)	2 (3.3)	25 (41.7)	32 (53.3)	57 (95.0)
8	Better than video learning	0 (0.0)	0 (0.0)	1 (1.7)	17 (28.3)	42 (70.0)	59 (98.3)
9	Increases confidence	0 (0.0)	0 (0.0)	2 (3.3)	32 (53.3)	26 (43.3)	58 (96.7)
10	Provides safe learning environment	0 (0.0)	0 (0.0)	0 (0.0)	28 (46.7)	32 (53.3)	60 (100.0)
11	Produces better graduates	0 (0.0)	0 (0.0)	2 (3.3)	23 (38.3)	35 (58.3)	58 (96.7)

SD: Strongly Disagree; D: Disagree; N: Neutral; A: Agree; SA: Strongly Agree
Positive responses included “Agree” and “Strongly Agree.”

[Table 3]: Student preferences for suturing simulation models(n=60).

Simulation model	Number of students (n)	Percentage (%)
Banana peel	47	78.3
Suture practice kit	12	20.0
Orange	1	1.7
Tomato	0	0.0
None	0	0.0
Total	**60**	**100.0**

Faculty and Senior Resident Perceptions
Faculty members and senior residents expressed consistently favourable opinions regarding the educational intervention. All respondents agreed or strongly agreed that the banana peel model was feasible, cost-effective, safe, and suitable for teaching basic suturing skills to undergraduate students. Although minor variation was observed in previous awareness of the simulation model, responses to all other questionnaire items showed complete positive agreement.
The distribution of instructor responses is shown in **[Table 4]**.

[Table 4]: Faculty and senior resident perceptions (n=6).

S No.	Item	A n (%)	SA n (%)	A + SA n(%)
1	Awareness of simulation-based suturing	2 (33.3)	4(66.7)	6(100.0)
2	Feasibility for undergraduate training	0 (0.0)	6(100.0)	6(100.0)
3	Cost-effectiveness of model	0 (0.0)	6(100.0)	6(100.0)
4	Creates safe learning environment	2 (33.3)	4 (66.7)	6(100.0)
5	Produces better graduates	2 (33.3)	4 (66.7)	6(100.0)
6	Improves student performance	2 (33.3)	4 (66.7)	6(100.0)
7	Overall satisfaction with module	2 (33.3)	4 (66.7)	6(100.0)

Positive responses included “Agree” and “Strongly Agree.”

Qualitative Feedback (SWOC Analysis)
Thematic analysis of the open-ended responses identified several strengths of the training model, including its low cost, easy availability, safe learning environment, and suitability for repeated practice. Reported weaknesses included limited anatomical realism and the inability to reproduce tissue characteristics such as bleeding and tissue tension.

Participants identified opportunities for incorporating the model into routine undergraduate skills training, extending its use to larger student batches, and adapting it for teaching other basic procedural skills. The principal challenges included maintaining uniform training quality, coordinating practical sessions for large groups, and facilitating the transition from simulation-based learning to supervised clinical practice.

A summary of the qualitative findings is presented in **[Figure 2]**.

[Figure 2]: Strengths, Weaknesses, Opportunities and Challenges (SWOC) analysis of qualitative feedback.

Strengths	**Weaknesses**
-Low cost -Easily available -Safe learning environment -Allows repeated practice	-Limited realism -No tissue response (bleeding/tension -Does not fully simulate clinical condition
Opportunities	**Challenges**
-Can be scaled for large batches -Can be integrated into curriculum -Can be used for other basic skills -potential for further research	-Transition to real patient suturing -Maintaining training quality -Logistical coordination -Risk of over confidence

DISCUSSION

The present study demonstrated that a structured suturing module using banana peel as a low-cost simulation model is a feasible and effective approach for introducing basic suturing skills to undergraduate medical students in a resource-constrained setting. A large majority of participants achieved the predefined competency benchmark on DOPS assessment, while students, faculty members, and senior residents expressed highly favourable perceptions of the training programme. These findings indicate that structured simulation-based teaching, supported by supervised practice and objective assessment, can facilitate the acquisition of essential psychomotor skills during undergraduate surgical training. Similar observations have been reported in previous studies evaluating simulation-based education and structured procedural skills training [7–10].

Simulation-based medical education has become an important component of contemporary surgical education because it enables learners to acquire procedural skills in a safe and controlled environment before performing procedures on patients. Repeated practice, combined with immediate feedback and objective assessment, has consistently been shown to improve technical competence, learner confidence, and procedural performance [7–10]. The high proportion of students attaining competency in the present study is consistent with these reports and supports the value of structured simulation within competency-based undergraduate training.

Student perceptions further reinforced the educational effectiveness of the intervention. Nearly all participants considered the sessions engaging, reported increased confidence in performing basic suturing, and believed that simulation-based training enhanced patient safety. These findings are comparable with previous studies demonstrating that early exposure to procedural skills laboratories improves learner confidence while reducing anxiety associated with initial clinical practice [1–4]. Unlike the traditional apprenticeship model, simulation allows repeated practice without compromising patient safety and provides opportunities for immediate correction of technical errors before students perform procedures on patients.

The banana peel proved to be an appropriate low-fidelity simulation substrate for introductory suturing training. Its layered structure provides sufficient resistance to needle passage and enables practice of essential technical components, including needle handling, tissue bites, suture spacing, and knot tying. Although it does not reproduce the complete biomechanical characteristics of living tissue, such as elasticity, tissue tension, or bleeding, it adequately supports the development of basic psychomotor skills required during the early stages of surgical training. Compared with commercially available synthetic suturing pads, banana peel is inexpensive, readily available, biodegradable, and easily replaceable, making it particularly suitable for institutions with limited financial resources [11,14]. Animal tissue models offer greater anatomical realism but are associated with higher costs, storage requirements, infection control concerns, and ethical issues [14]. Consequently, banana peel represents a practical introductory model before progression to higher-fidelity simulation and supervised clinical practice [13,15].

Faculty members and senior residents uniformly considered the training module feasible, economical, safe, and educationally valuable. These observations highlight an important challenge faced by many government medical colleges, where large student cohorts and limited access to commercial simulators restrict opportunities for structured skills training. The findings suggest that educational effectiveness depends not only on the fidelity of the simulation model but also on the quality of instructional design, supervised practice, and objective assessment. Well-planned educational interventions using low-cost simulation models may therefore provide meaningful learning experiences despite limited institutional resources.

The SWOC analysis complemented the quantitative findings by identifying both the strengths and limitations of the intervention. Participants consistently recognised affordability, easy availability, safety, and opportunities for repeated practice as the principal strengths of the banana peel model. Conversely, limited anatomical realism and the inability to reproduce physiological tissue characteristics were identified as its major limitations. Similar observations have been reported in previous studies evaluating fruit- and vegetable-based simulation models, which describe them as useful introductory teaching aids but not substitutes for supervised clinical experience [13,15].

The present findings have important implications within the framework of Competency-Based Medical Education (CBME) introduced by the National Medical Commission in India. Undergraduate students are expected to demonstrate competency in basic suturing before graduation; however, many institutions continue to face challenges related to infrastructure, equipment, and faculty availability [5,7]. The structured training module evaluated in this study provides a practical, scalable, and economical approach for introducing procedural skills training to large student batches. The combination of objective competency assessment, favourable learner perceptions, and positive instructor feedback supports the incorporation of similar low-cost simulation models into undergraduate surgical skills laboratories.

Simulation should, however, be considered one component of a progressive educational strategy rather than a replacement for clinical experience. Development of procedural competence requires a staged approach beginning with low-fidelity simulation, progressing to higher-fidelity models where available, and ultimately culminating in supervised patient care [16,17]. Future research should evaluate long-term retention of acquired skills, transfer of competency to clinical practice, reproducibility across institutions, and comparative effectiveness with commercially available simulation models.

Limitations

The present study has certain limitations. It was conducted at a single government medical college and included only one cohort of undergraduate students, which may limit the generalisability of the findings. As a single-group educational intervention, no control group or pre-intervention assessment was included; therefore, improvements in performance cannot be attributed solely to the educational intervention. Competency was evaluated immediately after completion of the training programme, and long-term retention of skills or transfer to clinical practice was not assessed. Student perceptions were obtained through self-reported questionnaires and may therefore be influenced by response bias. In addition, the banana peel model does not fully reproduce the anatomical and physiological characteristics of living tissue, and supervised clinical training remains essential before independent patient care.

CONCLUSION

A structured banana peel-based suturing module is a feasible, inexpensive, and effective approach for introducing basic suturing skills to undergraduate medical students. Its incorporation into undergraduate skills laboratories may strengthen competency-based surgical training, particularly in resource-limited institutions.

Educational Implications

Low-cost simulation models such as banana peel can be integrated into undergraduate surgical skills laboratories to facilitate early acquisition of basic suturing skills. When combined with structured teaching, supervised practice, immediate feedback, and objective assessment, such models provide an affordable and scalable approach for competency-based surgical education before students' progress to supervised clinical practice.

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Conflict of Interest

None declared.

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